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Measuring the macroeconomic costs and benefits of higher UK bank capital requirements

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The baseline bank capital requirements in the United Kingdom are being set to comply with agreed international standards established in Basel III (as implemented in Europe through CRD IV). The minimum Tier 1 requirement to be met at all times is 6% of risk-weighted assets, comprised of at least 4.5% Common Equity Tier 1 and at most 1.5% Additional Tier 1 capital. Internationally-agreed buffers, on top of this minimum, can be used to absorb losses under stress.

This paper assesses whether these baseline requirements are appropriate for the United Kingdom, given the characteristics of the banking system and economy, and taking into account other areas of regulatory change such as liquidity requirements, structural reform and, most notably, the recent development of a bank resolution regime and requirements for additional capacity to absorb losses in resolution. In November, G20 leaders endorsed standards agreed by the Financial Stability Board for global systemically important banks to meet a minimum amount of Total Loss-Absorbing Capacity (TLAC). In December, the Bank of England will, in line with statutory requirements, consult on proposals for additional loss-absorbing capacity for other UK banks.

This paper uses a framework that measures and compares the macroeconomic costs and benefits of higher bank capital requirements. The economic benefits derive from the reduction in the likelihood and costs of financial crises. The economic costs are mainly related to the possibility that they might lead to higher bank lending rates which dampen investment activity and, in turn, potential output.

Using this conceptual framework, studies conducted in the aftermath of the financial crisis, such as the one by the Basel Committee on Banking Supervision, found appropriate Tier 1 capital ratios of 16-19% - well above the agreed Basel III standards. But our analysis suggests that:

i) once resolution requirements and standards for additional loss-absorbing capacity that can be used in resolution are in place, the appropriate level of capital in the banking system is significantly lower than these earlier estimates, at 10-14% of risk-weighted assets.

ii) The appropriate level of bank capital varies significantly with the risk environment in which the banking system operates. Our main conclusions relate to typical risk environments. But we also find that in periods where economic risks are elevated – such as after credit booms – the appropriate level of capital would be much higher.

iii) It would be inefficient to capitalise the banking system for these elevated risk environments at all times, based on our analysis of the economic costs of higher bank capital levels. This motivates the use of time-varying macroprudential tools, such as the countercyclical capital buffer.

As discussed in the December 2015 *Financial Stability Report*, the Financial Policy Committee took the results from this analysis into account when forming its view on the overall capital framework for UK banks.

1 Introduction

This paper sets out a cost-benefit framework for assessing the macroeconomic impact of higher UK bank capital requirements. As in previous studies, the costs of higher capital requirements are captured by the likely impact these have on bank lending feeding through to the wider economy, and the benefits derive from the reduced likelihood and severity of crises. This paper builds on previous work by the Basel Committee on Banking Supervision (BCBS (2010a)) by tailoring the analysis to the United Kingdom as well as taking into consideration the significant changes to the regulatory environment in the post global financial crisis period.

As was the case in many advanced economies, the large and persistent economic costs associated with the 2007-09 global financial crisis highlighted the critical role that the banking industry plays in facilitating credit and supporting economic growth in the UK. Banks provide essential services to the economy as deposit takers, payments facilitators and credit providers. During the crisis, UK banks made large losses, with some institutions coming close to failure and others requiring recapitalisation by the government. Lending to the real economy fell sharply, households and businesses cut back on spending and the economy suffered its worst recession since the Second World War. Seven years after the crisis, output in the United Kingdom remains significantly lower than suggested by its pre-crisis trend.

A key reason why so many UK banks got into difficulty during the crisis was that they had levels of equity capital that were too low relative to the risks they were taking. The high economic cost of the crisis, and the role that banks played, provide the rationale for regulatory capital requirements. These are designed to ensure that banks appropriately internalise the costs to the wider economy of their business practices and risk-taking behaviour. Higher bank capital reduces the likelihood of a banking crisis since it enables banks to absorb unexpected losses better and to continue to provide credit to the real economy. Moreover, it ensures that when a bank does suffer losses, it is able to maintain investor and depositor confidence without the need for a sharp reduction in the provision of credit. Higher capital requirements therefore benefit the economy by reducing the likelihood of a banking crisis as well as reducing the costs in the event that banks do get into difficulty.

But alongside these benefits, there are likely to be costs to the economy associated with higher levels of bank equity capital, given that equity finance is a more expensive means of bank finance than deposit or wholesale debt funding. Consequently, higher capital requirements may increase banks' overall funding costs which in turn could push up on their lending rates and the cost of capital, reducing potential economic output.

With these trade-offs in mind and against the backdrop of the global financial crisis experience, there has been a major international effort to raise bank capital requirements. The overall design of the prudential regulatory framework has now been largely established, with Basel III, developed by the Basel Committee on Banking Supervision (BCBS), setting out the international framework for going concern capital requirements (BCBS (2011)). In Europe, the Basel III agreement has been implemented through the Capital Requirements Directive (CRD IV) and Capital Requirements Regulation (CRR).

In addition, as part of its work on reducing the impact of the failure of a global systemically important bank (G-SIB), the Financial Stability Board (FSB) has reached agreement on the minimum amount of 'total loss-absorbing capacity', or TLAC, that G-SIBs should meet in order to be able to absorb losses in resolution without requiring public support or threatening financial stability.[1]

For the purposes of our analysis, we treat the TLAC standard as implying that, in addition to their minimum Tier 1 requirement, banks must, by 2022, have at least a further 12% of risk-weighted assets (RWAs) that can be used in

[1] See FSB (2015).

resolution. This additional loss-absorbing capacity can be in the form of equity or eligible debt.

A number of advanced economy jurisdictions have already set additional domestic regulatory capital requirements over and above the agreed international standards to address risks within their jurisdictions which they judge are not adequately addressed by the Basel minima (Box 1).

This paper examines the macroeconomic costs and benefits of raising bank equity capital requirements in the United Kingdom. It focuses on what might be an appropriate level of *going concern* capital for the UK banking system in the steady state, taking as given that *gone concern* loss-absorbency requirements for systemically important UK banks will be such that total loss-absorbing capacity is in the range that the FSB has agreed as part of the development of its international TLAC standard.

There are a number of features of the UK banking system and economy that could cause the consequences of a banking crisis to be greater than for other advanced economies, suggesting that international bank capital standards might not be appropriately calibrated for the United Kingdom. First, the UK banking sector is much larger (with total assets approximating 450% of UK GDP) than the average for other advanced economies. Second, there are high levels of concentration in the provision by banks of critical economic activities such as mortgage and corporate lending. While such concentration in the provision of banking services is not unique to the United Kingdom, the failure of a systemically important bank could have severe consequences for the wider economy. Third, at almost 140% of income, UK household indebtedness is currently higher than in many other countries. This level of indebtedness could leave the economy more vulnerable to shocks and amplify business cycles. Fourth, UK sovereign debt has risen significantly – to over 80% of GDP – limiting the fiscal space to respond to future needs for recapitalisation. Finally, small and medium-sized enterprises (SMEs) have relatively limited access to sources of non-bank finance in the United Kingdom. Given the importance of the SME sector to UK productivity, any disruption to bank credit activity could have relatively more pronounced impacts on growth in this country. While this last factor is not unique to the United Kingdom, it will likely have important interactions with the other factors.

In reaching a judgement on the appropriate capital requirements for the UK banking system as a whole, the Financial Policy Committee (FPC) needs to take into consideration its primary objective with regard to financial stability and its secondary objective with respect to supporting the Government's economic policies.[2] The FPC's two objectives are, in most cases, complementary. However, there may be circumstances where the Committee faces trade-offs between its primary and secondary objectives. The cost-benefit analysis framework used in this paper explicitly considers this trade-off.

Exploring the trade-offs between stability and the provision of finance to the real economy is not straightforward. There are numerous modelling challenges, making it difficult to derive definitive conclusions about an appropriate capital calibration. The relatively small number of banking crises in advanced economies in the past 50 years, for example, makes estimating the relationship between capital ratios and such events highly uncertain. As a result, judgement has to be applied both in deriving our measures of costs and benefits and also in interpreting these estimates. This paper highlights the limitations of our framework and signposts where key judgements have had a material impact on our results. That said, a key aim of this paper is to improve the evidence base that can be used to calibrate UK bank capital requirements.

[2] In August of 2015, the Chancellor requested that the FPC also consider how, subject to its primary objective to protect and enhance the stability of the UK's financial system, its actions might affect competition and innovation, and their impact on the international competitiveness of the UK financial system (see HM Treasury (2015)).

A number of previous studies have tried to assess the macroeconomic impact of higher bank capital requirements.[3] Our cost-benefit assessment approach is similar in many respects to that employed by the Basel Long-term Economic Impact (LEI) study of the optimal capital level.[4]

We have modified the LEI study approach to include data from the recent global financial crisis and targeted the assessment to a greater extent on the United Kingdom. We have also considered the effects of the introduction of TLAC and a credible resolution regime (including, implicitly, the effects of the ring-fencing structural reform policy due to come into effect in 2019) and the likely effects of the new Bank of England liquidity regime. We have not, however, attempted to quantify the effects arising from the introduction of other regulatory initiatives, including for example, the remuneration and governance reforms that have been targeted on banks. Instead, we discuss qualitatively how these other measures might affect the net benefits of additional capital (Box 3).

We have also assumed that current definitional shortcomings in measures of risk-weighted assets and regulatory capital are, in due course, corrected.

Our estimates suggest that net benefits are highest at a Tier 1 capital ratio of 10%-14%.

We generate a different conclusion to the LEI study, which found the optimum Tier 1 capital ratio to be 16-19% of RWAs, assuming financial crises had some permanent effect.[5] One of the reasons why we have arrived at a lower optimum capital ratio is that we have taken into account the expected beneficial effects of TLAC requirements and improvements in the UK's resolution regime.

