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Optimal capital adequacy ratios for Norwegian banks

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Banking crises are very costly to society. Higher capital levels improve banks' capacity to bear losses and avoid crises. However, banks' owners may consider increasing equity to be costly and therefore opt to hold insufficient capital. They may, for example, have expectations that banks will be bailed out by the authorities in a crisis. For society, on the other hand, it will be profitable to ensure that banks hold sufficient capital to absorb substantial losses. Calculations of optimal capital levels for Norwegian banks suggest that the economic benefits of increasing capital ratios from current levels are higher than the costs. In line with a number of international studies, we also find that Norwegian banks' Common Equity Tier 1 (CET1) ratio should be higher than the European Commission's proposed minimum requirement of 4.5 percent. The results of our analysis indicate that the optimal level of the CET1 ratio (excluding the Basel I transitional floor) for Norwegian banks is between 13 and 23 percent. Experience from the 1988–1993 banking crisis indicates that such estimates are not unreasonable. There is considerable uncertainty attached to the calculations. However, the analysis is based on a number of assumptions without which our estimates of optimal capital levels would have been higher.

1 Introduction

The economic challenges ensuing from the financial crisis drew attention to the issue of bank solvency. Equity capital acts as a buffer against losses. Equity ratios in banks are relatively low compared with other sectors, partly reflecting banks' role as financial intermediaries, with lending largely funded by deposits. At the same time, one bank's decisions expose other banks to risk. If banks do not take sufficient account of this additional risk, overall risk in the banking system will be greater than the sum of risk for each bank. An equity ratio that may seem adequate from the point of view of an individual bank can be insufficient from an economic perspective. Deposit guarantees and expectations of government bailouts in periods of substantial losses can also induce banks to hold less equity capital than is optimal in economic terms. The equity capital banks must hold is therefore subject to regulatory requirements.

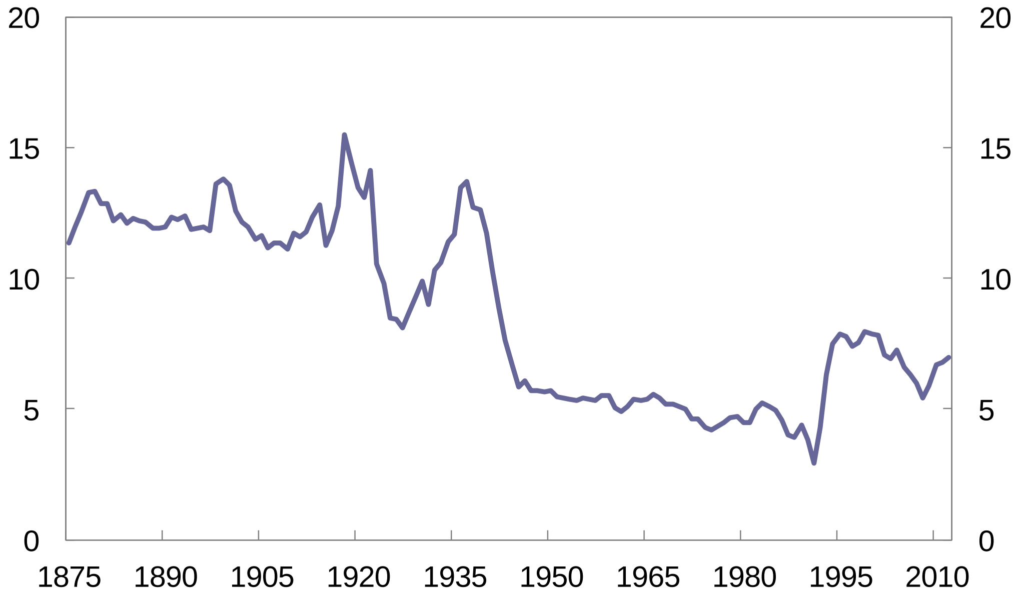
Banks' equity ratios are now low from a historical perspective (see Chart 1). As a result of the financial crisis, the authorities in many countries have imposed stricter solvency requirements for banks. Under the European Commission's proposal for a new capital requirements directive (CRD IV), the Common Equity Tier 1 (CET1) minimum ratio requirement will be increased from 2 to 4.5 percent.[2] The minimum total capital requirement will remain at 8 percent, but an important change here is that it must be composed of more CET 1 capital. The proposed directive also includes an additional capital conservation buffer requirement of 2.5 percent, and there is a proposal to introduce a

[1] Thanks to Henrik Andersen, Ingvild Svendsen, Amund Holmsen, Knut Kolvig, Bjørne Dyre Syversten, Bent Vale, Farooq Akram, Sigbjørn Atle Berg, Thea Kloster and other colleagues at Norges Bank for valuable input and comments.

[2] In somewhat simplified terms, the CET1 ratio is equity capital minus goodwill and intangible assets as a percentage of risk-weighted assets.

systemic risk buffer. Both buffers are to be composed of CET1 capital.[3] According to the Basel III schedule, the new minimum requirements are to be phased in from 2013, while the buffer requirements will be phased in from 2016.

Chart 1: Banks' equity from 1875 - September 2012. As a percentage of total assets.



Sources: Klovland (2007), Statistics Norway and Norges Bank

Some national authorities require even higher capital levels than proposed in CRD IV. The European Banking Authority (EBA) introduced a temporary CET1 ratio requirement of 9 percent for the largest EU banks from 1 July 2012, plus an additional capital buffer against potential losses on sovereign debt exposures. The Swedish government has signalled its intention to require the largest Swedish banks to have a CET1 ratio of 10 percent in 2013 and 12 percent in 2015. Similar developments are in progress in Norway; Finanstilsynet (Financial Supervisory Authority of Norway) expects all Norwegian banks to comply with the EBA requirement of a minimum CET1 ratio of 9 percent (including the transitional floor).[4] Results from the Basel Committee (BCBS, 2010), Miles, Yang and Marcheggiano (2011), and Sveriges Riksbank (2011) suggest, however, that socially optimal capital levels are higher than these requirements. Miles et al. (2011) concludes that the optimal level of CET1 is 16 to 20 percent, although the study disregards the most extreme events. BCBS (2010) finds that the optimal level of capital in banks is at least 15 percent, while Sveriges Riksbank (2011) estimates a minimum interval of between 10 and 17 percent.

