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Banks' buffer capital: How important is risk?

by

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Banks' buffer capital: How important is risk

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Abstract

Most banks hold a capital to asset ratio well above the required minimum defined by the present capital adequacy regulation (Basel I). Using bank-level panel data from Norway, important hypotheses concerning the determination of the buffer capital are analysed. Focus is on the importance of: (i) risk, particularly credit risk, (ii) the buffer as an insurance, (iii) the competition effect, (iv) supervisory discipline, and (v) economic growth. A negative or non-significant risk effect is found, which suggests that introducing a more risk-sensitive capital regulation (Basel II) is likely to affect Norwegian banks. Support is found for the hypothesis that buffer capital serves as an insurance against failure to meet the capital requirements.

Keywords: Banking; Excess capital; Risk; Panel data
JEL classification: C33, G21, G32

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1. Introduction and motivation

Despite the last decades of market deregulation of the banking industry in many countries, banking is still one of the most regulated industries in the world. Regulation is in general justified on the basis of market failures and the importance of preserving financial stability, although there is still no consensus on how banks should be regulated (Santos (2000)).

As other forms of regulation disappear, capital adequacy regulation becomes relatively more important, and the result is an increased focus on banks' capital to asset ratio. In addition, the experience from banking crises in several countries during the last decades have made both regulators, supervisory authorities, the banks themselves and probably also their shareholders more aware of the importance of a sufficient capital to assets ratio. (See Reidhill (2003), for Norway see Stortinget (1998) and Steigum (2003).) Both the 1988 Basel Capital Accord (Basel I) and the proposals from the Basel Committee on Banking Supervision to update and revise this legislation (the forthcoming Basel II) include minimum capital requirements, although Basel II implies a more risk-sensitive regulation. However, banks' balance sheets show that most banks hold a capital ratio well above the required minimum[1], and a better understanding of how these capital buffers are determined and how they vary with risk, across banks and over time may help us to understand the need for and effect of a new capital adequacy regulation.

From a regulator's perspective, one would prefer that banks with a relatively risky portfolio, i.e. with a high credit risk, hold a relatively high level of buffer capital. Otherwise, these banks are more likely to fall below the minimum capital ratio, which could give rise to a credit crunch. Poorly capitalised banks may even spur systemic risk and hence threaten financial stability. It has been argued that a more risk sensitive capital adequacy regulation may reduce banks' willingness to take risk. If banks already risk-adjust their total capital, i.e. minimum capital plus buffer capital, more than implied by Basel I, replacing Basel I with Basel II may not affect the capital to asset ratio or risk profile of banks' portfolio as much as feared. Therefore, it is clearly of interest to understand how banks' buffer capital varies with credit risk under the present regulation.[2]

[1] According to Basel I, banks must hold a "capital to risk adjusted asset" ratio of minimum 8 per cent. In Norway, Basel I was fully implemented in December 1992.

[2] The theoretical literature has shown that although capital adequacy regulation may reduce the total volume of risky assets, the composition may be distorted in the direction of more risky assets, and

In the literature, it is argued that banks hold excess capital to avoid costs related to market discipline and supervisory intervention if they approach or fall below the regulatory minimum capital ratio, see e.g. Furfine (2001). A poorly capitalised bank runs the risk of loosing market confidence and reputation. Thus, excess capital acts as an insurance against costs that may occur due to unexpected loan losses and difficulties in raising new capital. The price of raising new capital, i.e. the required return on equity or interest rate on subordinated debt, is interpreted as the price of this insurance.[3] We expect an increase in price to affect excess capital negatively. Furthermore, one may argue that the value of this insurance depends on the uncertainty the bank is facing, i.e. on the probability of experiencing an unexpectedly large fall in the capital ratio without being able to rebuild this ratio relatively frictionless. If this "value-argument" is important, the buffer capital should vary positively with the uncertainty that the bank is facing. However, banks may well behave in accordance with less sophisticated rules, by for example aiming at a relatively constant buffer.