Our conclusion reflects the amount of capital that would be optimal for banks to hold given an average financial stability risk environment. Of course, the probability of a crisis will be larger and the benefits of additional capital considerably greater in a high risk environment such as at the peak of a credit cycle. Consequently, there would be merits in setting capital ratios higher than those outlined in this paper when there is evidence of elevated risk. The FPC may want to consider using its countercyclical capital buffer (CCyB) instrument to impose higher capital requirements under such circumstances.

Our findings come with a number of caveats and are subject to considerable uncertainty. In particular, as outlined later in the paper, we have made three key judgements related to (i) the persistence of crises costs, (ii) the efficacy of new resolution procedures and (iii) the costs of capital. Each of these judgements has a significant impact on the estimated optimal capital ratio.

The rest of this paper is arranged as follows. Section 2 sets out the baseline for our analysis: minimum Tier 1 requirements under Basel III. Section 3 reviews previous impact studies and their implications for our analysis. Section 4 discusses the general approach taken to analyse the costs and benefits of capital requirements. Sections 5 and 6 respectively discuss economic benefits and costs of higher capital. Section 7 weighs the costs and benefits and develops our estimates of optimal capital for the UK banking system. Section 8 concludes.

[3] See Rochet (2014) for an overview.
[4] See BCBS (2010a).
[5] The LEI study reported optimum Tier 1 ratios ranging from 13.5-17.5% expressed in Basel II terms. We have converted these to a Basel III equivalent, reflecting the stricter definitions of capital and focus on going concern loss absorbency, as well as revisions to the risk-weighted framework. These include revising the market risk framework, better capturing the risk of off-balance sheet exposures and securitisation, and strengthening requirements for counterparty credit exposures. But we also make allowance for improvements in balance sheet resilience which brings down the average risk weight. For full details of this conversion, see the footnotes to Chart 9.

2 Baseline for the analysis

We have taken the requirements for *going concern* Tier 1 capital under Basel III as our baseline. We have also taken as given that *gone concern* loss-absorbency requirements for systemically important UK banks will be as set out by the FSB's recent standards on TLAC (FSB (2015)).

These requirements are set out in detail in the supplement to the Bank's December 2015 *Financial Stability Report*.

As discussed below, our cost-benefit assessment focuses on evaluating the impacts of higher capital requirements on the likelihood and cost of crises for an average risk environment. The analysis can be treated as informing the setting of the CCyB at points where the risk environment is not unusually heightened or uncertain. Because the cost-benefit assessment covers the banking system as a whole, it is not designed to calibrate systemic risk buffers for individual institutions. Nevertheless, by giving a view on the net benefits of overall requirements, the framework can inform the appropriate calibration of these buffers.

3 Review of previous impact studies

Our emphasis is on the long-term, steady-state impact of higher bank capital requirements on the real economy. Reflecting that, this section reviews studies which have had the same focus. We begin by summarising the results of the LEI study (mentioned above) that was used to help calibrate the Basel III reforms, and then describe the findings from more recent studies.

The LEI study

The LEI study incorporated analysis from Basel member organisations (including the Bank of England and the UK Financial Services Authority). It examined the expected net benefits for an average advanced economy of an increase in capital requirements. It did this by considering the equation below. The amounts are expressed in terms of the long-run change in the annual level of output from its pre-crisis path.

Net benefits of higher capital =

{Reduction in probability of crisis due to higher capital × Net present cost of a crisis}

– {Reduction in output due to higher lending spreads}

The LEI study emphasised that its estimated results abstracted from any costs that might be associated with the transition to new capital levels.[6] The starting point of the cost-benefit assessment corresponded to the pre-reform steady state, approximated by historical averages of total capital ratios (ie 7% CET1 and 9.5% Tier 1 capital ratios) and the average probability of banking crises. The results suggested that long-run, expected annual net economic benefits would be maximised at a Tier 1 RWA capital ratio of around 13.5% if crises were expected not to have permanent effects on output. The optimal Tier 1 RWA capital ratio was estimated to increase to around 17.5-19% if a crisis were assumed to have moderate permanent effects. These estimates were, however, based on the definitions of risk weights and eligible capital that were prevailing at the time. Since then, a number of reforms have been introduced. We have attempted to adjust for these changes and estimate that the original LEI study numbers respectively equate to 16 and 19% using today's definitions. **Table 1** presents the headline conclusions from the LEI study.

The LEI study drew on a number of studies from BIS members incorporating different methodologies and models. The LEI study's central conclusion reflected a blend of these national results. The LEI study highlights (in its sensitivity analysis and technical annexes) the wide ranges around its results and the

[6] The transition costs to the new Basel III requirements were estimated by the Macroeconomic Assessment Group (MAG) (BCBS, 2010b). The MAG focussed only on costs and did not provide an estimate of benefits. Estimated costs of moving to higher ratios were expressed in terms of the reduction in lending and impact on GDP for an 'average' advanced economy. The MAG found that the impact on lending to the economy was not only larger in the short-run than in the long-run, but that a shorter implementation period amplified this effect.

potential uncertainties associated with its estimates.

Table 1 Results of Basel LEI study

	Assuming financial crises have no permanent effect	Assuming financial crises have a 'moderate' permanent effect
Tier 1 capital ratio at which maximal net benefits are achieved (% of RWA)	13.5%	17.5-19%
Long-run net economic benefits relative to pre-Basel III capital ratios.[(a)]	~ 0.33% of Annual GDP	~ 2.00% of Annual GDP

Source: BCBS (2010a) and Bank calculations using capital quality conversion factors from BCBS (2010a), Table A5.1.
(a) The amounts are expressed in terms of the long-run change in the level of annual output, so a 1% net benefit equates to expected national annual income being one per cent higher than it otherwise would have been this year and for every year in perpetuity.

Other studies of net benefits

While there have been a number of studies that have evaluated the impact of higher capital requirements on bank lending (rates or volumes) and on economic output, only a few have extended that analysis to include a comparison with economic benefits. Those that have focused on the effects on lending have, in line with the LEI study, generally assumed that higher capital requirements increase banks' overall funding costs and that, in response, banks raise the spreads between lending rates and funding rates to offset these additional costs. To gauge the effect of such responses on economic output, many studies assume the increase in bank spreads passes through fully to a rise in the cost of capital. Semi-structural models are used to assess the impact of this higher cost of capital on potential output.

Table 2 summarises findings from several of these studies. The LEI study suggested an upper-bound estimate of the impact of a one percentage point increase in capital requirements on lending rates of around 20 basis points. It assumed that higher capital requirements would not affect the returns that shareholders and other creditors were likely to demand in return for being exposed to bank credit risk. In practice, however, we would expect that additional equity capital would reduce the volatility of a bank's share price and the riskiness of its debt. Empirical evidence supports the existence of such a relationship and indicates that the cost of equity declines (all other things equal) as the level of equity increases. We refer to this effect in the rest of this paper as a Modigliani-Miller offset (Box 2).

Table 2 Impact of a 1 percentage point increase in capital requirements on lending spreads

	Lending spread (basis points)	Pass-through	Modigliani-Miller offset
BCBS LEI (2010a)	9 to 19	100%	Not Applied
Cosimano and Hakura (2011)	9 to 13	100%	Not Applied
Elliott (2009)	5 to 10	25% to 50%	Not Applied
King (2010)	15	100%	Not Applied
Slovik and Cournede (2011)	16	100%	Not Applied
Baker and Wurgler (2013)	6 to 9	100%	Applied
Kashyap et al (2010)	2.5 to 4.5	100%	Applied

Note: Pass-through is the amount by which cost of capital to the wider economy increases. A 100% pass-through means that lending spreads change by the full amount of any change in the cost of capital.

In addition to the LEI study, a number of other studies have assessed the economic benefits of higher bank capital requirements. Consistent with the LEI study, the framework used for measuring these benefits has been an estimation of the reduction in the annual probability of a banking or financial crisis due to a rise in capital requirements, and an estimation of the output losses that result from banking crises.

Table 3 lists several of these studies and their main conclusions. While each offers unique insights, there are reasons why some of these studies are unlikely to be directly relevant for evaluating optimal UK capital requirements.

Table 3 Overview of recent impact assessments

Study	Conclusions	Optimum CET1 Ratio
BCBS LEI (2010)	The net benefits of doubling the capital ratio from 7% to 14% when banking crises may impose moderate permanent effects is about 2.0% measured in terms of steady-state GDP.	10% to 13%[(a)]
Schanz et al (2010)	There is room to increase capital ratios above the regulatory minima and still realise net benefits.	10% to 15%[(a)]
Miles et al (2013)	There is room to increase capital ratios above the regulatory minima and still realise net benefits.	16% to 20%
de-Ramon et al (2012)	There is room to increase capital ratios above the regulatory minima and still realise net benefits, although estimates are subject to considerable uncertainty and there is decreasing statistical confidence that net benefits are positive for capital levels beyond Basel III standards.	Regulatory bank capital ratios can rise by a further 22 percentage points before total net benefits are exhausted
Bank of England (2013)	There is room to increase capital ratios above the regulatory minima and still realise net benefits; however, estimates are subject to a high degree of uncertainty.	Not applicable
Yan et al (2015)	There is room to increase capital ratios above the regulatory minima and still realise net benefits.	10% yields significant net GDP gains
Junge and Kugler (2012)	The net benefits of doubling the capital ratio when banking crisis may impose large and permanent effects is about 12% of GDP.	Up to twice the Basel III minima
Rochet (2014)	There is room to increase capital ratios above the regulatory minima and still realise net benefits.	Up to twice the Basel III minima

Note: Except where otherwise stated, optimum ratios represent CET1 ratios.
(a) These figures do not take into account increases in risk weights and changes to the definition of capital under Basel III.

The studies by Junge and Kugler (2012) and Rochet (2014) customize their analysis using Swiss data to account for the relatively concentrated nature of the banking sector in Switzerland and the implications this has for the cost of crises in that country. Their results suggested that for Switzerland there would be net economic benefits realised for capital ratios up to around twice the Basel III minima. The focus on Swiss data, however, means that it is unclear how applicable this result might be for the United Kingdom.

