MEMORANDUM FOR	FSO Committee
FROM	Financial Policy (Author: Charles Lilly)
MEETING DATE	7 September 2016
SUBJECT	**Literature review of optimal levels of bank capital**
FOR YOUR	Information

It is recommended that the Committee:

1. **Note** that a number of recent studies have investigated the macroeconomic effects of higher bank capital requirements and, using a cost-benefit framework, estimated an 'optimal' level of minimum capital requirements.

2. **Note** that recent empirical studies of the Modigliani-Miller theorem suggest that the effect holds only at a rate of around half, that is, changes in banks' funding structures towards costlier sources (equity) pass through to higher lending rates at a rate of around 50%.

3. **Note** that recent estimates suggest that a one percentage point increase in banks' tier 1 capital ratios leads to around a 5-8 basis point increase in lending rates.

4. **Note** that the effects of higher capital requirements on the steady-state level of GDP (through lower credit availability) are modest, at around a 0.01% to 0.05% fall per percentage point increase in banks' tier 1 capital ratios.

5. **Note** that, across a range of studies, estimates of optimal CET1 capital ratios using this type of cost-benefit framework arrive at a range of 10% to 20%, with a number of estimates landing around the 14-18% level depending on modelling assumptions.

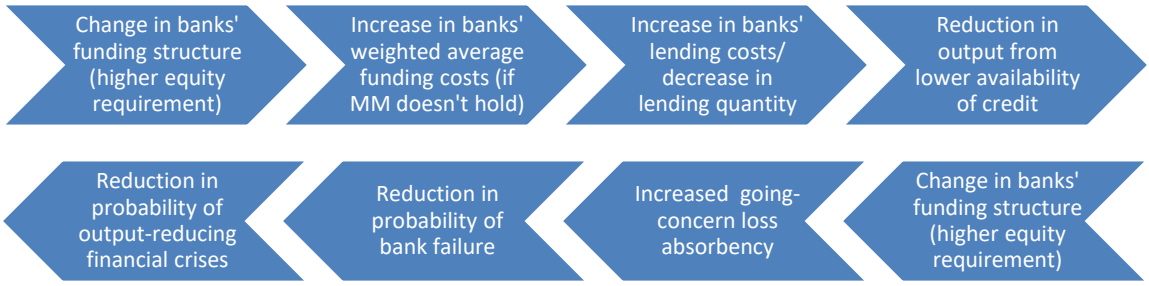
6. **Note** that an alternative method suggests that risk-weighted total capital ratios in the range of 15-23% would have avoided creditor losses in around 85% of the 27 advanced economy banking crises experienced in the past 40 years.

1. This paper is one component of Financial Policy's review of bank capital requirements, and should be read in conjunction with other papers being presented to the Committee (#6656094, #6656095). The present paper brings together a range of empirical estimates from recent studies of the macroeconomic effects of changes in bank capital requirements, and of 'optimal' levels of bank capital.

2. The starting point for this type of analysis is the 'capital structure irrelevance' theorem of Modigliani-Miller (1958). The theorem states that changes in a firm's funding structure, i.e. the ratio of equity finance to debt finance, would have no impact on its weighted average cost of capital. Increases in profitability through the greater use of leverage will be offset by a higher unit cost for the remaining equity capital, since that equity becomes relatively riskier. Therefore in the context of banks, if the MM theorem holds fully, changes in capital requirements should have no effect on the cost of lending.

3. For a number of reasons the MM theorem may not be likely to hold in practice, and hence lending costs can be materially affected by the funding structure. In many jurisdictions, debt has a more favourable tax treatment than equity. A number of frictions can mean that decreases in leverage do not result in a lower required return on equity from the point of view of shareholders. Furthermore, for banks in particular, implicit or underpriced deposit insurance, and too-big-to-fail subsidies that benefit bank debt more than equity, can mean that increases in the equity share of banks' financing can increase banks' overall costs of funding. The magnitude of the 'pass-through' of higher capital requirements to lending costs is one of the key parameters for the analysis of an optimal capital ratio requirement.