Unexpected loan losses may be due to purely random shocks or asymmetric information in the lender-borrower relationship. In the latter case, more extensive screening and monitoring of borrowers could increase the banks' understanding of the risk involved in each project (see Hellwig (1991) for a discussion and references therein). Screening and monitoring are costly, however, and banks probably balance the cost of and gain from these activities against the cost of excess capital. In the presence of scale economies in screening and monitoring, one would expect large banks to substitute relatively less of these activities with excess capital. Hence, one may find a negative size effect on excess capital. A negative size effect may also be due to a diversification effect. The argument is that portfolio diversification reduces the probability of experiencing a large drop in the capital ratio, and that diversification increases with bank size. A third argument for a negative size effect comes from the "too-big-to-fail" hypothesis. If large banks expect support from the government in the event of difficulties, while this is not, to the same degree, expected by small banks, we should expect large banks to hold lower capital buffers.

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average risk may increase. Risk consistent weights are not sufficient to correct for this moral hazard effect in limited liability banks. See Koehn and Santomero (1980), Kim and Santomero (1988), Rochet (1992a,b) and Freixas and Rochet (1997), section 8.3.3). We do not address these issues in this analysis, since we do not include the introduction of capital adequacy regulation or a more risk-sensitive regulation.

[3] Norwegian banks face restrictions on the ratio of subordinated debt to equity capital in addition to the minimum capital-ratio requirement.

According to Furfine (2001), changes in supervisory monitoring of banks affect their capital ratios. In the presence of a supervisory discipline effect, we would expect a positive relationship between supervisory scrutiny and banks' capital buffer. Furthermore, a bank may use excess capital as a signal of its solvency or probability of non-failure. Hence, excess capital may serve as an instrument, which the bank is willing to pay for, in the competition for unsecured deposits and money market funding. We, therefore, expect banks to care about their relative buffer, i.e. the size of their own capital buffer relative to those of their competitors.

Berger, Herring and Szegö (1995) argue that banks may hold excess capital to be able to exploit unexpected investment opportunities. Although the relevance of this argument is likely to depend on how difficult it is for the bank - on very short notice – to increase its capital, one may expect banks' buffer capital to decline in periods with high economic growth, since more interesting investment projects are likely to exist. The variation in the buffer capital over the business cycle may be of interest also from the perspective of the pro-cyclicality of both the present and the forthcoming capital legislation.[4] As a result of their evaluation of future risk and investment opportunities today contra tomorrow, banks may use their buffer capital to either dampen or increase the pro-cyclical effects embedded in the legislation. However, a systematic relationship between economic growth and buffer capital must be interpreted with care, since the change in buffer capital may reflect changes in the volume of capital as well as in the volume of loans.

In this paper, we analyse empirically the relationship between banks' credit risk and buffer capital. A reduced form framework is applied, hence controlling for other variables of importance for the determination of the buffer capital.[5] We focus on the issues discussed above: i) Whether excess capital depends on the risk profile of the banks' portfolios, particularly the credit risk involved, ii) Whether excess capital acts as an insurance against falling below the required minimum capital to asset ratio, iii) Whether banks use excess

[4] See, among others, Basel Committee on Banking Supervision (2001), Borio et al. (2001), Danielsson, Embrechts, Goodhart, Keating, Muennich, Renault and Shin (2001) and European Central Bank (2001) for a discussion of the pro-cyclicality issue.

[5] An alternative approach is to model banks' total capital ratio as in Barrios and Blanco (2003). They argue that some banks are affected while others are not affected by the capital adequacy regulation. To describe the behaviour of these two types of banks they develop a regulatory model and a market model. In this paper, we assume that the behaviour of all banks is affected by the current regulation and test for market effects and in addition a supervisory discipline effect.

capital as a signal, i.e. a competition parameter, and relative capital buffers matter, iv) Whether the level of supervisory monitoring matters, and v) Whether the buffer capital depends on economic growth.

We also emphasise bank heterogeneity, which, within a financial stability framework, is clearly important. Although the (arithmetic) average buffer capital of Norwegian banks has varied around 8-12 per cent since the early 1990s, i.e. the average capital ratio of Norwegian banks' is around twice the required minimum level, the data show important variation across banks. It is clearly of interest to understand how the buffer capital of different banks or groups of banks is connected to the different factors discussed above. In the empirical part, we split the banks in two sub-groups, i.e. savings banks and commercial banks. Their behaviour is likely to vary systematically, and the average buffer capital of savings banks is in general well above that of commercial banks. In Norway, there is a relatively large number of small and, in general, locally-based savings banks and a small number of larger commercial banks, of which some have branches across the country. While the capital of commercial banks basically consists of equity capital, accumulated retained profits and subordinated debt, the capital of savings banks is very much based on accumulated retained profits and a hybrid capital instrument intended to mimic equity capital. This hybrid capital instrument does not give the holder the same right as share holders in commercial banks to vote at a general meeting, however. Traditionally, these two groups of banks have served different purposes. While savings banks have served as intermediaries for a local population, granting mortgage loans and loans to small businesses, commercial banks have also served large commercial customers. In addition, commercial banks have been profit-making businesses with pressure to maximise shareholders' returns. The philosophy of savings banks has been to offer loans and deposit accounts with favourable interest rates.