Recent studies that have been calibrated for UK data have also suggested there may be room for going beyond the regulatory minima (Schanz et al (2010), de-Ramon et al (2012), Miles et al (2013), PRA (2013) and Yan et al (2015)). An important caveat with these studies, however, is that none of them explicitly considered the effects of TLAC and improvements in the UK bank resolution regime. Hence, it is possible that the results from these studies may have overstated the optimum equity capital requirement. Also, these studies rely on data from before 2010, and, therefore, incorporate only a partial assessment of the impact of the global financial crisis and its aftermath. The approach taken in this paper tries to address these potential shortcomings.

Studies on the costs of banking crises

One factor that determines the economic benefits of higher capital is the long-run expected GDP losses that are avoided by having a more resilient banking sector. **Table 4** summarises the results from recent studies of the economic costs of banking crises in terms of foregone GDP. The estimates are in most cases large. Differences between the results of these studies relate to – among other things – the assessment of the persistence of such losses, the countries included in the sample, and the approach used to define a crisis.

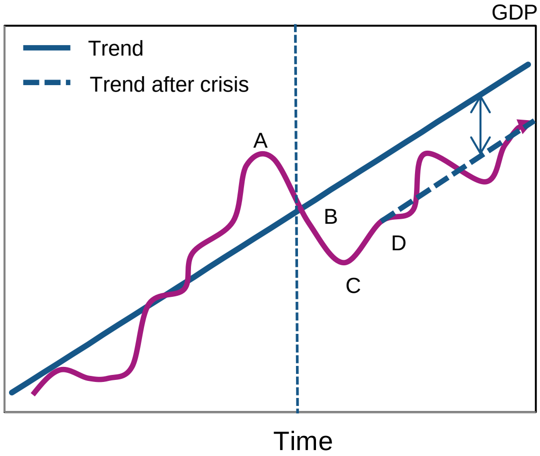
Table 4 Summary of literature on the costs of crises

Study	Peak loss (% GDP)	Long-run impact (% GDP)
Barrell et al (2009)	6	3
Cecchetti et al (2009)	9	N/A
Cerra and Saxena (2007)	8	7
IMF (2009)	10	10
LEI study (2010a)	9	6
Romer and Romer (2015)	4	3
Brooke et al (2015)	**5**	**4**

Note: To allow for comparison across the studies, these cost estimates have not been discounted over time. The peak loss refers to the GDP difference between points B and C in Charts 1 and 2; and the long-run impact refers to the difference between the trend lines before and after the crisis as shown in Chart 1.

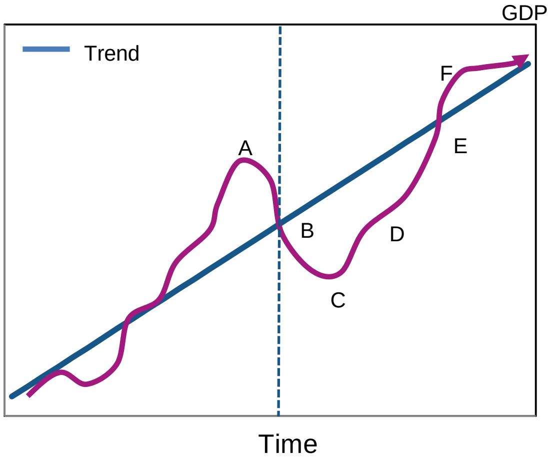
The LEI study found that around half of the studies that it reviewed had allowed for GDP to be on a permanently lower path following a crisis (a stylised example is shown in **Chart 1**), while the remaining studies had measured the cost of a crisis by considering the period from the peak of GDP to the point at which output catches up with its pre-crisis peak, or by simply assuming that crises last a fixed number of years (**Chart 2**). In the LEI study, costs were translated into a net present value (NPV) basis by summing future output losses, discounted at a rate of 5%. On this basis, the average cost of a financial crisis where the effects are permanent was estimated to be 145% of GDP. In contrast, for those studies that assumed only temporary effects of a financial crisis, the average cost of a crisis was estimated to be 19% of GDP. The LEI study's reported results focussed on the temporary effects case and also on an intermediate case which was derived as the median of all comparable approaches in the literature; this average was 63% of GDP.

Chart 1 An example of a crisis with permanent effects



Point A = pre-crisis peak; B = onset of crisis; C = post-crisis trough; D = GDP growth equals pre-crisis trend for the first time after the crisis.

Chart 2 An example of a crisis with temporary effects



Point A = pre-crisis peak; B = onset of crisis; C = post-crisis trough; D = GDP growth equals pre-crisis trend for the first time after the crisis; E = return to pre-crisis GDP peak; F = return to the path of pre-crisis GDP levels.

4 Framework for measuring costs and benefits

Our framework for measuring the net benefits of higher capital requirements is the same as that used in the LEI study and is outlined in the equation below.

Net benefits of higher capital =

{Reduction in probability of crisis due to higher capital × Net present cost of a crisis}

– {Reduction in output due to higher lending spreads}

In applying this framework, we have used updated model estimates that incorporate data from the post-crisis period, and we have used UK data wherever possible to calibrate our models. Two other important changes we have made relative to the LEI study approach are that we have attempted to account for the effect of having a credible resolution regime and derived results that are explicitly focussed on the costs and benefits of higher capital for normal risk conditions (broadly equivalent to the 'mid-point' of the credit cycle). The LEI study approach was different – it drew on data for the full range of the credit cycle.

In what follows, we consider the three components of the cost-benefit equation separately. Section 5 considers both the probability and the costs of a crisis. The costs of a crisis are translated into NPV terms using the discount rate as set out in the Green Book.[7] This is lower than the LEI study's discount rate of 5%. Section 6 considers the reduction in steady-state output due to higher lending spreads. Similar to the LEI study, we have drawn on a number of methodologies and models in each of these dimensions of the framework. We then bring together these components to illustrate the range of potential capital requirements which might maximise macroeconomic benefits.

Given data constraints, particularly with long-run time series, some of our analysis is based on the relationship between crises and bank capital as a share of total (rather than risk-weighted) assets. To ensure applicability to UK bank capital requirements at present, we have converted our results to risk-weighted capital ratios using the current average risk weight for major UK banks (37%).[8]

5 The economic benefits of higher capital requirements

Probability of financial crises

The first step in our approach is to estimate the impact of higher capital requirements on the probability of a crisis. We measure this probability in percentage terms such that, for example, a 1% probability equates to one crisis every 100 years. We have used two complementary models. One is a *bottom-up approach* based on losses at individual banks and the other is a *top-down approach* based on the past relationship between banking system capital ratios and the subsequent frequency of crises. Both approaches were used in the LEI study. The LEI study also used information from market prices and from a calibrated stress test model. Our two models generate materially different probability curves, highlighting the large degree of uncertainty around any estimate of the probability of a banking crisis.

Bottom-up approach

The bottom-up approach uses information from the past experiences of bank losses to gauge the likelihood of individual bank failure for any given capital ratio and then translates this into the likelihood of a crisis. We used semi-annual data from banks' published accounts on their pre-tax net income and assets from a sample of 22 advanced economies. A large proportion of the most extreme losses in this sample were made by Greek banks and large US government-sponsored enterprises (GSEs). We decided to exclude these results from our central estimates since their experience seemed unlikely to be representative for the United Kingdom. The evolution of the Greek financial crisis was heavily influenced by Greece's position within a currency union and its starting position of an exceptionally high sovereign debt to GDP ratio. And there is no equivalent

[7] HMT guidance for public sector bodies on how to appraise proposals before committing funds amounts to 3.5% for the first 30 years then decreases very gradually over time in increments of 0.5 percentage points until it reaches 1% and is flat thereafter.

[8] This average reflects data as of year-end 2014.

arrangement to the US GSEs in the United Kingdom.

Our data sample included the experiences of 185 large or medium-sized banks over the period since 1993, although we have data going back that far for only 21 banks. For the overwhelming majority (90%) of data observations, banks had positive pre-tax net income. While there were some very large losses, they are rare.

To estimate the probability of a single bank failure at different given starting levels of capital, we estimated the distribution of losses in the data sample described above. Drawing on this loss distribution, we then used simulation analysis to apply a random loss scenario for each of a range of starting capital ratios. If banks suffered large enough (net) losses, irrespective of the time horizon, to push them below the regulatory capital minimum, then they were considered to fail. By repeating this many times, we can model how often banks would fail for any given starting capital position. This approach is conceptually similar to that used in a study conducted by the Federal Reserve Board (2015) which also used past loss histories to link capital buffer size to the probability of failure.

We ran separate simulations using loss data drawn from a typical risk environment (broadly equivalent to the mid-point of the credit cycle) and also from peak periods of the credit cycle.[9]

These failure probability estimates are necessarily conservative because they reflect only losses that are booked to the profit and loss account; they will be understated to the extent that losses can be 'smoothed' between periods and that accounting standards have allowed firms not to recognise losses in a timely manner. They also ignore the possibility that banks could fail for reasons besides credit losses, including liquidity stress or other market pressures.

[9] We identified peak cycle periods as those when the change in the credit to GDP ratio and risk appetite proxy (equity market volatility) pointed to risks in the top third of the distribution. These periods vary across countries. In the bottom-up approach, we then look for losses one and two years after these periods and categorise these as losses coming from peak periods.

Table 5 shows the results of the simulations. The probability of individual firm failure declines rapidly as risk-weighted Tier 1 capital ratios rise above 8%. Banks with larger capital buffers are better able to withstand adverse shocks. In addition, our data sample indicates that the loss distribution falls rapidly. There are not that many very large loss experiences in our sample; although the top seven losses in the sample averaged 10% of assets (27% of RWAs).

Table 5 Results of the bottom-up approach[(a)(b)]

Tier 1 capital ratio	Tier 1 leverage ratio	Probability of individual firm failure		Probability of systemic crisis	
		Mid	Peak	Mid	Peak
8	3	7.5	10.2	0.5	2.2
11	4	2.3	4.1	0.4	1.5
14	5	1.1	2.3	0.3	1.3
16	6	0.8	1.5	0.3	1.0

Source: Bank calculations.
(a) All numbers are percentages.
(b) 'Mid' and 'peak' refer to average and peak risk environments.