4. If it is believed that changes in banks' funding structures lead to changes in economy-wide lending costs or the quantity of lending, it follows that capital requirements may have a material impact on broader economic activity. Hence determining an optimal capital ratio is a question of quantifying the negative effects of increases in banks' equity funding through reduced economic activity against the benefit, being a reduction in the probability of financial crises and associated output losses due to the lower default probability of better-capitalised banks. The two basic mechanisms are represented in the following diagrams: [1]



5. This aim of this paper is to present recent quantitative estimates of key components this framework of cost-benefit analysis, namely, the degree to which the MM theorem holds in observed data, how changes in capital ratios affect lending costs, and how changes in capital ratios may reduce steady-state GDP. The paper also presents a range of estimates of 'optimal' capital ratios estimated using this cost-benefit framework. In large part the paper draws on a recent, comprehensive literature review and quantitative model of the costs and benefits of higher capital requirements from the Bank of England.[2] The paper also draws on a similar review by the Research Task Force of the BCBS.[3]

6. As noted in the cover note for this set of capital review papers, attempts to be precise about the appropriate calibration of prudential rules are fraught with difficulty. Even using superficially similar analytical frameworks, the studies covered in this paper produce a reasonably wide range of estimates of the parameters under consideration, and the authors of each study are careful to present their results as being sensitive to various modelling assumptions. As such, this survey does not aim to present the Committee with the 'right' number,

[1] The models surveyed do not generally consider the effect of foreign ownership of the banking system. More elaborate models (e.g. the updated Harrison model) attempt to model the effect of transfers to foreign shareholders.

[2] *Measuring the macroeconomic costs and benefits of higher UK bank capital requirements* (Brooke, et al., 2015).

[3] *Literature review on integration of regulatory capital and liquidity instruments* (Research Task Force, 2016).

but rather an indication of a plausibly sensible range of answers produced from a common analytical framework.

7. Other factors can also enter into the decision on what the optimal capital requirement should be. One of these is the provision of socially desirable deposits. Banks produce socially valuable outputs on both sides of their balance sheets; loans to borrowers and deposits to savers. Some economic agents value bank debt for its high and often immediate liquidity and safety, relative to other options. Hence materially reducing the share of banks' liabilities that can be funded through debt could reduce societal wellbeing. To some extent this argument can support either higher or lower capital requirements, depending on the share of socially valuable deposits in banks' debt funding (whether it is a binding constraint), and also to the extent that a higher equity funding share makes these deposits safer.

8. Furthermore, when considering capital requirements at a systemic level, competitive pressures may justify a higher system-wide minimum capital requirement or buffer above what may be optimal when considering the case of an individual bank. This line of argumentation proposes that weak or zombie banks will "gamble for resurrection" through taking excessive risks, for example through reducing lending standards or intermediation margins. To the extent that banks' managers and shareholders cannot fully evaluate a bank's risk-adjusted performance, at least ex ante, competitive pressures will bear on the managers of healthy banks to similarly lower their lending standards in order to protect their market share and match the riskier banks' profitability (Caballero, Hoshi, & Kashyap, 2008).

Modigliani-Miller pass-through

9. A number of studies attempt to estimate, based on observed market data, the pass-through of changes in banks' funding structure to their overall cost of funds. The typical approach is to identify banks' stock price 'beta' within the framework of the capital asset pricing model (CAPM). Beta measures the riskiness of a given stock relative to a diversified equity portfolio. Given beta, a risk-free return and a diversified market yield (the 'equity-premium'), the model can estimate the unit cost of bank equity. Alternatively, one can directly estimate an equation that arises from the MM theorem without specifying a complete CAPM model.

10. The following table presents recent estimates of the degree of 'MM offset' – the proportion of the increase in banks' weighted-average cost of capital from a higher share of equity funding that does not occur because of the decline in the cost of equity. If the MM theorem were to hold fully, the expected offset would be 100%. The simple average of the following results suggests a rate of 46%.