Section 2 presents the model to be estimated. The data and empirical results are discussed in Section 3. Section 4 concludes, and the Appendix presents the empirical variables in more detail.

2. The model

In the empirical analysis of banks' buffer capital, our starting point is Ayuso, Pérez and Saurina (2002), who analyse the behaviour of the buffer capital of Spanish banks using annual data for 1986-2000. We add to the literature in several ways. First, we take explicitly into account the "insurance against falling below the required minimum capital ratio" argument. Second, we take into account that relative capital buffers may matter due to competition. Third, to test the conclusion in Furfine (2001) that a supervisory discipline effect is present, we include a variable that represents the supervisory authorities' monitoring of banks. Fourth, we analyse the importance of banks' risk for the buffer capital. We apply a more sophisticated credit-risk measure than Ayuso et al. Fifth, while Ayuso et al. include fixed effects in their model and a shift parameter for small and large banks, we apply a random effect approach and estimate the model on two sub-groups of banks, i.e. savings banks and commercial banks. This allows all slope coefficients to vary across the two sub-groups.

Our most general model is defined in Eq. (1). Subscripts *i* and *t* denote bank and period respectively. Small letters indicate data on logarithmic form, i.e. buf=ln(BUF), pec=ln(PEC), etc. Lags in explanatory variables are introduced to avoid simultaneity problems.

$$\begin{aligned} \text{buf}_{it} = {} & \alpha_{0i} + \alpha_1 \text{ risk}_{it} + \alpha_2 \text{ pec}_{i,t-1} + \alpha_3 \text{ vprof}_{i,t-1} + \alpha_4 \text{ cbuf}_{t-1} + \alpha_5 \text{ sup}_t + \alpha_6 \text{ gdpg}_t \\ & + \alpha_7 \text{ size}_{it} + \alpha_8 \text{ uslp}_{i,t-1} + \alpha_9 \text{ trend}_t + \alpha_{10} \text{ Q2} + \alpha_{11} \text{ Q3} + \alpha_{12} \text{ Q4} + \text{u}_{it} \end{aligned} \tag{1}$$

where **BUF** is the capital buffer measured as the "excess-capital to risk-weighted asset" ratio; **RISK** represents the bank's credit risk. A measure based on predicted bankruptcy probabilities of limited liability firms and loss given default is applied; **PEC** is the price of excess capital. Two alternative empirical proxies are applied. (i) The lagged predicted interest rate on subordinated debt ($\text{PEC1}_{i,t-1}$), which varies both over time and across banks, and (ii) the β-coefficient (PEC2_t) of the banking industry[6], which varies over time but not across banks; **VPROF** is the variance of each bank's quarterly profits calculated over past observations; **CBUF** is the competitors' average capital buffer calculated separately for the two groups, i.e. for savings banks and commercial bank. Banks are expected to compete most heavily with banks of the same category; **SUP** represents supervisory scrutiny and is measured by the number of on-site inspections by the supervisory authority in Norway, i.e. the Banking, Insurance and Securities Commission; **GDPG** denotes the four-quarter growth rate of gross domestic product; **SIZE** is total financial assets incl. guarantees and represents bank size; **USLP** is the stock of unspecified loan loss provisions relative to risk-weighted

[6] The β-coefficient is calculated in accordance with the Sharpe-Lintner capital asset pricing model (CAPM), and reflects, in our setting, the risk premium of investing in the Norwegian banking industry as compared to the Oslo Stock Exchange All Share Index. More details are given in the Appendix.

assets; **TREND** is a simple deterministic trend variable; **Q2**, **Q3**, **Q4** are quarterly dummy variables included to capture seasonal effects; u is an added disturbance. A more detailed presentation of the empirical variables is given in the Appendix.