Next, using the characteristics of the UK banking system, such as its size and concentration, we translated the probability of failure for individual banks into the probability of a systemic banking crisis. In each run of the simulation, the hypothetical banks start with a given level of capital, made up of the regulatory minimum and a usable buffer, the sizes of which match those of the United Kingdom's largest banks as of end-2014. We assigned a loss to each bank as before. Banks are assumed to be recapitalised if they breach the regulatory minimum, with the recapitalisation being of a size sufficient to restore their capital to the regulatory minimum.

We assumed that a systemic banking crisis occurs when system-wide recapitalisation costs exceed 3% of GDP, which is consistent with the definition of a crisis used by Laeven and Valencia (2012). This definition of a crisis requires there to be evidence of bank runs, large bank losses or bank liquidations and significant policy interventions in the banking sector (such as liquidity support, recapitalisations or nationalisations). In practice, this measure picks out only severe crises and does not include smaller crises such as the secondary banking and small banks crises in the United Kingdom.[10] This approach provides a lower bound on the probability of a crisis, as recapitalisations would in reality be expected to go further than just the regulatory minimum, in addition to the failure probabilities themselves being conservative.

The results of these simulations suggested that, for the United Kingdom, there is less than a 1% probability of a crisis in an average risk environment for all capital ratios above the current regulatory minimum (**Table 5**). As one would expect, this is lower than the equivalent probability of an individual bank failure because the failure of one firm does not necessarily lead to a systemic banking crisis.

These probabilities are very low compared to the actual frequency of systemic crises, which has been about once every 25 years. There are two reasons for this:

- The analysis assumes that banks operate in a typical risk environment like the average of the past. But systemic crises often occur after a build-up of risks, including through rapid credit growth. When we replicate the analysis using loss data from peaks of credit cycles, the probability of systemic crises reaches 3% - closer to, but still below, actual experience.
- The exercise only captures ex post book losses, whereas banks can fail due to confidence effects, with restricted access to funding markets when there are concerns about large expected losses. For this reason, it is difficult to rely solely on this model for estimating benefits.

[10] This definition may be less appropriate in future if bail-outs are less common (because of resolution). However, we assume that absorbing losses via bail-in rather than bail-outs would on its own not help avoid a crisis altogether.

Top-down approach

In our second approach we used various cross-country panel logit models[11] to estimate the relationship between banking crises and the capital ratios of banking *systems*, controlling for other factors that contribute to crises. The model is similar in nature to those used in Barrell et al (2010) and de-Ramon at al (2012), who also examined the drivers of systemic banking crises.

The dataset we used in this top-down approach included more banks and has a longer history than the first approach, but this comes with the trade-off that the capital metric we have used was based on total assets rather than RWAs. This means that we then had to translate the results back into RWAs using the 37% average UK risk weight mentioned previously.

We used data on the ratio of tangible common equity (TCE) to tangible assets for a sample of 840 advanced economy banks (a median of 20 banks per country) over the period since 1980. These data were aggregated to derive banking system level capital ratios. We measured crises using an index of systemic banking crises developed by the Laeven and Valencia (2012). Using these criteria, we identified 23 crises in our sample, of which 7 occurred before 2007.

The TCE capital ratio used in this modelling approach is similar but somewhat higher than the Basel III leverage ratio (in 2014 it was 0.6 percentage points higher in the United Kingdom). The maximum TCE capital ratio observed in the sample is 11.1% (Singapore in 1999) and the minimum is 1.4% (France in 1987).

To establish the empirical relationship between banking system capital ratios and systemic crises, we compared the frequency of crises

[11] A logit model is a regression model where the dependent variable is categorical, taking on, for example, only two values, such as crisis = 1 / no crisis = 0 or fail = 1 / survive = 0. The logit regression measures the relationship between the dependent variable and one or more independent variables by estimating probabilities using a logistic function, which is the cumulative logistic distribution.

for a range of TCE capital ratios. As in the bottom-up exercise, we also distinguished between the positions in the credit cycle. We found a negative relationship between the capital ratio and crisis frequency, and also that crises have occurred much more frequently following the peak of the credit cycle.

We then used a logit model to estimate the probability of crises. This model reflects the past relationship between the system-wide average bank tangible equity capital ratio and crises, conditioning on the credit cycle, as proxied by the ratio of total credit to GDP (Credit_GDP), the market volatility index (VIX), and other banking system characteristics such as the ratios of liquid assets to total assets (Liquid_TA) and deposits to total liabilities (Deposits_TL). All of the determinants of crises were lagged three periods, with the final specification as follows:

$$Probability(Crisis) = f(TCE_{-3}, Credit\_GDP_{-3}, VIX_{-3}, Liquid\_TA_{-3}, Deposits\_TL_{-3})$$

In calibrating the model results, we set the liquid asset and deposit ratios to levels that would make banks broadly compliant with post-crisis liquidity reforms, considering the expansion of the Bank of England's liquidity facilities.[12] Our central estimates are based on setting the initial levels of Credit_GDP and VIX at their respective means in order to deliver a typical risk environment (roughly equivalent to a mid-point in the credit cycle). We then examined how the likelihood of crises changed over a plausible range of TCE capital ratios. This approach suggests that the Tier 1 leverage ratio associated with a 1% crisis probability in normal times is estimated to lie between 3% and 4% (**Table 6**).

Table 6 Results of the top-down approach[(a)]

Tier 1 capital ratio	Tier 1 leverage ratio	Probability of systemic crisis	
		Mid	Peak
8	3	1.8	11.8
11	4	0.8	5.9
14	5	0.5	3.9
16	6	0.4	2.7

Source: Bank calculations.
(a) See footnotes to Table 5.

The top-down model's main weakness is the low number of observations for high capital ratios and the limited number of crisis events.

Comparing and verifying the models

Tables 5 and **6** highlight large differences between the results from the bottom-up and top-down models. For example, at a Tier 1 capital ratio of 8%, the bottom-up model gives a probability of crisis in an average risk environment of 0.5%, almost four times lower than the top-down model's estimate of 1.8%.

Given these differences and the fact that both models have limitations, we have chosen not to rely on a single one. In addition, we had particular concerns about the bottom-up approach not reflecting the actual frequency of financial crises we have seen in advanced economies. To capture the confidence and amplification effect that this approach misses, we therefore adjusted the probability of crisis estimates derived from the bottom-up approach such that the probability of crisis at low capital ratios was in line with the frequency of crisis seen for advanced economies (ie roughly every 25 years). We then take the average of the results from the top-down model and adjusted bottom-up model as our central estimate of crisis likelihood.

[12] Summarised in the Bank of England 'Red Book' (see Bank of England (2015)).

Adjusting for other factors

Our estimates of the probability of crisis also attempt to take into account the impact of the new stronger resolution framework.[13] The main channel considered here is through stronger market discipline – holders of bank debt and equity instruments are more likely to influence bank management to make less risky investment choices (either directly or indirectly by the cost of funding becoming more risk-sensitive) if they do not anticipate to be bailed out in the case of failure. To quantify this market discipline effect, we have used the same method as the FSB's TLAC Impact Assessment (FSB (2015)). This assessment relied on work by Afonso et al (2014) and Brandao-Marques et al (2013) which suggested that removing government support assumptions (as measured via ratings) could induce systemically important banks to change the riskiness of their business models in a way that would reduce their probability of default by individual banks by around 30%. For an average jurisdiction, this is predicted to reduce the probability of a crisis by slightly less than 30% (eg a reduction from 4% to 2.8%).

Results

Table 7 shows that our estimates of the probability of a crisis relating to a normal risk environment (roughly a mid-point of the cycle) are less than the equivalent probability estimates used in the LEI study.

The main drivers of this difference are: (i) the lower probabilities generated by our bottom-up model, even when adjusted; (ii) the fact that we condition on average risk conditions; and (iii) the adjustments we have made to take into account the market discipline effect from the introduction of TLAC requirements and credible resolution arrangements that will apply to all global systemically important banks.

[13] As set out in the Bank's approach to resolution (see Bank of England (2014)).

Table 7 Comparison of Bank and LEI findings on the probability of crises[(a)]

Tier 1 capital ratio	Tier 1 leverage ratio	Average of our models		Average of our models after TLAC	
		Mid	Peak	Mid	Peak
8	3	1.2	5.5	0.8	3.9
11	4	0.7	4.1	0.5	2.9
14	5	0.5	3.1	0.4	2.2
16	6	0.3	2.4	0.3	1.7

Tier 1 capital ratio	Tier 1 leverage ratio	LEI[(b)]
8	3	6.3
11	4	2.9
14	5	1.3
16	6	0.8

Sources: BCBS (2010a) and Bank calculations.
(a) See footnotes to Table 5.
(b) Taken from the 'all models' column of Table 3 of BCBS (2010a), with TCE ratios converted to Tier 1 ratios as described in Table 1.

Costs of financial crises

This section sets out our approach to estimating the output costs of crises. The objective is to obtain a central estimate of the expected discounted cost of a financial crisis in the United Kingdom.