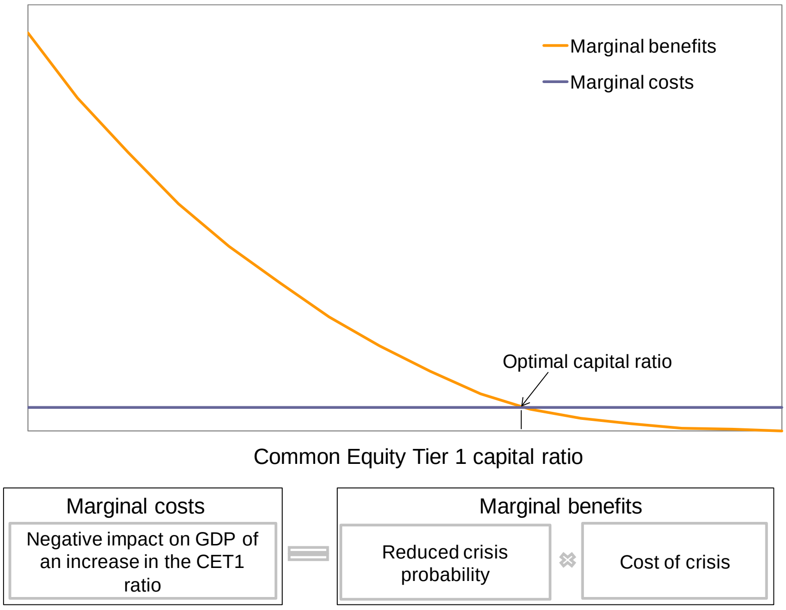
This *Staff Memo* presents calculations of the optimal level of capital for Norwegian banks in terms of economic costs and benefits, based on the analytical framework used in BCBS (2010), Miles et al. (2011) and Sveriges Riksbank (2012). Optimal capital levels in the banking sector are calculated by weighing the marginal economic cost of increasing CET1 ratios against the economic benefit (see

[3] If banks do not satisfy the conservation buffer requirement, measures must be implemented to increase the buffer. In periods of high systemic risk, banks will also be subject to a countercyclical buffer requirement of up to 2.5 percent.

[4] Corresponds to approx. 10 percent excluding the transitional floor for the banks in the sample (see Appendix A). According to the transitional rule, the minimum requirement for banks' regulatory capital in 2012 measured in accordance with Basel II must be at least 80 percent of the minimum under Basel I. The requirement is referred to as the transitional floor. In several of the calculations in this *Staff Memo*, we have converted the different solvency measures used by Norwegian banks and by countries. For more information about these conversions, see Appendix A.

Chart 2). Economic costs and benefits are estimated in the form of lower and higher expected long-term GDP.

Chart 2: Analytical framework. Marginal benefits and marginal costs of increasing CET1 ratio by one percentage point from different levels. As a percentage of GDP.



The benefit of higher capital ratios is an increase in bank's resilience to losses. More resilient banks reduces the likelihood of banking crises. Since experience has shown that banking crises lead to a substantial fall in GDP, the potential benefits can be considerable, gradually becoming smaller as capital ratios increase. When capital is increased, the probability of a banking crisis declines, eventually becoming so low that further increases will have virtually no effect (see Chart 2).

The calculation of the benefits associated with raising capital ratios is based on the relationship between bank capital levels and the probability of a crisis according to the Basel Committee on Banking Supervision (BCBS, 2010) and Miles et al. (2011). In addition, Norges Bank's bank model is used to simulate conditions in Norway.[5] There is considerable uncertainty attached to the potential magnitude of the decline in GDP as a result of a crisis. The benefit of increasing capital ratios is calculated based on the assumption that the cumulative cost of a widespread banking crisis is 30% or 60% of GDP. These figures are in line with estimates used in international studies (see for example BCBS (2010)).

Higher capital ratios may lead to higher costs for banks, but this is not necessarily the case. According to the Modigliani-Miller theorem (1958), banks' funding costs are unaffected by funding structure. Although equity is more costly than debt, holding more equity will reduce the volatility of the return on that equity and the risk associated with debt capital. As a result, the required return on both equity and debt decreases and the weighted sum of funding costs remains unchanged. International studies suggest, however, that the theorem is untenable and that banks' overall funding costs may rise somewhat when capital ratios increase (see ECB (2011)). If these costs are passed on to customers, economic costs will arise.

[5] See Andersen and Berge (2008) for a description of Norges Bank's bank model.

Two different methods have been applied to calculate the economic cost of increasing capital ratios for Norwegian banks.[6] Both methods indicate that higher capital ratios lead to higher costs for banks. Although increased costs result in higher lending rates, the negative impact on GDP of higher lending rates is relatively small. It is reasonable to assume that the marginal cost, in most cases, will not depend on initial capital levels. This is illustrated by a horizontal curve for the marginal cost of increasing capital ratios (see Chart 2).

Our calculations result in a considerably higher capital adequacy requirement than the proposed minimum requirement in CRD IV. Overall, the calculations suggest that the optimal CET1 ratio (excluding the transitional floor) for Norwegian banks is between 13 percent and 23 percent. This is in line with results in international studies. Experience from the 1988–1993 banking crisis indicates that such estimates are not unreasonable. Losses at that time were equivalent to a 5 to 15 percentage point fall in the three largest banks' CET1 ratios. The results reflect the very high social cost of banking crises, indicating that it would be profitable in terms of the overall economy to ensure that banks hold sufficient capital to absorb substantial losses.

There is considerable uncertainty attached to the calculations. A higher estimate of the cost of a crisis will entail a higher optimal level of bank capital. The calculations do not include the possibility that higher capital ratios could lower the value of government guarantees, thereby reducing risk-taking in banks and thus reducing the probability of a crisis. It has been assumed that banks' increased funding costs will be passed on in their entirety to borrowers. If a smaller portion of the rise in costs is passed on to customers, or if higher capital ratios reduce the cost of obtaining debt capital, the economic cost will be lower. In this case, the optimal capital ratio will be higher.

The remainder of this *Staff Memo* is organised as follows: Part 2 presents our calculations of the economic benefits of increasing capital ratios and Part 3 the economic costs. Part 4 presents optimal capital ratios based on the results in Parts 2 and 3. The results are discussed in the light of the assumptions on which the calculations were based, the 1988-1993 banking crisis in Norway and the results of international studies. Part 5 concludes.

2 Benefits of increasing capital ratios

The marginal benefit of increasing capital ratios is the product of the reduced probability of a banking crisis and the negative effect of banking crises on GDP. Our calculation of the link between the probability of a crisis and bank capital levels is based on the results from BCBS (2010) and Miles et al. (2011). We also utilise Norges Bank's bank model, which is based on Norwegian data. The decline in GDP given a crisis is based on estimates for international crises and the 1988-1993 banking crisis in Norway.

2.1 Probability of a crisis for different capital ratios

BCBS (2010) uses six different methods to estimate the relationship between the probability of a crisis and banks' capital ratios. Three of these methods use a large sample of crises from different countries to analyse how the frequency of banking crises has varied with capital ratios. The other three methods estimate the probability of a crisis in an individual bank for different capital ratios.