Table: Estimates of Modigliani-Miller effects (100% corresponds to MM theorem holding fully)

Study	Estimated MM Offset	Approach	Notes
(Yang & Tsatsaronis, 2012)	Around 10%	Regression of 50 global banks located in 11 OECD countries for 1990-2009 using CAPM framework	
(Junge & Kugler, 2012)	36%	Regression of 5 Swiss banks for 1999-2010 using	

		CAPM framework	
(ECB, 2011)	41-73% (CAPM) 78% (simple regression)	Regression of 54 international banks for 1995-2011 using CAPM and simple regression models	
(Toader, 2015)	42%	Regression of 65 European banks for 1997-2011 using CAPM framework	
(Miles, Yang, & Marcheggiano, 2012)	45%	Regression of 7 UK banks for 1997-2010 using CAPM framework	Other specifications suggest an effect between 45-90%
(Cline, 2015)	45%	Regression of 54 US banks for 2001-2013, directly estimating MM result	
(Brooke, et al., 2015)	53%	Updated dataset of Miles et al (2012) study	Estimate is for data post-2010
(Kashyap, Stein, & Hanson, 2010)	Around 70%	Regression of US banks for 1976-2008 using CAPM framework	

Impact of higher capital requirements on the cost of bank credit

11. In line with the results presented in the above table, most studies identify that, ceteris paribus, higher capital requirements result in foregone lending through a rise in the average cost of bank credit. However once MM offsets are incorporated the magnitude of changes appears to be small.

12. The following table presents recent estimates of the effect of a one percentage point increase in the ratio of tier 1 capital to risk-weighted assets[4] on lending spreads:

Table: Estimated increase in lending spread from a percentage point increase in the tier 1 capital ratio

Study	Impact (basis points)	Incorporates MM offset?	Approach	Notes
(Elliot, 2009)	5-10	No	Regression of US bank data	Note - uses leverage ratio (therefore the effect will be around half for a tier 1 ratio)
(MAG, 2010)	12.2	No	Metastudy of 53 models from national supervisory authorities	
(BCBS LEI, 2010)	9 to 19 (central estimate: 13)	No	Point estimates using 6660 OECD country banks from 1993-	

[4] The studies under consideration generally cover the 1990s to late 2000s, meaning Tier 1 ratios mostly refer to Basel I ratios. It is difficult to say with precision how an average Basel I Tier 1 ratio compares with the Basel III Tier 1 ratios that our banks now report. However given the Bank's relatively conservative implementation of Basel II risk weightings we consider these estimates to be broadly applicable for NZ.

			2007	
(Kashyap, Stein, & Hanson, 2010)	2.5 to 4.5	Yes	Regression of US banks for 1976-2008 using CAPM framework	Note - uses leverage ratio (therefore the effect will be around half for a tier 1 ratio)
(King, 2010)	15	No	Regression of bank data from 13 OECD countries from 1993-2007	
(Cosimano & Hakura, 2011)	9 to 13	No	GMM regression for OECD country commercial banks and BHCs from 2001-2009	Note - uses leverage ratio (therefore the effect will be around half for a tier 1 ratio)
(Slovik & Cournède, 2011)	14.4	No	Accounting model for US, EU, Japan	
(de-Ramon, Iscenko, Osborne, Straughan, & Andrews, 2012)	9.4	No	Regression of UK banks from 1992 to 2010	Note - uses leverage ratio (therefore the effect will be around half for a tier 1 ratio)
(Martin-Oliver, Ruano, & Salas-Fumas, 2013)	6.8 to 8.5	Yes	Regression of Spanish banks from 1992 to 2007	
(Baker & Wurgler, 2015)	6 to 9	Yes	CAPM model using data on 400 US banks from 1996-2011	
(Brooke, et al., 2015)	5	Yes – with no MM, the impact is 10 basis points	Accounting model based on UK bank data from 1997-2014	

13. Taking into account that some studies apply a leverage ratio (i.e. not risk weighted), and applying the 46% MM offset calculated in the previous section to those studies that do not explicitly model it, we consider a reasonable range for the estimated increase in lending spreads as a result of a percentage point increase in the tier 1 capital ratio to be around 5-8 basis points.