Approach

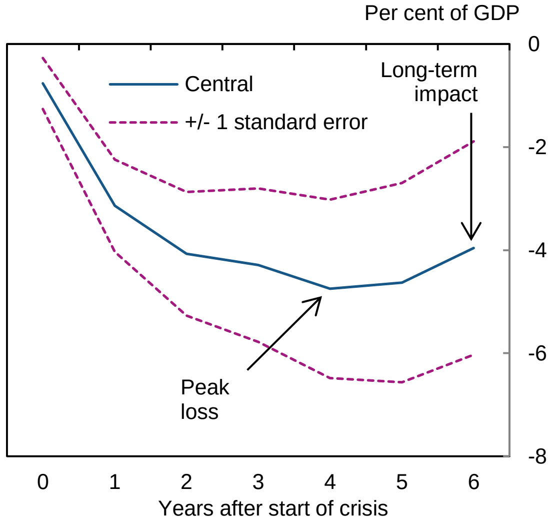
As noted in Section 3, since the LEI study, additional studies have been published that have estimated the costs of financial crises (**Table 4**). Unfortunately, none of these studies fully captures the effects of the 2007-09 global financial crisis. Of these studies, we think the results derived by Romer and Romer (2015) are likely to be the most relevant for the United Kingdom. Their estimate is focussed on advanced economies. Such economies have generally experienced lower costs of crises as they tend to have greater capacity to use monetary and fiscal policy to partially offset the negative impact of a crisis. The LEI study, on the other hand, used studies that considered a mix of crisis experiences from advanced and emerging market economies, where such capacity is less likely.

We have built on Romer and Romer (2015) by including the experiences of the global financial crisis, and narrowing their sample of countries somewhat to make it more appropriate for the UK.[14]

We updated recent work by the IMF (2009) to assess whether any UK-specific factors, such as the size and interconnectedness of the financial system and a flexible exchange rate regime, should give us cause to aim off the result for a generic advanced economy. The IMF study explored which factors were correlated with the costs of crises in 80 pre-2007 crisis cases. We adapted the IMF study approach by examining a broader range of variables – in particular, to include possible determinants for which the UK values are unusual; variables which might speak to the impact of post-crisis reforms; and other variables whose values might be quite different in the post-crisis world (eg public debt to GDP ratios). Overall, we found little evidence to suggest we should make any UK-specific adjustments.

Based on these findings, our estimate of the average impact of a crisis on the level of GDP six years after the crisis, relative to its pre-crisis trend, is 4% for a generic advanced economy (**Chart 3**).

Chart 3 GDP impact of banking crises for an average advanced economy

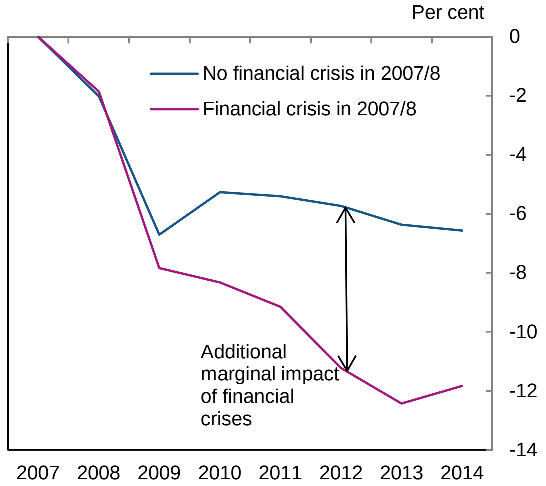


Source: Bank calculations.

[14] We excluded countries with insufficient data (the Baltic states, Malta, Slovenia, Slovakia) or whose banking systems are dominated by foreign-owned banks (Luxembourg, the Czech Republic and Finland).

These costs might seem small in the context of 2015 UK GDP still being around 10% below its pre-2008 trend. The explanation for this is that our method (like that of Romer & Romer) examines the *marginal* impact of a financial crisis. During the global financial crisis, output in advanced economies that did not experience financial crises also fell significantly, due to global shocks and spill-overs from countries that did experience financial crises (**Chart 4**). We have deducted this general recession element from the total impact to derive an estimate of the marginal additional impact of a financial crisis.

Chart 4 Output experiences for crisis and non-crisis countries



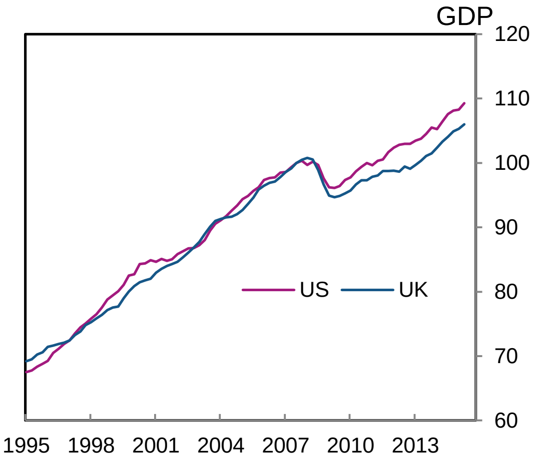
Source: Bank calculations.

This approach of trying to separate out the marginal additional cost of a financial crisis has a material impact on our results – it leads to a lower estimate of the cost of a crisis and, therefore, a lower estimate for the optimum capital ratio. One implication of this approach is that our estimates of the optimum capital ratio do not include the potential spillover costs onto other countries. These may be large given the open and interconnected nature of the UK economy and financial system.

Persistence of crisis effects

A key judgement we have made is that we allow for crises to have permanent effects. This is consistent with the recent experience of the United Kingdom and the United States. As shown in **Chart 5**, both economies have returned to pre-crisis GDP growth rates but have remained below their respective paths of trend GDP that would have been expected had the crises not occurred.

Chart 5 GDP paths for the UK and US economies pre and post crisis(a)



Sources: ONS, Datastream and Bank calculations.
(a) GDP indexed to 100 at end-September 2007

Impact of post-crisis reforms

Another key judgement we have made is that the costs of future crises are likely to be less than the average cost experienced in past crises due to regulatory reforms introduced since the global financial crisis. A range of reforms – namely the creation of a resolution regime with bail-in powers, the introduction of TLAC requirements, and structural reform of the UK banking sector – have been designed with the intention that they will reduce the costs of future crises. Below we set out the most important of these channels and our approach to their quantification.

(i) More timely bail-in of private-sector creditors in bank recapitalisations

The new resolution arrangements should reduce uncertainty around the way in which bank failures will be addressed, and they may be capable of accelerating the process of addressing a systemic crisis. This is the combined aim of the introduction of TLAC requirements and the structural reform requirements to separate out the major UK banks' retail banking operations into ring-fenced banks with higher capital requirements. If market participants expect the new regime to deliver more timely and predictable recapitalisations of systemically important banks, this may instil greater market confidence in the firm and shorten the period of disruption in banks' lending and other critical economic functions. This would, in turn, lower the cost of a crisis.

Homar and Wijnbergen (2014) attempted to quantify this effect. They found that recessions have been significantly shorter in countries which restructured or recapitalised their banking systems quickly. For this group of countries, the typical recession (from the sample of 2007 to 2013 crises) during which banks were recapitalised was estimated to last 6.3 quarters. In contrast, for those countries whose banks had been recapitalised slowly or not recapitalised, the same recession had, on average, persisted for 11 quarters.

We try to capture this effect quantitatively by separating our sample between countries that have had quicker and more comprehensive interventions and those that have addressed crises more slowly and less comprehensively. There was inevitably a large degree of judgement involved in making these distinctions. We used the following criteria: the types of intervention measures used (such as guarantees of bank liabilities, bailouts, asset purchase facilities, bad banks, asset quality reviews and stress tests); the speed of those interventions; and how sizeable they were as a proportion of GDP.

Using this approach, we isolated two distinct groups in our sample. We found 13 examples that fitted into the rapid / more credible resolution category. Among these, the Nordic examples (Finland, Sweden and Norway in the 1990s)[15] put in place measures to deal with problem loans and lax accounting standards and the US approach in 2008-09 was quick to introduce a wide range of measures. Switzerland also reacted quickly in 2008-09 by creating a stabilisation fund to hold non-performing assets and through its early financial support for UBS.

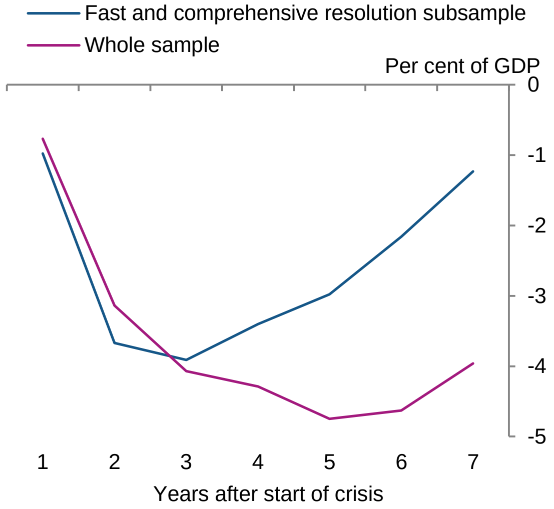
[15] The global growth backdrop was more supportive during this period and the economies recovered in part through strong demand for exports, but we do not consider this channel strong enough to affect our findings.

We found eight cases that fitted into the slow / less credible resolution category. Among these, Japan's lost decade was characterised by regulatory forbearance and inadequate recapitalisations; Spain did not recognise the extent of the fall in the value of domestic loans until several years into the global financial crisis; and in the US savings and loan crisis from the mid-1980s to 1990s there was extensive regulatory forbearance.

The FSB (2015) discusses this channel qualitatively, noting that future crises may be more akin to the Nordic crises in the 1990s which are often cited as a blueprint for how to resolve a financial crisis in an efficient way and minimise the economic impact. Quantifying these additional beneficial effects from a credible resolution regime is difficult, but we have attempted to do so.

Our results indicate that countries which had more rapid and effective crisis resolution policies had similar initial annual crisis costs but then recovered more quickly, such that the reduction in GDP relative to the pre-crisis trend was around 1-2% of GDP six years after a crisis, compared to 4% for a generic advanced economy historically (**Chart 6**). A credible resolution could limit the otherwise long-lasting nature of financial crises.

Chart 6 Impact of banking crises on the profile of GDP



Source: Bank calculations.

In our results, we have assumed that the introduction of a credible resolution regime will lower the cost of future UK banking crises to be in line with the average for the above group of countries that have deployed rapid and effective resolution policies. This assumption reduces the assumed NPV cost of a crisis by over 60% and has a material impact on our estimate for the optimal amount of bank capital.