Miles et al. (2011) defines a crisis as a situation where the loss in the value of bank assets in the banking sector as a whole is as large as their equity capital. In addition, using data for banks' losses

[6] Short-term costs related to adjustment to new levels are not included in this calculation. A similar delimitation is applied in other studies (see for example BCBS (2010) and Elliot, Salloy and Santos (2012)).

and GDP figures for a number of countries, the study finds a one-to-one relationship between a fall in GDP and banks' capital levels. Based on this, they assume that the probability of a crisis for a given capital level is equal to the probability of a corresponding fall in GDP and then apply GDP figures for 31 countries over a period of 200 years to estimate the annual probability of a crisis for different levels of bank capital.

Crisis probabilities calculated based on data for other countries will not necessarily be representative for Norway. In order to take conditions in Norway into account, we calculate crisis probabilities for different capital levels using Norwegian data. We use Norges Bank's bank model and data on the Norwegian banking sector's problem loans to households and non-financial enterprises in the period from the third quarter of 1990 to the fourth quarter of 2011. The problem loans are assumed to be exponentially distributed. This provides a continuous distribution from which random observations can be drawn and used to simulate the stock of problem loans in the six largest Norwegian banks. Random observations of the problem loans are drawn and then allowed to follow a process equivalent to a historical average.[7] This provides estimates of banks' potential losses in such situations. By varying the level of banks' initial capital ratios, we can calculate the probability of a crisis for different capital ratios. A banking crisis is defined here as a fall in CET1 ratios for two or more of the six largest banks to below the proposed minimum requirement in CRD IV of 4.5 percent. The simulations are repeated N times and the crisis frequency is used as an estimate of the probability of a crisis for different capital ratios.[8]

Table 1 shows the reduction in the annual probability of a crisis for different CET1 ratios according to BCBS (2010), Miles et al. (2011) and our simulation of problem loans using Norges Bank's bank model. The benefit of increasing capital ratios declines at the margin. When capital ratios are increased, the probability of a banking crisis becomes lower, eventually becoming so low that further increases will have virtually no effect (see Chart 2). For example, the Basel Committee estimates (BCBS, 2010) show that the likelihood of a crisis is reduced by 2.6 percentage points when CET1 is increased from 7.8 to 9.1 percent, while the probability of a crisis is reduced by 0.1 percentage point when CET1 is increased from 18.3 to 19.6 percent.

Increasing bank capital ratios from lower levels results in a larger reduction in crisis probability in Norges Bank's bank model than in the other two models. This probably reflects the use of different crisis definitions. In our calculations, a banking crisis occurs when CET1 levels in two or more banks fall below 4.5 percent, while in Miles et al. (2011), a banking crisis only occurs when the loss on assets in the banking sector as a whole exceeds equity capital.

[7] The historical correlation between households' and non-financial enterprises' problem loans has been taken into account. Problem loans follow an AR (1) process. All variables other than the problem loans are taken from the baseline scenario in the May *Financial Stability* report (1/12).
[8] In the analysis, N is set equal to 1000. See Appendix B for sensitivity analyses.

Table 1: Reduction in annual probability of a crisis for different levels of CET1. Percentage points.

CET1 (excluding floor)	BCBS (2010)	Miles et al. (2011)	Norges Bank's bank model
7.8			
9.1	2.6	0.46	7.0
10.4	1.6	0.4	4.2
11.7	1.1	0.41	2.1
13.1	0.5	0.44	1.7
14.4	0.4	0.45	0.9
15.7	0.3	0.42	0.8
17.0	0.2	0.37	0.3
18.3	0.1	0.27	0.3
19.6	0.1	0.19	0.2
20.9		0.11	0.2
22.2		0.07	0.0
23.5		0.04	0.0
24.8		0.01	0.0
26.1		0.008	0.0

Sources: BCBS (2010), Miles et al. (2011), Sveriges Riksbank (2011) and Norges Bank.

2.2 Costs in the form of lost GDP

The benefits of avoiding a crisis depend on the economic cost of a banking crisis in the form of lost output.[9] The economic cost of different banking crises in terms of GDP has been calculated in a number of studies. The estimates vary widely (see Appendix C) because of the difficulty of knowing how GDP would have developed if a crisis had not occurred. In the absence of alternative GDP developments, an alternative path must be estimated and compared with GDP developments in the years following the crisis. Some studies are based on actual GDP given that a crisis had not occurred, while others calculate losses relative to potential GDP. In addition, studies apply different crises, different countries and different dates for the same crisis.

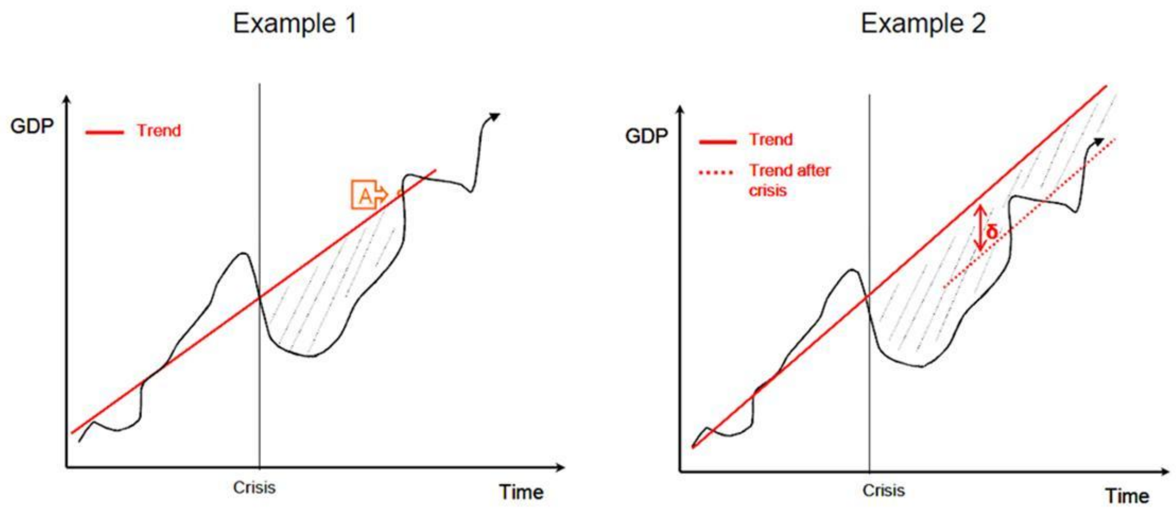
The estimated economic cost of a banking crisis depends in particular on to what extent effects on output are assumed to be permanent or not.[10] Banking crises can lead to a lower investment level, misallocation of capital or a permanent reduction in employment. The effects of a crisis can thus be permanent. The difference between non-permanent and permanent effects on GDP is illustrated in Chart 3. In the chart on the left, banking crises have no permanent effects on GDP. GDP reverts to its pre-crisis trend level and remains around this level in the post-crisis period. In the chart on the right, banking crises have permanent effects on GDP. GDP never recovers to the long-term trend level prior to the onset of the crisis. The trend remains at a permanently lower level, although trend GDP growth is assumed to be unchanged. The annual permanent effect is derived from the difference between the pre-crisis trend and the new, lower trend. Since GDP never regains its pre-crisis trend level, the cost of the crisis must be estimated into an infinite horizon and all future losses must be discounted (see BCBS (2010)).