Steady-state impact of higher capital requirements on GDP

14. The next step in the process is to translate higher costs of bank credit and the associated lower availability of/demand for credit to the steady-state level of GDP. In general, the estimated effects long run effects are low. The following table presents estimates of the impact of a one percentage point increase in the tier 1 capital ratio on the steady-state level of GDP:

Table: Estimated impact on steady-state level of GDP from a percentage point increase in tier 1 capital ratio

Study	Impact (median)	Range	Countries in study	Notes
(BCBS LEI, 2010)	-0.09%	-0.35% to -0.02%	13 OECD	Metastudy of 13 models
(MAG, 2010)	-0.1%	Lower bound of -0.15%	17 OECD	Metastudy of 97 models from national supervisory

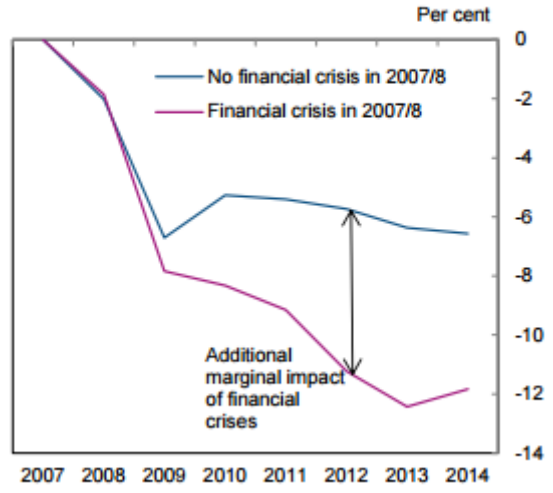
				authorities
(Slovik & Cournède, 2011)	-0.2%		3 OECD	
(Angelini & Gerali, 2012)	-0.05%	-0.36% to 0%	Euro Area	
(Vitek & Roger, 2012)	-0.11%	-0.24% to -0.09%	15 large countries	
(de-Ramon, Iscenko, Osborne, Straughan, & Andrews, 2012)	-0.3%		UK	Estimate is for the full Basel III implementation (not a single percentage point change)
(Miles, Yang, & Marcheggiano, 2012)	-0.25%		UK	Estimated effect of a 1% increase in funding costs
(Martin-Oliver, Ruano, & Salas-Fumas, 2013)		-0.14% to -0.11%	Spain	
(Mendicino, Nokolov, Suarez, & Supera, 2015)	-0.04%		Euro Area	
(Brooke, et al., 2015)	-0.03%	-0.05% to -0.01%	UK	Incorporates MM effects

15. These estimates typically rely on the estimated effects on lending rates in the previous section, meaning that some are sensitive to assumptions about whether the MM hypothesis holds. For instance, the BCBS estimate of a 0.09% decline in steady state GDP assumes a 13 basis point increase in funding costs when the capital ratio is increased by one percentage point, and does not incorporate an MM offset. Taking into account the variety of estimation methods, and assuming that the MM effect is approximately 50%, the recent Bank of England survey of the literature (Brooke, et al., 2015) settles on a range of permanent annual output losses of between 0.01% to 0.05% per percentage point increase in the tier 1 capital requirement. We consider this to be a reasonable range, based on the material we have assessed.

Deriving an optimal capital ratio

16. The preceeding sections detail the main parameters that need to be estimated when determining the long run costs of higher capital requirements. On the benefit side of the equation one needs to make assumptions about how capital levels affect the probability of financial crises occurring, and the output costs of crises. Key judgements involved are the extent to which output losses from financial crises are transitory or permanent (i.e. a level shift in the path of output), and in terms of calibration, the extent to which the observed output losses can be solely attributed to the concurrent financial crisis, to avoid overcounting. This latter effect is perhaps best illustrated in the following chart of “crisis” and “non-crisis” countries after 2008, from (Brooke, et al., 2015):

Chart 4 Output experiences for crisis and non-crisis countries



Source: Bank calculations.