(ii) Reducing the need for fiscal consolidation by reducing the need for bailouts

As well as achieving a faster and more comprehensive response to crises, moving from *bail-out* by the authorities to *bail-in* of private creditors will shift losses from the government to private creditors. This has two immediate effects. Bail-outs may crowd out other fiscal stimuli or require subsequent fiscal consolidation. Such a reduction in government spending typically reduces GDP. Moreover, this effect tends to be even larger in a recession.[16] On the other hand, because private creditors of banks will include foreign investors and a greater proportion of wealthier domestic investors, it is likely that the impact on domestic spending following a bail-in of private creditors will be less than the negative impact from a bail-out operation. Hence, imposing losses on bondholders is expected to have a smaller effect on GDP than imposing the same losses on taxpayers. We therefore expect the net impact to reduce the cost of a financial crisis.

Consistent with the FSB (2015) , we calculate a reduction in the NPV of output lost in a crisis in the case of bail-in of 3.8 percentage points of GDP – small but non-negligible.

(iii) Preventing sharp increases in the cost of private sector borrowing linked to government borrowing costs

Improved resolution capacity implies that any increase in sovereign borrowing costs in a crisis will be much smaller or avoided altogether. This, in turn, implies a smaller

[16] There is empirical evidence that fiscal multipliers are higher in a crisis. Possible explanations are that the zero lower bound on interest rates is binding, and a reduction in government spending cannot be offset by monetary policy; or that there is more spare capacity in the economy and a reduction in demand has a larger impact on output.

increase in the cost of any private sector borrowing that is explicitly or implicitly linked to the yields of sovereign debt. We relied on estimates from the FSB (2015) and factored into the analysis a reduction in the NPV of output lost in a crisis of 1.6 percentage points of GDP through this channel.

(iv) Costs of contagion

It is also possible, however, that these reductions in costs could be partially or fully offset through contagion effects from the triggering of an individual bank bail-in if investors had not factored in the likelihood of such an event in their investment decisions and their pricing of risk. To some extent this risk may be mitigated by the restrictions that will be applied to the amount of other banks' bail-inable debt that banks will be allowed to hold. However, we do not have any empirical evidence on this effect and – given the large uncertainties over the consequences of bail-in – we have not captured this possible larger cost in our framework.

Results

Overall, we assume that future UK crises are likely to have permanent costs that are broadly typical of an advanced economy with a fast and effective resolution regime and with having sufficient loss-absorbing capacity to recapitalise through resolution if necessary. We have also assumed bail-in will reduce the need for fiscal consolidation and prevent sharp increases in private sector borrowing costs. Combining all of these considerations, we estimated the NPV cost of a crisis to be 43% of GDP. This is lower than the 63% of GDP used for the LEI study's case where a crisis is assumed to have a 'moderate permanent effect'.

Sensitivity analysis

If we were to instead assume that the United Kingdom's improved resolution arrangements were likely to have no impact, or a smaller impact, on the costs of future crises, this could increase our estimate of the optimal bank capital ratio by up to 5 percentage points.

6 The economic costs of higher capital requirements

Consistent with the LEI study approach, we have assumed that the main cost of higher capital requirements arises from the knock-on implications for higher bank lending rates. Given that equity-based financing is more expensive than deposit-based or bond-based financing, an increase in bank capital requirements will raise banks' weighted average cost of funds. We assume that banks target a certain return on capital. They will therefore respond to the increase in their average cost of funds by raising their lending rates. This raises the cost of capital to the economy more broadly, depressing investment activity and, in turn, potential output in perpetuity.

We assume that monetary policy would not be able to mitigate the impact of higher bank lending rates on output by setting a lower-than-otherwise Bank Rate. To the extent that the increase in bank lending rates reduces investment, it will imply a negative effect on both demand and supply. Hence, it is likely that monetary policy will not be able to counter the negative effect on output without also pushing inflation above target.

We derived the increase in bank lending rates using a basic loan pricing model together with information on UK banks' recent funding costs and balance sheet structure.[17] The model indicates that as banks increase the proportion of relatively more expensive equity capital, lending rates increase by the difference between the relatively more expensive cost of equity and the cheaper cost of debt, scaled by the ratio of loans to assets.

Recent data on UK bank funding costs suggest the average cost of UK banks' equity is likely to be around 10 percentage points higher than the cost of debt.[18] We estimated the cost of equity as the sum of the risk-free

[17] Banks also set lending rates to cover expected losses and any administrative costs. We have not included this in our approach since we are interested in the impact of funding costs only.
[18] The cost of debt reflects the cost of all (non-equity) interest- and non-interest-bearing liabilities that support the balance sheet.

rate (proxied by the 10-year UK gilt rate) and the UK equity risk premium (7% at the end of 2014) scaled by firm-specific equity risk betas (obtained from rolling six-month regressions of daily bank-level stock returns on daily returns for the FTSE 100). We proxied the cost of debt by 10-year government bond rates along with information on UK financial institutions' monthly interest rates on household deposits. Using these funding costs together with the relevant corporate tax rate and a loan to asset ratio of 40% (based on average end-2014 UK bank balance sheet data), the necessary lending rate increase needed to offset a 1 percentage point increase in the equity to asset ratio is around 25 basis points. This translates to roughly 10 basis points for a comparable 1 percentage point increase in risk-weighted capital ratios.[19] This estimate is similar to the LEI study's estimate of 13 basis points.

Empirical evidence suggests that increases in banks' equity holdings tend to be associated with some reduction in their cost of debt funding due to the perceived reduction in the riskiness of the bank – this effect is often referred to as the Modigliani-Miller (MM) irrelevance theorem. Using data on UK banks covering the period 1997 to 2014, we found evidence that partial MM offsets are likely to hold for UK banks (Box 2). Our empirical results suggest that banks' overall cost of capital (and therefore the necessary increase in lending rates) will increase by about half of what they would have done if we had excluded this effect. This also means that our estimate of the associated output cost is about half of what it would have been otherwise.

To measure the impact of the increase in the cost of intermediation on GDP, we used a number of semi-structural macroeconomic models. The impact was estimated by increasing the cost of capital (to the economy more widely) in the models' embedded production functions. This leads to a decrease in investment and, in turn, potential output.

Several other assumptions underlying our approach are worth highlighting. First, the assumption that banks can fully pass through higher funding costs implies that they face no constraints in re-pricing loan portfolios. Importantly, this also means that banks make no strategic, permanent changes to business models or lending practices in response to higher capital requirements. Banks could, of course, take a number of alternative responses to higher capital requirements; for example, they could seek to increase their operating efficiency. If frictions, including competition in critical lending markets, were to prevent full pass through to lending rates, banks might reduce their provision of credit more broadly in order to reduce their RWAs. This may lead to higher economic costs.

Second, based on recent market evidence, we assume the interest spread between the costs of equity (11%) and debt (1%) is around 10%. This is slightly less than the spread used in the LEI study of roughly 12%.[20] The economic costs of higher capital requirements would be lower if we have overestimated the difference between debt and equity funding costs.

Results

Our estimates deliver a smaller impact on spreads and output from higher bank capital requirements than was assumed in the LEI study. Our estimates suggest that lending spreads could rise by between 5 and 10 basis points for a 1 percentage point increase in capital requirements. The LEI study used a median increase of 13 basis points (interquartile range of 9 to 19 basis points).

Assuming full pass-through of funding costs to lending spreads, our estimates of permanent annual output losses range from 0.01% to 0.05% of GDP for a 1 percentage point increase in equity capital requirements. The

[19] The conversion factor is approximately 40% based in year-end average risk weights.

[20] The cost of equity used in the LEI study was 15%. This figure reflected the 15-year average return on equity for a representative bank over the pre-crisis period 1993 to 2007 to proxy the cost of equity. The cost of liabilities in the LEI study is based on short-term and long-term wholesale debt, calibrated to match the historical ratio of interest expense to total assets observed in 13 OECD countries. The computation assumed fixed spreads over deposits of 100 basis points for short-term debt and 200 basis points for long-term debt.

LEI study assumed no MM offsets and reported a cost of 0.09% of GDP (with a range from 0.02% to 0.35%). So, our estimated cost is lower than the LEI study estimate.

Sensitivity analysis

Our lower estimate of the costs associated with higher capital requirements acts to increase our estimate of the optimal capital ratio. If we had used the LEI study's figures our estimate of the optimal risk-weighted capital ratio would have been about four percentage points lower. However, there are a couple of reasons that make our estimates more appropriate for the United Kingdom: (i) the funding costs employed in our analysis are more representative of the post-crisis UK banking sector and (ii) the influence of higher equity capital levels on a bank's risk and, in turn, overall funding costs is captured directly. While the LEI study acknowledged the existence of such effects, its estimates did not consider these offsets given its deliberately conservative stance in conducting its analysis.

There are, on the other hand, a couple of reasons why our approach might under-estimate the costs of raising capital requirements. First, the behaviour of banks in response to higher capital requirements might be different relative to the behaviour assumed in our approach. In particular, rather than raising lending rates, banks might choose to respond to higher capital requirements by reducing credit to bank-dependent borrowers such as SMEs. This, in turn, might lead to a larger reduction in GDP given that funding shortages are a key driver of the failure of bank-dependent SMEs.

Second, our long-term estimates also do not account for the macroeconomic implications of the transition to higher capital requirements. These are likely to be material, particularly if capital requirements were to change abruptly and be implemented quickly.

Banks have a number of options for meeting higher capital requirements, including balance sheet reduction (deleveraging) and balance sheet adjustment (shifting towards lower risk-weighted asset categories). These actions are likely to have very different implications for output that are not fully reflected in our analysis. They could raise costs and reduce funding for borrowers in the real economy during the transition to the new requirements. They therefore create some of the very problems that the capital framework is designed to avoid. To give a sense of the possible additional impact, we estimated economic costs under the assumption that the maximum loss in annual output during transition relative to baseline forecasts remains permanent.[21] Under this assumption, the annual output cost of an additional percentage point of capital almost doubles. Using this higher cost estimate would lower the estimate of our optimum Tier 1 capital ratio by three percentage points.