We have calculated and applied alternative empirical proxies for the risk profile of banks, RISK, but the empirical results are qualitatively independent of the choice of empirical variable.[7] Banks may vary significantly in their willingness to take risk, and the measures of risk-profile are assumed to contain information on bank type with respect to this. Although Basel I includes some risk sensitivity in the calculation of the capital requirement, it is in general assumed to be too rude, with the consequence that risk is not properly taken into account. Therefore, if banks consider the true credit risk of their portfolios when deciding on the total amount of capital, one would expect the buffer capital to vary positively with any risk measure that is closer to replicate the true risk profile of banks' portfolios than the risk weights in Basel I.

The motivation for including the price of excess capital, PEC, and the variance of each bank's past profits, VPROF, is to analyse how sophisticated insurance rules banks are following. While the price is assumed to reflect the development in the insurance premium, and hence represents a price effect, the variance of profits is assumed to reflect how valuable this insurance is for the bank. The banks can increase their buffer capital through retained profits, but this is an uncertain option if profits are highly variable. The probability of falling below the required minimum level of the capital ratio is therefore assumed to increase with VPROF. The value of the buffer capital, and hence also the buffer capital, are expected to vary positively with VPROF.

VPROF and RISK are related, since both capture information about risk. Both measures should therefore be taken into account when interpreting the importance of risk for banks' buffer capital.

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[7] Other measures for RISK applied in the analysis are: (i) The risk-weighted to unweighted assets ratio. The risk-weighted assets are calculated in accordance with the Basel I rules. This measure takes values between zero and one, and increasing value implies increasing risk. (ii) Twelve quarters moving average of the flow variable loan loss provisions relative to total assets. Ayoso et al. (2002) use the ratio of non-performing loans to total loans and credits as a risk measure. This is comparable with our measure (ii), since banks with non-performing loans are obliged to make provisions for loan losses.

The GDPG variable is included to capture economic growth effects. Our observation period does not include a whole business cycle, and the effect of this variable should therefore be interpreted with care and not used to draw conclusions about business cycle effects.

To some degree, banks have the option of making unspecified loan loss provisions. From the insurance against "falling below the minimum capital requirement" perspective, this represents an alternative to increasing the capital buffer. Therefore, we expect USLP to have a negative effect on the buffer.

The trend variable, TREND, is included to capture secular changes in the capital buffer not captured by the other variables, see Furfine (2001) and Boyd and Gertler (1994). However, the increased importance of off-balance-sheet items, such as letters of credit and loan commitments, is taken into account in the calculation of the capital buffer, and hence this should not give rise to trend effects in the capital buffer. In principle, the trend effect represents the net trend effect of all excluded variables.

We expect $\alpha_2 < 0$, $\alpha_3 > 0$, $\alpha_4 > 0$, $\alpha_5 > 0$, $\alpha_7 < 0$ and $\alpha_8 < 0$. If $\alpha_1 > 0$, then banks with more risky assets have a higher buffer capital, and if $\alpha_1 < 0$ the opposite is true. The economic growth and trend effects, represented by α_6 and α_9 respectively, and the seasonal effects, represented by α_{10}, α_{11} and α_{12}, can in principle take any sign.

3. Data and empirical results

The data

To estimate Eq. (1), we use an unbalanced bank-level panel data set for Norwegian banks. Primarily we use quarterly financial statements that all banks are obliged to report to Norges Bank, combined with Norwegian national account data and information from the Banking, Insurance and Securities Commission. The data applied cover the period 1995q4-2001q4, i.e. 25 quarters. The regressions start in 1996q1 due to a lag in explanatory variables, however. We have access to most of the data back to 1991q4, but we have chosen not to include the early 1990s in our sample for two reasons. First, in 1991-1992 banks were adjusting their capital ratios in accordance with the forthcoming Basel I capital adequacy requirements, which were fully implemented for Norwegian banks by 31 December 1992. Second, during the 1988-1992 banking crisis in Norway, many banks saw their capital erode. In the following years, banks rebuilt their buffer capital, and we need to exclude these years so that extraordinary behaviour will not affect the results. Most likely, the rebuilding of capital buffers was finished before early 1996, but the data needed to calculate the empirical proxies for the price on excess capital (PEC) are unavailable prior to this year.