17. While the basic cost-benefit structure described above is common to all of the papers that have been considered in this review, given the heterogeneity of methods authors have used to arrive at their 'optimal' capital numbers, for brevity this paper does not go into detailed methodological comparisons. Rather, we present below a table of authors' key conclusions:

Study	Conclusions	Optimum CET1 ratio	Notes
(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% (crises have no permanent effects on GDP) 13% (crises have moderate permanent effects on GDP)	Uses pre-Basel III definition of CET1
(Schanz, et al., 2011)	There is room to increase capital ratios above the regulatory minima and still realise net benefits.	10% to 15%	Uses pre-Basel III definition of CET1
(Miles, Yang, & Marcheggiano, 2012)	We find that the amount of equity capital that is likely to be desirable for banks to use is *very* much larger than banks have used in recent years and also higher than targets agreed under the Basel III framework.	18% to 20% (crises have some permanent effects on GDP growth) 16% to 18% (crises have no permanent effects on GDP growth)	
(de-Ramon, Iscenko, Osborne, Straughan, & Andrews, 2012)	Our calculations also show that prudential standards could be raised further, by up to an additional 22 percentage points in terms of banks' aggregate risk-weighted capital ratio, and still be expected to produce overall positive net benefits in the long run.		The uncertainty around our estimates of the benefits is the greatest source of possible error in our analysis, but clearly skewed towards benefits being higher than shown in our central estimate.
(Yan, Hall, & Turner, 2012)		10%	
(Junge & Kugler, 2012)	The net benefits of doubling	Up to twice the Basel III	

	the capital ratio when banking crises may impose large and permanent effects is about 12% of GDP.	minima (i.e. 14%).	
(Mendicino, Nokolov, Suarez, & Supera, 2015)	Our benchmark optimized policy rule exhibits a minimum level slightly higher than that in Basel III, a 3 percentage points higher steady state level.	12% to 16% (total capital ratio)	
(Brooke, et al., 2015)		10% to 14% (baseline) 7% to 11% (costs of crises are temporary) 15% to 19% (improved resolution arrangements and other UK prudential reforms are ineffective) 7% to 11% (transition to higher capital is moderately costly)	
(Cline, 2016)		6.6% to 7.9% (leverage ratio), 11.7% to 14.1% (tier 1 ratio)	

Alternative approaches - backward induction

18. Rather than assessing optimal capital ratios in terms of the net benefits of moving from the status quo using microeconometric estimates, a simpler alternative is to consider the observed distribution of banking crises, and ask, "how much capital would have been needed ex ante to absorb the realised losses?" A recent IMF study[5] considers this question based on the IMF's database of systemic banking crises. Put simply, the method uses estimates of peak non-performing loan ratios in advanced country banking crises, and assumptions around a number of parameters such as loss given default, to estimate the quantum of capital that would have avoided losses to creditors or public recapitalisations.

19. The following charts depict peak NPL ratios (as of 2013) following 27 OECD country banking crises over the past 39 years, and the share of crises that could have been avoided (i.e. no creditor losses) for a given risk-weighted total capital ratio.

[5] (Dagher, Dell'Ariccia, Laeven, Ratnovski, & Tong, 2016)