7 Comparing the costs and benefits

In our simple framework, the net benefit associated with higher capital requirements is derived from the equation:

Net benefits of higher capital **=**

{Reduction in probability of crisis due to higher capital × Net present cost of a crisis}

– {Reduction in output due to higher lending spreads}

Chart 7 illustrates how there could be net positive benefits from increasing capital requirements. Starting from the baseline Basel III capital requirements,[22] in our assessment, benefits initially increase more rapidly than costs (which are assumed to rise linearly). The net benefit is equal to the vertical gap between the gross costs and benefit curves. In the diagram, net benefits are maximised at point K*.

[21] We obtained maximum annual output losses (during the first five years after policy implementation) from the macroeconomic models used in translating spreads to GDP impacts.
[22] The baseline here is the Basel III requirement for non-systemic banks which is 8.5% Tier 1, comprising 6% Pillar 1 and 2.5% conservation buffer.

Chart 7 The optimal capital ratio

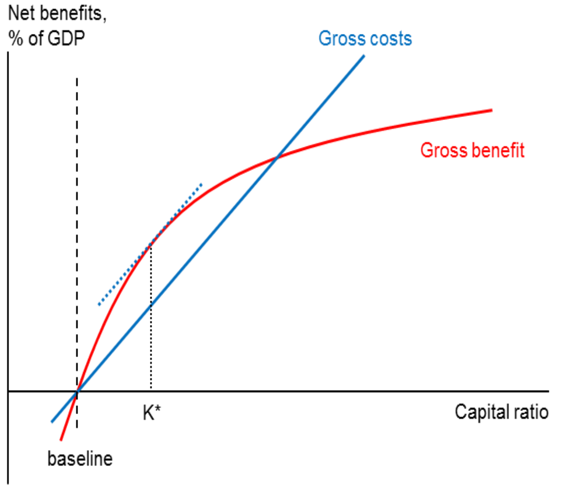
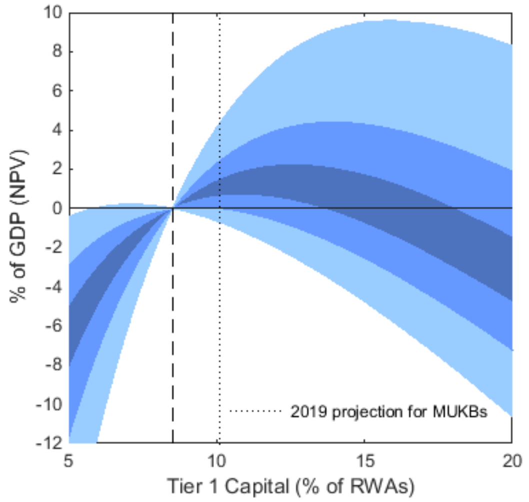


Chart 8 shows our estimated net benefit curve (as a percentage of GDP on an NPV basis), derived from the difference between our estimates of the gross costs and benefits. Our central view is that the optimum range of capital requirements is 10-14% of risk-weighted assets.

The uncertainty around our estimates of appropriate capital requirements is large. **Chart 8** illustrates how the variations in the estimates of the parameters that have been discussed in this paper can deliver considerable differences in the estimated 'optimum' level of capital.

In addition, the uncertainty surrounding our estimates widens as implied capital levels increase since there are very few instances of banks or banking systems in our sample having maintained high capital ratios.

Chart 8 Ranges of uncertainty around net benefits of higher capital ratios[a]



Source: Bank calculations.
(a) Ranges shown reflect the uncertainty around the costs of crises and impact of higher lending spreads. We put distributions for these parameters through our net benefits calculations, assuming that the range of our judgements comprise the 95% percentile. The shaded areas show confidence intervals of 20%, 50% and 80% respectively.

Key assumptions

As outlined in sections 5 and 6, our central estimate for the optimal capital requirement depends crucially on three key judgements. **Table 8** shows how these affect the optimum range. The first is whether crises have a permanent effect on GDP. Our central estimate reflects the assumption that banking crises have permanent effects on the level of GDP. This leads to an estimate for the net present value of the cost of crises of 43% of GDP. A judgement that the effects of crises are more likely to be temporary would reduce the estimate of the appropriate risk-weighted capital ratio by around 3 percentage points (to 7-11%).

Table 8 Impact of key judgements on optimal capital range

Judgement	Optimal range
Central case	10-14%
Costs of crises are temporary	7-11%
Resolution is ineffective	15-19%
Moderate transition costs	7-11%

Source: Bank calculations.

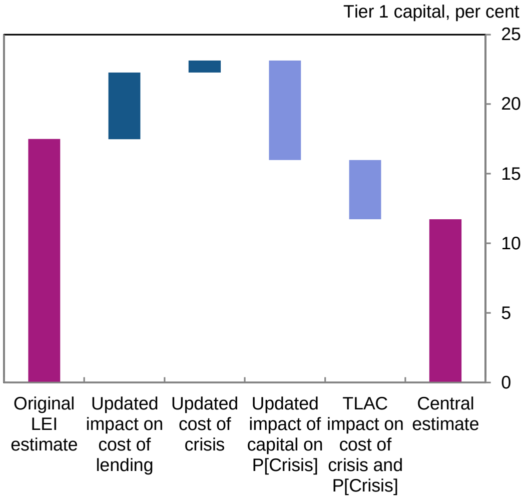
The second key judgement is that improvements in the United Kingdom's resolution arrangements will mean that the permanent cost of banking crises in the future will be smaller than has been the case in the past. At the other extreme, if the United Kingdom's improved resolution arrangements and other prudential reforms were expected to have limited impact on the costs of future crises, that could increase our estimate of the appropriate capital ratio by up to 5 percentage points (to 15-19%).

The final judgement is whether the transition to higher capital requirements will generate unavoidable economic costs. In our framework, we have assumed that there are no material and permanent transition costs to higher capital requirements. A moderate level of transitional frictions would imply that increased capital requirements would have a larger gross cost than in the central case, leading to a lower estimate of the appropriate level of capital. Incorporating transition costs would imply an optimal capital ratio that was 3 percentage points lower than our baseline estimate (to 7-11%).

Comparison with the LEI study

Our central range for the optimum Tier 1 capital ratio of 10-14% is lower than the comparable LEI study finding of 16-19% (which also assumes crises have moderate permanent effects). The two main reasons why we have derived a lower optimum are (i) our estimates of the probability of a crisis for a given capital ratio are lower; and (ii) our estimate attempts to take into consideration the beneficial effects of TLAC and an improved resolution regime (**Chart 9**).

Chart 9 Difference between LEI study and central estimate[(a)]



Source: BCBS (2010a) and Bank calculations.
(a) We have taken a 14% tangible common equity ratio as the optimum in the LEI study and converted this to a Basel III equivalent on a best endeavours basis. To do this, we use the capital quality conversion factors for euro-area banks from Table A5.1 of the LEI study to translate the optimum into a Tier 1 leverage ratio. We used capital ratios reported by UK banks under both a Basel II and Basel III basis for a common reporting date to estimate the impact of this regulatory change. We then applied this conversion factor to the leverage ratio to generate a proxy for a Tier 1 Basel III leverage ratio. Next, we apply the average risk weights in Table A5.1 and for UK banks at end-2014 to convert this back into a risk-weighted metric. The range we obtain is intended to reflect both a tightening of definitions under Basel III and the changes banks have made to reduce the average riskiness of their balance sheets since the global financial crisis. This gives an optimum range of 16-19%. We have used a central estimate of 17.5% for the LEI study for the chart.

Chart 9 also illustrates that two other differences between our approach and the LEI study acted to push our estimate of the optimal capital ratio up relative to the LEI study estimate. First, we have a lower estimate of the economic impact on lending spreads arising from higher capital requirements. Around four-fifths of this reduction is due to our inclusion of a Modigliani-Miller offset. And second, on a comparable basis (ie excluding the introduction of TLAC) we estimate a somewhat higher cost of crisis, given the impact of the global financial crisis.

8 Conclusion

This paper supports the FPC's medium-term priority to establish the medium-term capital framework for UK banks.

We provide a cost-benefit assessment for the case for raising UK bank capital requirements above the internationally agreed minimum levels. The methodology that we have used builds on the previous Basel Committee LEI study. We have tailored that framework to the features of the UK banking system and economy. And – importantly – we have also attempted to capture the beneficial effects of credible resolution and gone concern loss-absorbing capacity requirements.

The models we have used, combined with the judgements that we have made, suggest there should be positive net benefits from increasing the minimum Tier 1 capital requirement for UK banks to 10-14% in typical risk environments.

Our modelling approach attempts to generate an estimate for the optimal bank capital level that would be applicable at an average point in the risk environment, broadly equivalent to the mid-point in the credit cycle. Our analysis also indicates that the probability of a crisis is likely to be considerably greater at the peak of the credit cycle. Consequently, there would be benefits from setting capital ratios higher than those outlined in this paper when there is evidence of elevated risk. This, therefore, provides a justification for the FPC to consider using its countercyclical capital tool to impose higher capital requirements when the risk environment appears to be elevated.

This paper has also illustrated the large range of uncertainty around our estimates of the optimal capital level. Variations in the key assumptions that we have used can result in large changes in the estimated optimum risk-based Tier 1 capital ratio.

Our analysis includes only a limited number of potential channels through which capital requirements might affect economic output. We have not incorporated quantitative estimates for the possible impact of a number of channels. Box 3 outlines a number of considerations not explicitly captured in our cost-benefit assessment and qualitatively describes their expected impact on our estimates.

Box 1
Review of other countries' capital requirements

The FPC's secondary competition objective requires it to, where practicable, consider how its policy actions might affect the international competitiveness of the UK financial system. One aspect of that – though far from the only one – is how local capital requirements compare with those set by other authorities. A number of jurisdictions have already announced policies to ensure that global and domestic systemically important banks (D-SIBs) are subject to enhanced capital requirements. **Table 9** summarises the main initiatives and **Chart 10** illustrates the latest average published CET1 ratios for major banks by jurisdiction.