The dataset used for estimation includes 3401 observations. None of the banks in our sample have a capital ratio below the required minimum level. We have excluded only three observations due to missing observations on explanatory variables. The sub-sample for savings banks consists of 3101 observations on 131 different banks, of which 127 banks are observed over the whole estimation period. The sub-sample for commercial banks is much smaller and consists of 300 observations on 16 different banks, of which 10 are observed over the whole estimation period. The variables used in the analysis are summarised in Table 1.

Table 1. *Main features of the data, 1996q1-2001q4. Bank specific variables are based on 3101 observations on savings banks and 300 observations on commercial banks*

Variable	Mean	Std. dev.	Minimum	Maximum
BUF_i	9.379	5.963	0.069	38.333
$RISK_i$	0.016	0.005	0.004	0.043
$PEC1_i$[a]	2.008	0.181	1.175	2.871
PEC2[a]	0.750	0.343	0.191	1.512
$VPROF_i$	17776	146248	0.003	2360498
$CBUF_i$	12.120	23.155	3.919	366.383
SUP	11.377	1.027	10.000	12.750
GDPG[b]	3.012	2.226	-0.372	7.991
$SIZE_i$[c]	497	2861	1	$3.2 \cdot 10^4$
$USLP_i$	0.010	0.006	$1.0 \cdot 10^{-7}$	0.040

[a] PEC1 is the predicted interest rate on subordinated debt. A systematic measurement error affects the level of this interest rate. PEC2 is the β-coefficient of the banking industry.
[b] Mainland-Norway, i.e. excess oil, natural gas and shipping.
[c] NOK mill.

Figure 1-5 show the development over time in some of the variables. We calculate quarterly arithmetic means and split between savings banks and commercial banks. To better see the development over time, we include some years prior to our estimation period. Figure 1 shows that after the banking crisis, both savings banks and commercial banks built up their buffer capital (BUF). Although the buffer capital of savings banks was as high as 8-9 per cent in

1992, banks gradually increased their buffer capital until reaching a top in late 1995. Then the positive trend was reversed, and the buffer capital of savings banks declined steadily until reaching 8-9 per cent again in 2000/2001. Commercial banks started out with a buffer capital of 4 per cent in 1992. The buffer capital was more than doubled through 1993, i.e. in one year only, but then a long period with declining buffer capital started, which brought it down below 3 per cent. A reversion with increasing buffer capital started in late 1997. It is interesting to note that the buffer capital of savings banks in particular seems to follow a systematic seasonal pattern with a peak in the fourth quarter.

Figure 1. *Buffer capital, per cent of risk weighted assets. Quarterly unweighted means*