[9] We assume that the cost of a crisis is not changed by higher bank capital ratios. Higher capital ratios will reduce banks' need to tighten credit standards and the need for costly government bailouts. In isolation, the benefit of increasing capital ratios may therefore be higher.

[10] See Cecchetti, Kohler and Upper (2009), Haugh, Ollivaud and Turner (2009), Hoggarth, Reis and Saporta (2002) and Laeven and Valencia (2008) for crises without permanent effects. For permanent effects, see Abiad, Leigh, Tytell, Balakrishnan and Brooks (2009), Barrel, Davis, Karim and Liadze (2010), Cerra and Saxena (2008), Furceri and Mourougane (2009), Furceri and Zdzienicka (2012) and Turrini, Röger and Székely (2010). Some studies estimate cumulative GDP losses directly, see Boyd, Kwak and Smith (2005) and Haldane (2010).

Loss estimates in studies based on the assumption that effects on GDP are not permanent range between 16 and 21 percent of GDP (see Appendix C). Loss estimates in studies based on the assumption that the effects may be permanent are generally higher. However, loss estimates in these studies differ considerably, ranging from 40 to 302 percent of GDP. Few studies take account of other reasons for the fall in GDP and estimates of the economic cost of a banking crisis may be too high as a result.[11] A decline in GDP could also be the result of a fall in productivity or a decrease in the working-age population. A banking crisis can also have positive effects on long-term trend growth if necessary structural reforms are implemented as a result (OECD, 2007). The effects on GDP of factors other than the banking crisis itself are taken into account to a greater extent in estimates of output loss relative to potential output. Studies that suggest the effects of a crisis are permanent and estimate output loss relative to potential output (see Barrel et al., 2010; Furceri and Mourougane, 2009; Turrini et al., 2010) generally report somewhat lower loss estimates (40-42 percent) than other studies that find permanent effects. There is, however, considerable uncertainty attached to the estimation of potential output.

Chart 3: Measuring the costs of crises: a schematic overview



Source: BCBS (2010)
In the chart on the left, GDP crosses the pre-crisis trend at point A. The crisis has no permanent effects and output loss given a crisis is shown by the shaded area. In the chart on the right, GDP remains on a new, lower path, but with the same trend growth rate as that prevailing prior to the crisis. The crisis has a permanent effect on GDP. The cost of the crisis must be estimated into an infinite horizon and all future losses must be discounted.

Since the magnitude of the loss in GDP as a result of a crisis is highly uncertain, we have conducted calculations for two different loss estimates, 30 and 60 percent of GDP. This is considerably lower than the highest loss estimates used in previous studies. A loss of 60 percent is in line with the median estimate in BCBS (2010)[12], and the loss estimates are not unreasonable based on experience of the 1988-1993 banking crisis (see Table 2).

[11] Nevertheless, studies that include the possibility that banking crises may be a result of economic decline report substantial costs (Bordo, Eichengreen, Klingbiel and Martínez-Peria, 2001; Haugh et al., 2009; Hoggarth et al., 2002; Cerra and Saxena, 2008; IMF, 2009; Claessens, Kose and Terrones, 2008). In addition, Alfaro and Drehmann (2009) find that banking crises do not usually arise after a period of declining GDP.
[12] The median loss for all studies reviewed in BCBS (2010) is 63 percent of GDP.

Table 2: Cumulative loss in GDP. 1988-1993 banking crisis in Norway. As a percentage of pre-crisis GDP.

	Cumulative loss
Studies estimating cumulative loss to end of crisis	
Haugh et al. (2009)	34.8
Hoggarth et al. (2002): GAP2	27.1
Hoggarth et al. (2002): GAP3	11.2
Schwierz (2004): T_{spline}	21.6
Schwierz (2004): T_{spline} minus T_{HP}	12.9
Schwierz (2004): net loss	6.8
Studies with cumulative loss and permanent effects	
Boyd et al. (2005): Method 1	86.4

Different crisis dates may also explain some of the variation across different studies. The method applied in Schwierz (2004), based on net loss, includes the benefit of above-trend GDP in the years prior to the crisis. Including such a "benefit" is unusual and is not included in the other studies. This explains why the cumulative loss is only just over 6 percent.

3 Cost of increasing capital ratios

3.1 Costs calculated in two steps, Small Macro Model (SMM)

3.1.1 Effect on banks' funding costs of higher capital ratios

Higher capital ratios can lead to higher costs for banks as a larger share of their assets must be funded with equity. The increase in funding costs is determined by the difference between required rates of return on equity and debt and the extent to which capital ratios rise. Shareholders require higher returns than creditors because they take on more risk. First, shareholders will be last in line to get their money back in the event of a bankruptcy. Second, return on equity, in contrast to the interest paid on debt, will vary with banks' profits.

It is not, however, self-evident that higher capital ratios will lead to higher costs for banks. According to the Modigliani-Miller theorem (1958), holding more equity capital reduces the volatility of the return on that equity and the risk associated with debt capital. Thus, required rates of return on both equity and debt fall in such a way that the weighted average cost of funding is unaffected.[13] However, international studies suggest that this theorem does not hold and that banks' overall funding costs may rise somewhat when banks are required to hold more capital (see for example ECB (2011), Miles et al. (2011), Kashyap, Stein and Hanson (2010) and Elliot et al. (2012).[14] There are several reasons why the theorem does not hold. The theorem presupposes that creditors and shareholders will bear their respective losses in full if banks should encounter severe problems. Interest rates on debt financing should thus be reduced when equity ratios increase as the investment will be safer. But in practice, implicit and explicit government guarantees could reduce the risk that creditors will have to take

[13] Admati, DeMarzo, Hellwig and Pfleiderer (2011), King (1990), Schaefer (1990), Berger, Herring and Szegö (1995), Miller (1995) and Brealey (2006) argue that any discussion of capital regulation should be based on the Modigliani-Miller theorem.