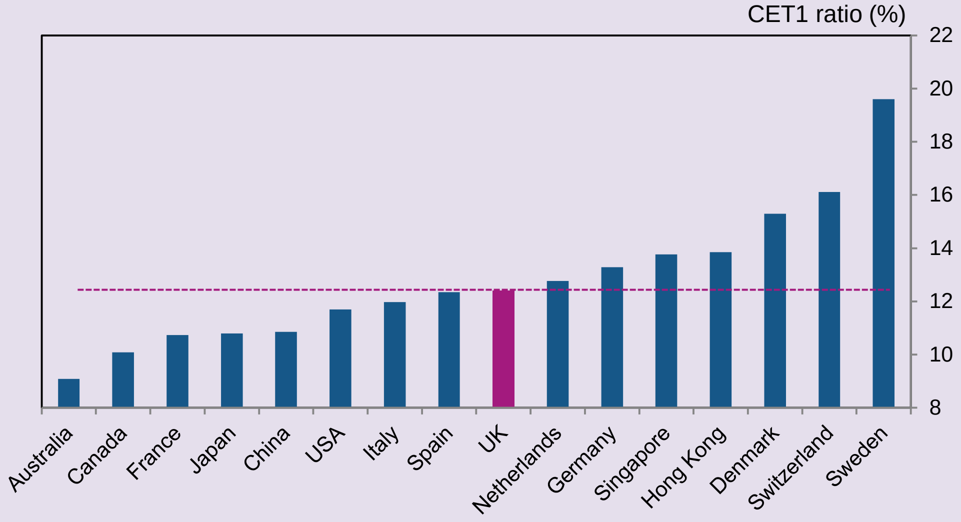
Table 9 G-SIB and D-SIB add-ons by jurisdiction

	G-SIB add-ons	D-SIB add-ons
UK	Standard Basel III requirements (1-2.5% CET1)	SRB proposal to be finalised
Australia	N/A	1% D-SIB buffer
Austria / Finland / Netherlands (similar D-SIB frameworks)	ING covered by D-SIB requirement (non-cumulative)	Additional buffer of 1% to 3% for D-SIBs
Belgium	N/A	Additional buffer of 0.75% or 1.5% for D-SIBs
Canada	N/A	1% D-SIB buffer for 6 largest banks. Proposal for Higher Loss Absorbency for D-SIBs of 17-23% of RWAs.
Denmark	N/A	Additional buffer of 1% to 4% for D-SIBs
Hong Kong	N/A	Additional buffer of 1 to 3.5% for D-SIBs
Norway	N/A	Additional buffer of 5% for D-SIBs, 3% for all banks
Singapore	N/A	7 D-SIBs required to meet minimum CET1 capital adequacy ratio (CAR) of 6.5%, Tier 1 CAR of 8% and total CAR of 10%
Sweden	Nordea covered by D-SIB requirement (non-cumulative)	Additional buffer of 5% for D-SIBs
Switzerland	G-SIB buffer of 3% CET1 and 9% contingent convertible bonds required for UBS and Credit Suisse	D-SIB requirements not yet published
United States	Additional buffer of 1-4.5% for G-SIBs based on Basel or US specific methodology	No specific D-SIB requirements but firms with total assets >$50bn subject to enhanced supervision including CCAR stress tests

Note:
i) N/A refers to countries that do not have any G-SIBs.
ii) Red boxes denote where a country has exceeded international legislation in terms of level or implementation timeline.
iii) Where buffers are described as 'additional' this is additional to minimum requirements (4.5% CET1 and 6% T1)
iv) The Table excludes the capital conservation buffer, where countries are either implementing the 2.5% buffer in full or phasing it in. The notable exception is the Swiss capital conservation buffer, set at 5.5% for G-SIBs and 2.5% for other banks.
v) The CCyB is also excluded from the Table.

Leverage ratio requirements are excluded from the Table for simplicity. EU countries are on track to introduce a 3% requirement from 2018. In Australia, the Financial System Inquiry recommended a leverage ratio of between 3 and 5%. Switzerland has introduced a requirement of up to 5%, to be met by 2019. The United States has adopted the Basel III leverage ratio and issued enhanced supplementary leverage ratio standards for G-SIB bank holding companies and their insured depository subsidiaries of 5% and 6% respectively.

Chart 10 Average published CET1 ratios for major banks by jurisdiction[(a)]



Sources: published accounts and Bank calculations, based on most recently available data.
(a) Data are not fully comparable as not all countries are implementing Basel III consistently. For further details, see the BCBS (2015).

Box 2
Evidence of Modigliani-Miller effects

Modigliani and Miller (1958) showed that, under certain assumptions, moving to higher levels of funding in the form of common stock, and therefore lower levels of debt and financial leverage, would leave the total cost of funding unchanged. In particular, the Modigliani-Miller (MM) theorem implies that as more equity capital is used, return on equity becomes less volatile and debt becomes safer, lowering the required rate of return on both sources of funds. It does so in such a way that the overall weighted average cost of funds remains unchanged. This idealised situation represents the case where there is a complete (100%) offset in relative funding costs as the debt and equity compositions change.

The MM theorem assumes competitive and frictionless markets that are free of information and agency problems. These assumptions, however, are unlikely to hold in most cases. This may be especially true for banks given the relatively more opaque nature of their balance sheets (Morgan (2002)) and explicit or implicit government guarantees. The extent to which the MM theorem – and, therefore, such offsetting effects – holds in practice is an empirical question.

Miles et al (2013) examined this issue for the UK banking system. Using data on the largest six UK banks from the period 1997 to 2010, they find a statistically significant positive association between UK banks' systematic equity risk and their financial leverage (ie assets to Tier 1 capital) ratio. Under standard asset pricing models (eg Capital Asset Pricing Model), this result indicates that banks' cost of equity decreases as financial leverage decreases. Their estimates, however, suggest that while the MM theorem holds in the UK, it does so only partially, with their central estimate at 45%. This offset means that any increase in banks' overall funding costs due to higher capital requirements is 45% lower than it would have been in the absence of MM offsets.

Using similar methods to Miles et al (2013), several other studies document MM offsets for banks in other countries that may help inform the UK calibration. For example, Junge and Kugler (2012) estimate an offset of 36% using Swiss banking data from 1999 to 2010. Toader (2014) uses a broader set of European banking data from 1997 to 2011 and estimates a 42% offset, while the ECB (2011) documents offsets ranging from 41% to 73% for a sample of 54 larger international banks from 1995 to 2011. Focusing on US banking data spanning 1996 to 2012, Clark et al (2015) estimate offsets of 43% to 100%.

As another step to improve the UK calibration, we updated the study by Miles et al (2013) to include data to the end of 2014 and tested whether the MM effects changed since 2010, the last data period in that study. Consistent with Miles et al (2013), we find a statistically significant positive association between banks' systematic equity risk and financial leverage. We also find this association to be statistically significantly higher in the post-2010 period, with our central estimate suggesting an offset of around 53% versus 45% in Miles et al (2013). While slightly higher, our updated estimate is not inconsistent with ranges reported by other researchers and implies output costs are about half of what they would be if we were to assume no MM effects.

Box 3

Effects not explicitly captured in our estimates of optimal capital requirements, and key judgements around them

Panel A: Effects implicitly captured

Channel	Description	Expected impact on our estimates
Market liquidity and asset composition	• Higher capital requirements could subdue market liquidity by increasing banks' cost of maintaining trading inventory. • Our framework assumes that all of banks' increased funding cost is exclusively passed on to borrowers. • This would only overstate the optimal capital level if reductions in lending are assumed to be socially less costly than reductions in market-making activity.	↔
Structural reform	• Structural reform should reduce the probability of crises by making resolution more credible and improving market discipline. • This effect of structural reforms should be implicitly captured by our estimates of the impact of TLAC and credible resolution. • We have not included any ring-fence buffers in our baseline, the calibration of which will be informed by this cost-benefit assessment.	↔
Liquidity Coverage Ratio / Net Stable Funding Ratio	• The introduction of liquidity requirements clearly boosts UK bank resilience and should lower optimal capital requirements. • We have conditioned on liquid asset ratios that are higher than UK banks have now (and on average UK banks now meet both the Liquidity Coverage Ratio and the Net Stable Funding Ratio).	↔

Panel B: Effects not captured

Channel	Description	Expected impact on our estimates
Contagious effects of resolution	• If there is substantial uncertainty around the effectiveness of TLAC-eligible debt in absorbing losses (perhaps due to contagion risks), higher capital requirements may be appropriate. • Conversely, for crises where governments struggle to fund bail-outs, TLAC may help break the bank-sovereign feedback loop and reduce the cost of a crisis by more than our estimates suggest.	↔
Non-crisis downturns	• Non-crisis, economic downturns, which occur three times as often as financial crises, could force banks to contract lending. • Usable capital buffers may mitigate such contractions, suggesting that the optimal amount of capital (buffers) may be slightly higher.	↑
Impact on total factor productivity growth	• Higher capital requirements may have an impact on long-term growth (eg via changes in SME lending). Such effects are uncertain. • There is mixed evidence regarding the importance of bank credit to SMEs as a driver of innovation.	↔
Domestic competition	• If higher capital requirements were applied to G-SIBs only, this could affect competition by reducing any competitive advantage of G-SIBs (eg due to implicit or explicit subsidies).	↔

	• The link between increased competition and financial stability is ambiguous: competing theories of fragility and stability exist. Hence, it is not clear if these considerations would affect the optimal level of capital requirements.	
Governance and remuneration	• Initiatives such as the Senior Managers Regime should ensure that banks are better run and less likely to fail. New rules on remuneration should strengthen the alignment between long-term risk and reward. • This should lower optimal requirements, but it is too soon to tell what the magnitude of the impact might be.	↓
Voluntary buffers	• Banks may choose to have voluntary buffers, so a slightly lower regulatory requirement would still be sufficient to deliver the optimal capital ratios presented here.	↓

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