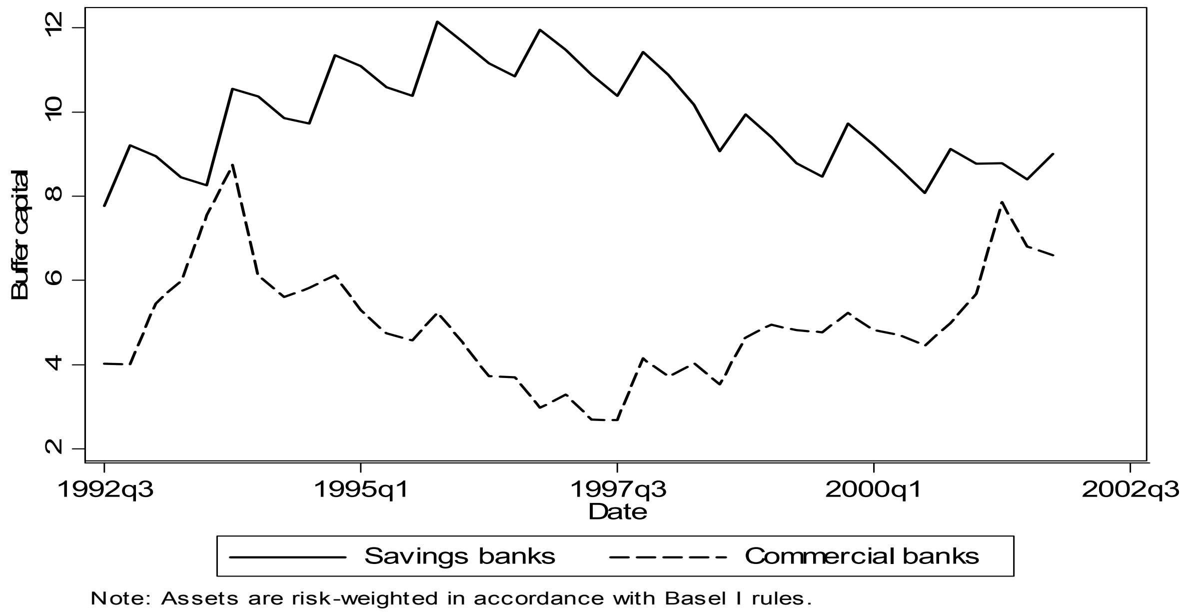


Figure 2 shows the cumulative variance of quarterly profits (VPROF), i.e. the variance of previous profits. The smooth development in the mean of VPROF conceals a more erratic picture at the bank level.

Figure 2. *Cumulative variance of banks' quarterly profits. Quarterly unweighted means, 1992q3=100*

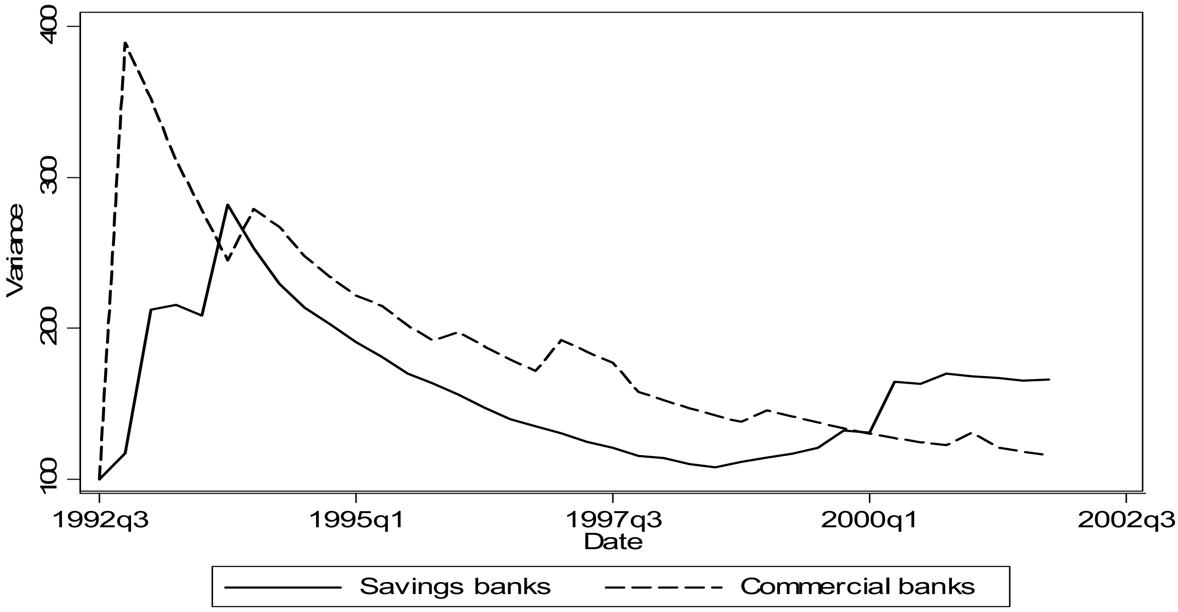


Figure 3. *Risk profile of banks' assets measured by predicted bankruptcy probabilities of limited liability firms with bank loans, in per cent. Quarterly unweighted means*