[14] ECB (2011) finds that an increase in the equity ratio results in a lower correlation with the reference index and estimates that between 41 and 73 percent of the cost of increasing the equity ratio is offset by lower required return on equity. The corresponding interval in Kashyap et al. (2010) and Miles et al. (2011) ranges between 45 and 75 percent. Overall, this indicates that the Modigliani-Miller theorem holds to a certain extent.

losses. Banks' funding largely derives from customer deposits, which are covered by an explicit guarantee under the government deposit guarantee scheme. In addition, creditors may perceive large banks as de facto being covered by government "insurance". Creditors may regard these guarantees as so important that lending rates are virtually unaffected by capital levels, and debt capital will be a cheaper source of funding for banks. Thus, increasing capital levels may entail some increase in banks' costs.

We apply the assumption that borrowing rates are independent of capital ratios, so that the Modigliani-Miller theorem does not fully hold (see also Vale (2011)). We also apply different assumptions regarding the extent to which higher capital ratios affect the required return on equity.[15] In the first approach, the required return on equity is also assumed to be independent of capital ratios (see Vale (2011).[16] Under such an assumption, the cost of higher capital ratios will probably be overestimated as it implies that the Modigliani-Miller theorem does not hold at all. The assumption can nonetheless ensure that the cost of raising capital ratios is not underestimated.[17] We call this the "naïve method".

We also use two methods based on the assumption that the required return on equity will fall when capital ratios increase (see also Vale (2011)). The cost of increasing capital ratios will therefore be lower than under the naïve method. In a *linear specification using the OLS method* (linear OLS), the marginal cost of increasing capital ratios is constant. The change in costs is therefore independent of whether capital ratios are changed from 6 to 7 percent or from 10 to 11 percent.

Vale (2011) assumes that in a *non-linear specification using fixed effects* (non-linear FE), the required return on equity falls as capital ratios increase, as in the linear OLS specification. In contrast to the linear OLS, the marginal cost of increasing capital ratios is assumed to be non-linear. For a given increase in capital ratios, the higher capital ratios are initially, the greater the reduction in the required return on equity. As a result, marginal costs fall as capital ratios increase. With the assumption of falling marginal costs, the non-linear FE produces lower cost estimates than the linear OLS.

3.1.2 Effect of higher funding costs on GDP

We assume that an increase in bank funding costs will be passed on in full to borrowers. Higher lending rates can reduce consumption and investment and thereby lead to lower GDP in the long term. The economic costs of higher capital ratios would have been lower if we had assumed that banks did not pass on the cost increase in full to customers. Banks can also choose to reduce their operating costs and/or increase non-interest income (see for example Elliot et al. (2012)).

The negative impact on GDP of higher lending rates is estimated using the long-term, steady-state solution in Norges Bank's Small Macro Model (SMM) (see Hammersland and Træe (2012)). A one percentage point increase in lending rates is equivalent to a one percent reduction in GDP in the long term.[18] The analysis can be regarded as a comparison of two long-term equilibriums. The marginal cost of increasing capital ratios depends on the estimation methods used (see Chart 4). Using the

[15] In Vale (2011), the required return on equity and the borrowing rate are 13.86 and 3.48 percent respectively.
[16] There are some differences in the assumptions underlying the studies by BCBS (2010), Sveriges Riksbank (2011), Miles et al. (2011) and Vale (2011) regarding how capital ratios affect the required return on equity. However, all the studies include an alternative where the required return on equity is not dependent on capital ratios. Vale (2011) and Miles et al. (2011) also present alternative methods in which the required return on equity varies with capital ratios.
[17] There may be other costs related to increasing capital ratios in addition to those captured in our analysis. This can provide justification for the inclusion in this study of a case where costs are probably overestimated.
[18] We assume that a nominal change in lending rates results in the same change in real rates.

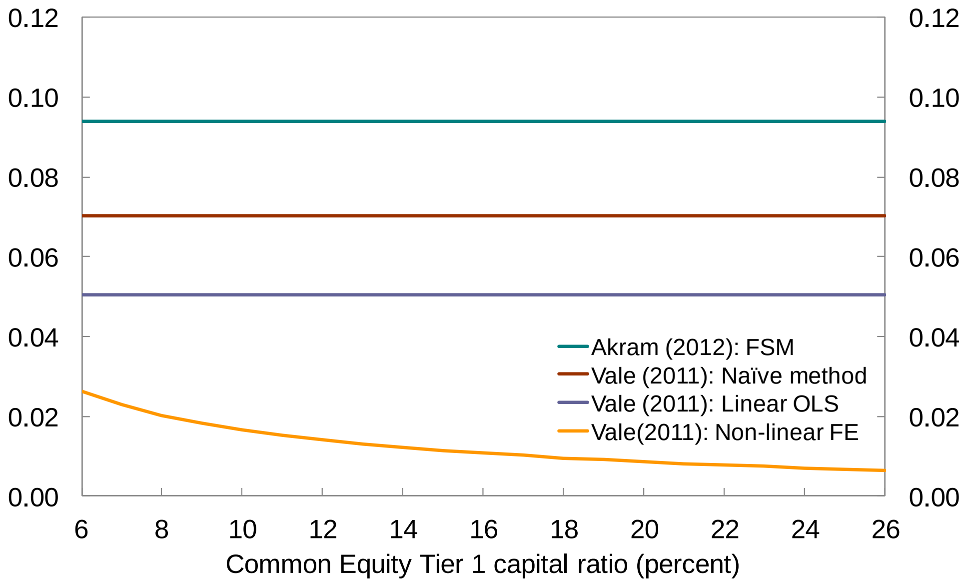
methods in Vale (2011), the cost of increasing capital ratios by one percentage point varies from 0.006 percent to 0.07 percent of GDP.

3.2 Costs estimated directly in the FSM

In the second method, we use Norges Bank's Financial Stability Model (FSM) to estimate the effect on GDP of increasing capital ratios (see Akram (2012)). The FSM is based on the SMM, but is somewhat smaller and includes a relationship for capital adequacy. This allows us to calculate the negative effect on GDP of increased capital ratios directly. In the model, increased capital ratios lead to higher lending rates, which in turn result in lower house prices, credit to households and enterprises and GDP. The effects are amplified by feedback loops between the variables, but are dampened by the reduction in the key rate. The annual marginal cost of increasing capital ratios by one percentage point is 0.094 percent of GDP in the long term (see Chart 4).[19] This is somewhat higher than the result using the other methods.