Figure: Peak non-performing loan ratios in OECD country banking crises

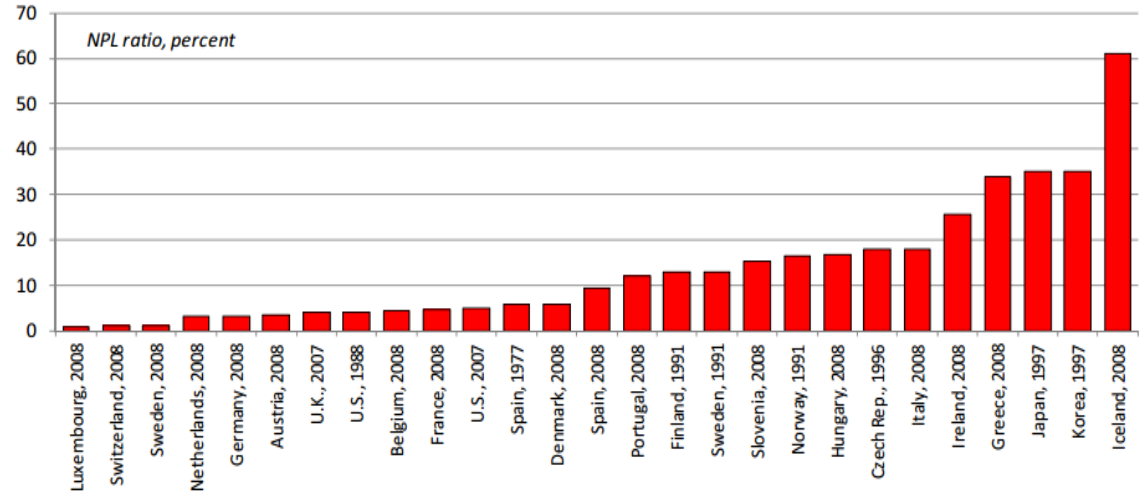


Figure: Share of OECD country banking crises without creditor losses, based on the loss absorption capacity of bank capital

Source: (Dagher, Dell'Ariccia, Laeven, Ratnovski, & Tong, 2016)

20. The results presented in the paper are sensitive to a number of assumptions and parameters, including the loss given default, provisioning practices, and average risk weightings. This approach does not take into account losses on other parts of banks' balance sheets (trading books).

21. Reflecting this inherent uncertainty, the authors conclude that *"the marginal benefits of higher bank capitalisation in terms of absorbing losses in banking crises are substantial at first, but decline rapidly once capitalisation reaches 15-23% of risk-weighted assets, …, bank capital in the 15-23% range would have avoided creditor losses in the vast majority of past banking crises, at least in advanced economies"*.

Alternative approaches – "big equity"

22. The studies discussed in this paper quantitatively assess the marginal effects of changing minimum capital ratios relative to status quo levels. In recent years a number of academics have called for more fundamental reconsideration of the

role of capital requirements in prudential regulation, such as Anat Admati (this year's Professorial Fellow), John Cochrane and Miles Kimball. The thrust of the argument is that increases in equity requirements are not *socially* costly.

23. The presence of tax advantages and implicit guarantees creates distortions that encourage bank shareholders to increase their leverage beyond a socially optimal level. Rolling back the ability of banks to take advantage of these subsidies through enforcing higher capital requirements may lead to increases in lending costs, as reflected in the estimates reported in this paper, however these costs are private, not social. Admati maintains that, if they wish to continue to do so, there are more effective ways that governments can subsidise lending than through the destabilising effects of encouraging high levels of leverage. Proponents of the "big equity" view suggest that substantially higher capital requirements, in the region of 30-50% of assets or more, would offset these distortions, promote better lending decisions, and bring about large social benefits, in terms of financial stability and reduced contingent public liabilities, for minimal social costs.

24. Though there are a number of interesting arguments both for and against such proposals, we have left active consideration of an order-of-magnitude increase in capital levels outside of the scope of our review. We can present further analysis of the "big equity" proposal if the Committee wishes for us to reconsider.

References

Admati, A., DeMarzo, P., Hellwig, M., & Pfleiderer, P. (2013, October 22). Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is not Socially Expensive. *Stanford Graduate School of Business Working Paper*(2065).

Angelini, P., & Gerali, A. (2012, July). Banks' reactions to Basel III. *Banca D'Italia Working Papers*.

Baker, M., & Wurgler, J. (2015). Do Strict Capital Requirements Rise the Cost of Capital? Bank Regulation, Capital Structure, and the Low-Risk Anomaly. *American Economic Review: Papers & Proceedings*, 315-320.

BCBS LEI. (2010). *An assessment of the long-term economic impact of stronger capital and liquidity requirements.* Basel Committee on Banking Supervision.

Brooke, M., Bush, O., Edwards, R., Ellis, J., Francis, B., Harimohan, R., . . . Siegert, C. (2015, December). Measuring the macroeconomic costs and benefits of higher UK bank capital requirements. *Bank of England Financial Stability Paper*(35).

Caballero, R., Hoshi, T., & Kashyap, A. (2008). Zombie Lending and Depressed Restructuring in Japan. *American Economic Review*, 1943-1977.