Even though the four estimates of marginal costs vary somewhat, the analyses indicate that the economic cost of increasing capital ratios is fairly small. The cost estimates are in line with the median result in BCBS (2010), indicating that a one percentage point increase in the CET1ratio reduces annual GDP by 0.07 percent in the long-term.[20] This corresponds to the next highest estimate in Chart 4.

Chart 4: Percentage reduction in GDP in the long term of a one percentage point increase in CET1 for different capital levels



Sources: Akram (2012), Hammersland and Træe (2012), Vale (2011) and Norges Bank.
CET1 excluding the transitional floor.

4 Optimal capital ratios

We estimate socially optimal capital ratios for Norwegian banks given our assumptions about marginal benefits (Part 2) and costs (Part 3). The optimal capital ratio is where the marginal cost is equal to the

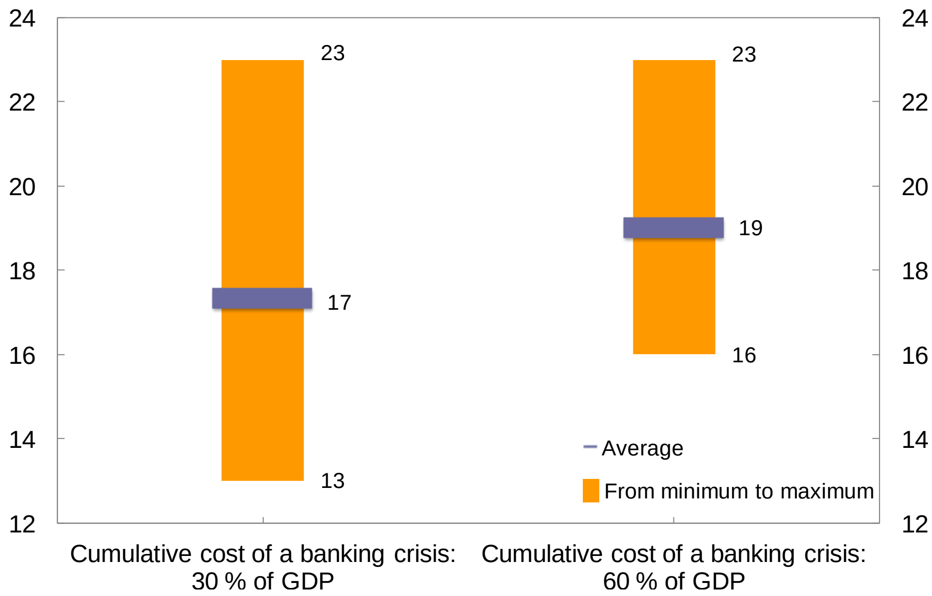
[19] The long-term effect corresponds to the reduction in GDP after 32 quarters. The cost is the same whether it takes 8 or 16 quarters to reach the new level.
[20] The actual figure given in BCBS (2010) is 0.09 percent. However, we have converted these results as described in Appendix A.

marginal benefit of increasing capital ratios. There is substantial uncertainty attached to the calculations and the choice of method has considerable impact on the estimated optimal capital ratio. Since banking crises are relatively rare, it is at the same time difficult to produce precise estimates for both costs and benefits. However, using results produced by different methods can smooth out possible errors in the data.

Chart 5 shows the intervals for the optimal CET1 level when the cumulative loss as a result of a widespread banking crisis is assumed to be 30 and 60 percent of GDP respectively. The socially optimal level ranges between 13 and 23 percent. The lower end of the range results from applying the lowest estimate of reduced probability of a crisis (BCBS, 2010) and loss given a crisis and the highest estimate of marginal costs (Akram, 2012) (see Chart 6). If the estimated loss given a crisis is assumed to be 60 percent, the optimal CET1 level will be at least 16 percent, with an average level of 19 percent.

Our calculations indicate that Norwegian banks should have considerably higher CET1 levels than the proposed minimum requirement in CRD IV. The minimum requirement is increased from 2 to 4.5 percent. The proposed directive also includes an additional capital conservation buffer requirement of 2.5 percent, and there is a proposal to introduce a systemic risk buffer. Both buffers are to be composed of CET1 capital. In total, CET1 requirements may be close to 12 percent.[21] This is higher than the average level of capital held by the six largest Norwegian banks at end-2011 (9.9 percent at consolidated level). Based on banks' income statements at end-2011, further increasing capital ratios will probably yield net benefits (see Charts in Appendix D).The new capital requirements may therefore bring banks closer to socially optimal capital ratios according to our calculations.

Chart 5: Scatter diagram, optimal capital level for Norwegian banks based on different assumptions regarding marginal costs and benefits. CET1 ratio excluding floor. Percent.



Sources: BCBS (2010), Miles et al. (2011), Vale (2011), Akram (2012) and Norges Bank.

Since there is considerable uncertainty attached to the calculations, it may be useful to cross-check the results against previous Norwegian crises. The 1988-1993 crisis was a widespread banking crisis and

[21] The time-varying countercyclical buffer requirement, which can be between 0 and 2.5 percent, depending on developments in systemic risk, is not included.

can thus provide a useful basis for comparison.[22] Several banks lost all their equity capital (NOU, 1992:30). Losses during the banking crisis corresponded to a fall in CET1 for the three largest banks of between 5 and 15 percentage points.[23] This implies that a CET1 ratio of at least 13 percent is not unreasonably high. It should also be noted that although capital ratios in a number of other countries' banking sectors have been considerably higher than in Norway, this did not prevent them from experiencing banking crises.

Our estimates of optimal capital ratios of between 13 and 23 percent are also in line with results from other international studies.[24] Miles et al. (2011) concludes that the optimal level of CET1 is between 16 and 20 percent, even though the authors exclude the most extreme events. BCBS (2010) finds that the optimal capital level is at least 15 percent, while Sveriges Riksbank (2011) estimates a minimum interval of between 10 and 17 percent.

Our results are based on a number of assumptions without which our estimates of optimal capital ratios would have been higher:

- Our calculations do not include the possibility that higher capital ratios could lower the value of government guarantees, thereby reducing risk-taking in banks and thus reducing the probability of a crisis.
- It is assumed that banks' increased funding costs will be passed on in their entirety to borrowers.
- It is assumed that all borrowers will face higher bank lending rates. Higher lending rates could make borrowing in securities markets relatively less costly for firms that are large enough to have access to such markets. This may curb the effect on GDP of higher bank lending rates.
- It is assumed that interest rates on banks' debt funding are independent of banks' capital ratios. The possibility that higher capital ratios reduce the cost of obtaining debt capital cannot be excluded.[25]
- Increased capital ratios in the banking sector may also promote smoother business cycles. With higher capital levels in banks, credit standards may be less tight in downturns, even when the economy is not in a crisis.[26] Our calculations do not take the welfare gains of smoother business cycles into account.
- The estimates we use of the economic cost of a banking crisis do not take into account that the effects of the crisis would in many cases have been more severe if government measures had not been applied. Costly government measures may result in a level of sovereign debt that restricts governments' room for manoeuvre ahead.

Higher capital ratios may also result in lower-than-assumed net gains, by for example promoting the emergence of a shadow banking system, which would have a negative impact on the financial system.

[22] For Norwegian banks, the recent financial crisis was a crisis of liquidity rather than solvency, and Norwegian banks' solvency was never really put to the test.
[23] The fall in CET1 ratios is calculated as cumulative losses over the period 1990-1992 as a percentage of risk-weighted assets in 1991.
[24] See footnote 4.
[25] Akram and Christophersen (2012) studies factors that can explain the differences in interest rates on unsecured interbank lending for Norwegian banks. The study finds that banks with higher capital ratios during the financial crisis were able to obtain such loans at a lower rate than other banks.
[26] IMF (2012) studies 58 countries in the period 1998-2010 and finds that volatility in GDP and financial market stress are often lower in countries where financial institutions have higher capital ratios.

5 Conclusion

Banking crises are very costly to society. Higher capital levels improve banks' capacity to bear losses and avoid crises. However, banks' owners may consider increasing equity to be costly and therefore opt to hold insufficient capital. They may, for example, have expectations that banks will be bailed out by the authorities in a crisis.

We calculate the optimal level of capital for Norwegian banks in terms of economic costs and benefits, within the analytical framework used in similar international studies. The calculations indicate that Norwegian banks' CET1 ratios should be considerably higher than the proposed minimum requirement in CRD IV. Based on our assumptions concerning marginal costs and benefits, we find that the optimal CET1 capital ratio (excluding the transitional floor) is between 13 and 23 percent for Norwegian banks. This is in line with results from international studies. Simple calculations based on the 1988-1993 banking crisis show that these estimates are not unreasonable, indicating that it would be economically profitable to ensure that banks hold sufficient capital to absorb substantial losses. There is considerable uncertainty attached to the calculations. However, the analysis is based on a number of assumptions without which our estimates of optimal capital ratios would have been higher.

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Appendix A Conversion of different solvency measures

In this *Staff Memo,* we assess the effects of an increase in CET1 ratios (excluding the transitional floor), in contrast to Vale (2011) and Akram (2012), who calculate the effects of higher equity ratios and total capital (including hybrid Tier 1 and Tier 2 capital). To utilise the results in Vale (2011) and Akram (2012), equity ratios were converted to CET1 ratios. Such conversions will not be exact and will depend on the composition of banks' assets and how they are risk-weighted. While equity ratios are calculated using total assets as the denominator, CET1 ratios are calculated based on risk-weighted assets. Two banks with the same value in terms of total assets can, in principle, have a very different value in terms of risk-weighted assets.[27]

We base our conversion of the different solvency measures on the largest Norwegian banks' profit and loss statements at the end of the years 2010 and 2011. The six banks are DNB Bank, Nordea Bank Norge, Sparebank 1 SR-bank, Sparebank1 SMN, Sparebanken Vest and Sparebank 1 Nord-Norge. Estimates from several years can provide a more accurate picture of the actual relationship between different solvency measures. Notwithstanding, we do not use figures from the years before 2010 as DNB Bank made a substantial change in its calculation of risk-weighted assets between 2009 and 2010 (from the standardised approach to the internal ratings-based approach (IRB)). We use figures at the consolidated level since it is reasonable to assume that total risk is then captured more effectively. The six banks use the IRB approach to a varying degree to calculate risk weights for their positions. Andersen (2010) shows that banks achieve lower risk weights on most of their positions when they move from the standardised to the IRB approach. It is therefore likely that a conversion will be more suitable for internal calculations in IRB banks than for banks in Norway as a whole. Using this approach, we find that the equity ratio for IRB banks averaged approximately 2/3 (0.68) of CET1 capital excluding the transitional floor.

Comparing figures from BCBS (2010) and Miles et al. (2011) with CET1 ratios in Norwegian banks is challenging. First, equity-to- risk-weighted assets ratios are not necessarily comparable across countries. Calculation of both the numerator and the denominator can differ, depending on national regulations (Ministry of Finance, 2012). To avoid the problem of differences in risk-weighting, we compare equity ratios across countries, then convert the equity ratios to CET1 ratios excluding the transitional floor, as described in the paragraph above.

[27] See "Comparison of Nordic banks using different measures of solvency" in *Financial Stability* 1/12.

Appendix B Sensitivity analyses

Table B - 1: Norges Bank's bank model: Optimal capital ratios for different assumptions concerning loss given default (LGD) for households (h) and enterprises (e), and required capital buffer. Common Equity Tier 1 ratio excluding transitional floor.

Crisis requirement →	**0 %**		**4.5 %**		**7 %**	
	LGD (h) = 20 LGD (e) = 40	LGD (h) = 40 LGD (e) = 40	LGD (h) = 20 LGD (e) = 40	LGD (h) = 40 LGD (e) = 40	LGD (h) = 20 LGD (e) = 40	LGD (h) = 40 LGD (e) = 40
Cumulative loss given a crisis: 30% of GDP						
Different cost estimates:						
Vale (2011): Non-linear FE	16	18	18	21	22	25
Vale (2011): Linear OLS	13	14	18	18	18	20
Vale (2011): Naïve method	13	14	16	16	15	17
Akram (2012): FSM	12	14	13	16	15	17
Cumulative loss given a crisis: 60% of GDP						
Different cost estimates:						
Vale (2011): Non-linear FE	16	18	18	21	22	25
Vale (2011): Linear OLS	16	14	18	21	20	25
Vale (2011): Naïve method	13	14	18	21	20	25
Akram (2012): FSM	13	14	18	18	18	20

The crisis requirement is set at 0, 4.5 and 7 percent, i.e. a crisis is defined as when two or more banks breach capital ratios of 0, 4.5 and 7 percent. In our baseline scenario, the crisis requirement is set at 4.5 percent and LGD(h) = 40 and LGD(e) = 40.