Cline, W. (2015, April). Testing the Modigliani-Miller Theorem of Capital Structure Irrelevance for Banks. *Peterson Institute for International Economics Working Paper Series, 15*(8).

Cline, W. (2016, March). Benefits and Costs of Higher Capital Requirements for Banks. *Peterson Institute for International Economics Working Paper Series*.

Cohen, B., & Scatigna, M. (2016). Banks and capital requirements: Channels of adjustment. *Journal of Banking & Finance*, S56-S69.

Cosimano, T., & Hakura, D. (2011, May). Bank Behaviour in Response to Basel III: A Cross-Country Analysis. *IMF Working Papers*.

Dagher, J., Dell'Ariccia, G., Laeven, L., Ratnovski, L., & Tong, H. (2016, March). Benefits and Costs of Bank Capital. *IMF Staff Discussions*.

de-Ramon, S., Iscenko, Z., Osborne, M., Straughan, M., & Andrews, P. (2012, May). Measuring the impact of prudential policy on the macroeconomy. *FSA Occasional Papers in Financial Regulation*.

ECB. (2011, December). Common Equity Capital, Banks' Riskiness and Required Return on Equity. *Financial Stability Review*.

Elliot, D. (2009, September). Quantifying the effects on lending of increased capital requirements. *The Brookings Institute Working Papers*.

Junge, G., & Kugler, P. (2012, May). Quantifying the impact of higher capital requirements on the Swiss economy. *Mimeo*. University of Basel.

Kashyap, A., Stein, J., & Hanson, S. (2010, May). An Analysis of the Impact of "Substantially Heightened" Capital Requirements on Large Financial Institutions. Mimeo.

King, M. (2010, November). Mapping capital and liquidity requirements to bank lending spreads. *BIS Working Papers*.

Laeven, L., & Valencia, F. (2013). Systemic Banking Crises Database. *IMF Economic Review*, 225-270.

MAG. (2010). *Assessing the macroeconomic impact of the transition to stronger capital and liquidity requirements.* Macroeconomic Assessment Group (FSB and BCBS).

Martin-Oliver, A., Ruano, S., & Salas-Fumas, V. (2013, March). Banks' Equity Capital Frictions, Capital Ratios, and Interest Rates: Evidence from Spanish Banks. *International Journal of Central Banking*, 183-225.

Mendicino, C., Nokolov, K., Suarez, J., & Supera, D. (2015). Welfare analysis of implementable macroprudential policy rules: heterogeneity and trade-offs. *ECB Working Paper (forthcoming)*.

Miles, D., Yang, J., & Marcheggiano, G. (2012, March). Optimal Bank Capital. *Economic Journal*, 1-37.

Noss, J., & Toffano, P. (2016). Estimating the impact of changes in aggregate bank capital requirements on lending and growth during an upswing. *Journal of Banking & Finance*, 15-27.

Research Task Force. (2016, March). Literature review on integration of regulatory capital and liquidity instruments. *Basel Committeee on Banking Supervision Working Papers*(30).

Schanz, J., Aikman, D., Collazo, P., Farag, M., Gregory, D., & Kapadia, S. (2011). The long-term economic impact of higher capital levels. *BIS Papers*, pp. 73-81.

Slovik, P., & Cournède, B. (2011, February). Macroeconomic Impact of Basel III. *OECD Economics Department Working Papers*(844).

Toader, O. (2015, September). Estimating the impact of higher capital requirements on the cost of equity: an empirical study of European banks. *International Economics and Economic Policy*, 411-436.

Vitek, F., & Roger, S. (2012, February). The Global Macroeconomic Costs of Raising Bank Capital Adequacy Requirements. *IMF Working Papers*.

Yan, M., Hall, M., & Turner, P. (2012, December). A cost–benefit analysis of Basel III: Some evidence from the UK. *International Review of Financial Analysis*, 73-82.

Yang, J., & Tsatsaronis, K. (2012, March). Bank stock returns, leverage and the business cycle. *BIS Quarterly Review*.