Appendix C Costs in the form of lost GDP

Table C - 1: Studies without permanent effects

Study	**Crises, countries and period**	**Estimated trend and calculation of lost GDP**	**End-of-crisis definition**	**Calculated cumulative loss as percentage of GDP**
Cecchetti et al. (2009)	40 systemic crises, 35 countries, from 1980	No trend. Loss estimated as annual deviations from pre-crisis GDP level (peak).	When GDP reaches the pre-crisis GDP level	18
Haugh et al. (2009)	6 crises, 6 countries.	OECD estimate of potential output. Loss calculated as sum of annual deviations between actual and potential output.	Output gap closes	21
Hoggarth et al. (2002)	47 crises , 47 countries 1977-1998	Trend based on GDP for 10 years prior to crisis. Loss calculated as sum of annual deviations from trend.	Based on expert assessments	16
Laeven and Valencia (2008)	124 systemic crises, 1970 -2007	Trend based on data up to the year preceding crisis, and assumed to continue at same pace thereafter given that no crisis occurred. Loss calculated as cumulative distance from trend and actual GDP as from crisis year.	All crises assumed to last four years	20

Information about number of crises, countries and periods is not provided in all studies.

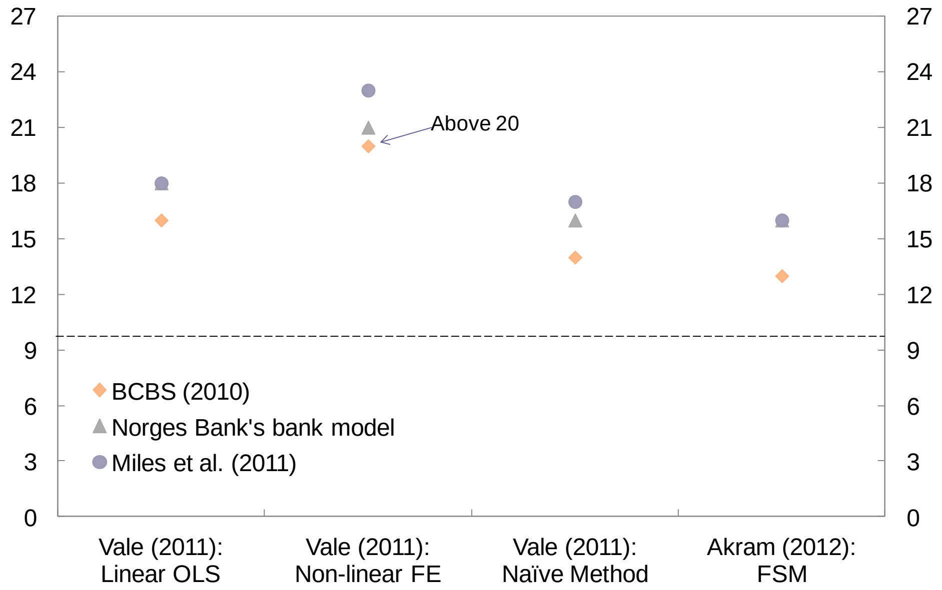
Table C - 2: Studies with permanent effects

Study	Crises, countries and period	Calculated trend based on	Estimated permanent fall (δ)	Calculated cumulative loss as a percentage of GDP (average)
Loss at time of crisis assumed to have permanent effects				
Barrel et al. (2010)	13 OECD countries, 1980-2008	Potential GDP	2.5 percent	42
Cerra and Saxena (2008)	190 countries, 1960-2001	Actual GDP	7.5 percent	158
Abiad et al. (2009)	88 crises, past 40 years	Actual GDP	10 percent	210
Furceri and Mourougane (2009)	1960-2007, 30 OECD countries	Potential GDP	2 percent	42
Furceri and Zdzienicka (2012)	159 countries, 1970-2006	Actual GDP	4.5 percent	95
Turrini et al. (2010)	53 crises, 56 countries, 1970-2008	Actual GDP/Potential GDP	9.4/1.9 percent	197/40
Studies measuring cumulative loss directly				
Boyd et al. (2005): Method 1	23 crises	Actual GDP		63
Boyd et al. (2005): Method 2	23 crises	Actual GDP		302
Haldane (2010)		Assumption of 3 percent GDP growth	6.5 percent	200

Information about number of crises, countries and periods covered is not provided in all studies.

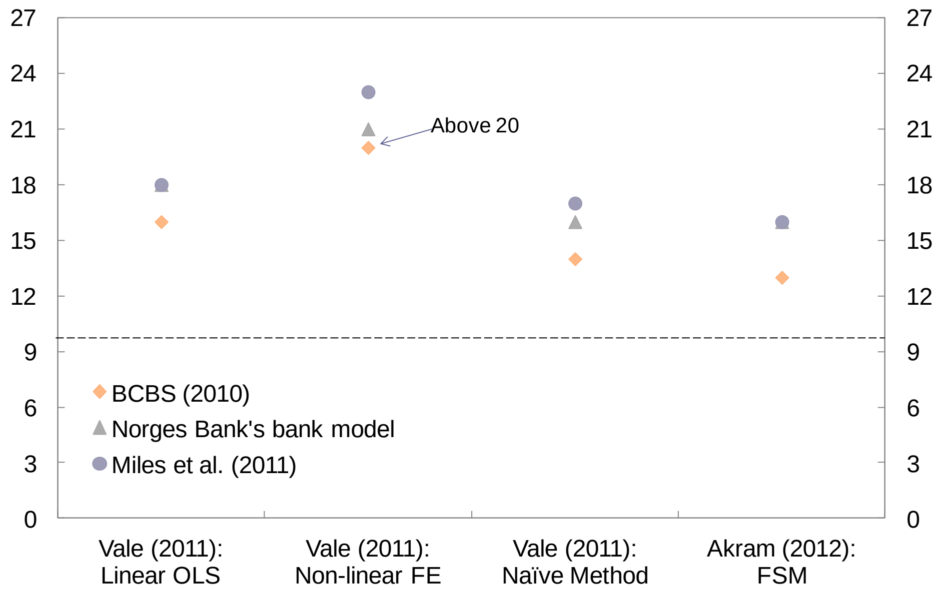
Appendix D Optimal capital ratios under different assumptions

Chart D - 1: Banks' Common Equity Tier 1 ratios (broken line) compared with optimal capital ratios based on different assumptions regarding marginal costs (x-axis) and benefits. Loss given a crisis: 30 percent. Percent.



Sources: BCBS (2010), Miles et al. (2011), Vale (2011), Akram (2012) and Norges Bank.
Common Equity Tier 1 ratio excluding the transitional floor for the six largest Norwegian banks is shown by the broken line (figures at 31 December 2011).

Chart D - 2: Banks' Common Equity Tier 1 ratios (broken line) compared with optimal capital ratios based on different assumptions regarding marginal costs (x-axis) and benefits. Loss given a crisis: 60 percent. Percent.



Sources: BCBS (2010), Miles et al. (2011), Vale (2011), Akram (2012) and Norges Bank.
Common Equity Tier 1 ratio excluding the transitional floor for the six largest Norwegian banks is shown by the broken line (figures at 31 December 2011).