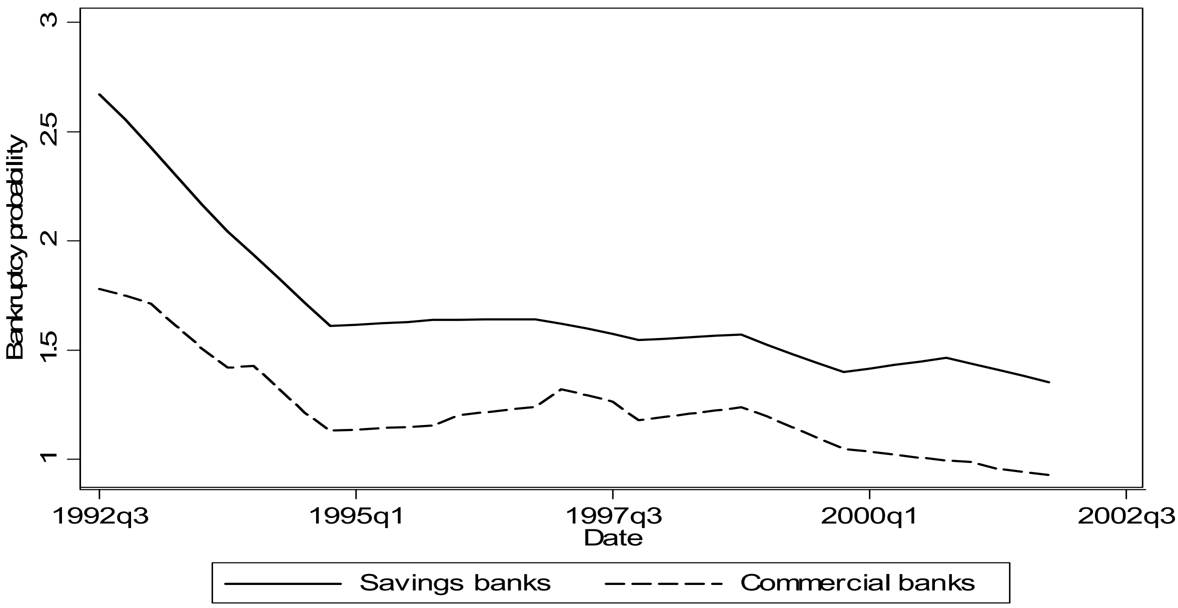
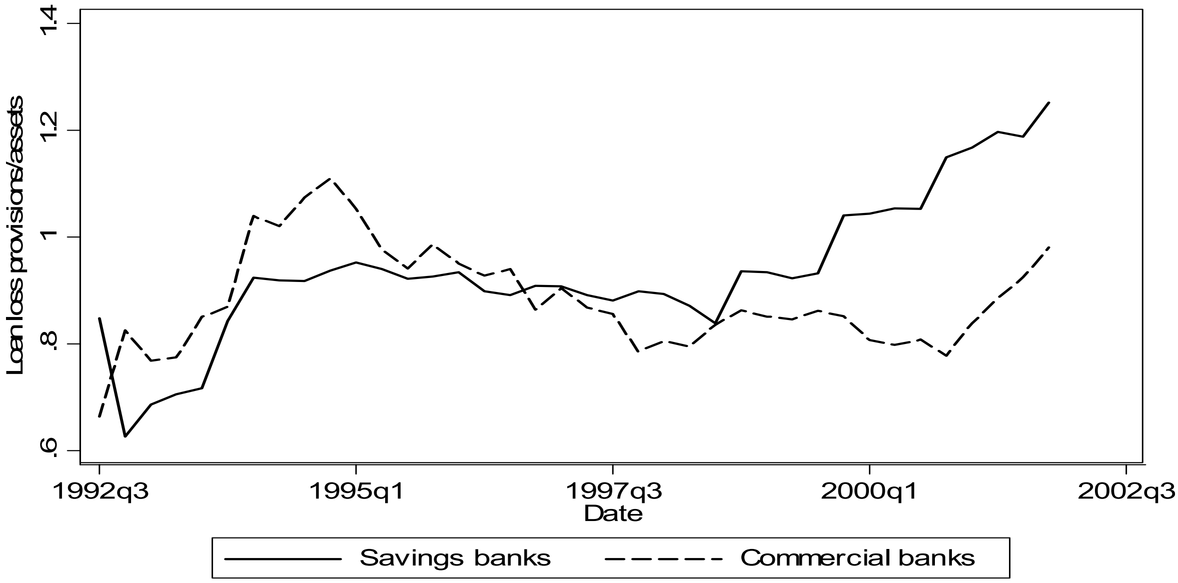


Figure 3 shows the average default probabilities (RISK). The banking crisis in Norway coincided with a downswing in the business cycle, and the fall in the bankruptcy probabilities in 1993/1994 reflects a more positive business climate due to an economic upswing. It is interesting to note that the average bankruptcy probability is higher for savings banks than for commercial banks. This reflects that savings banks in general lend to business sectors and counties with relatively high bankruptcy probabilities, such as the hotel and restaurant sector.

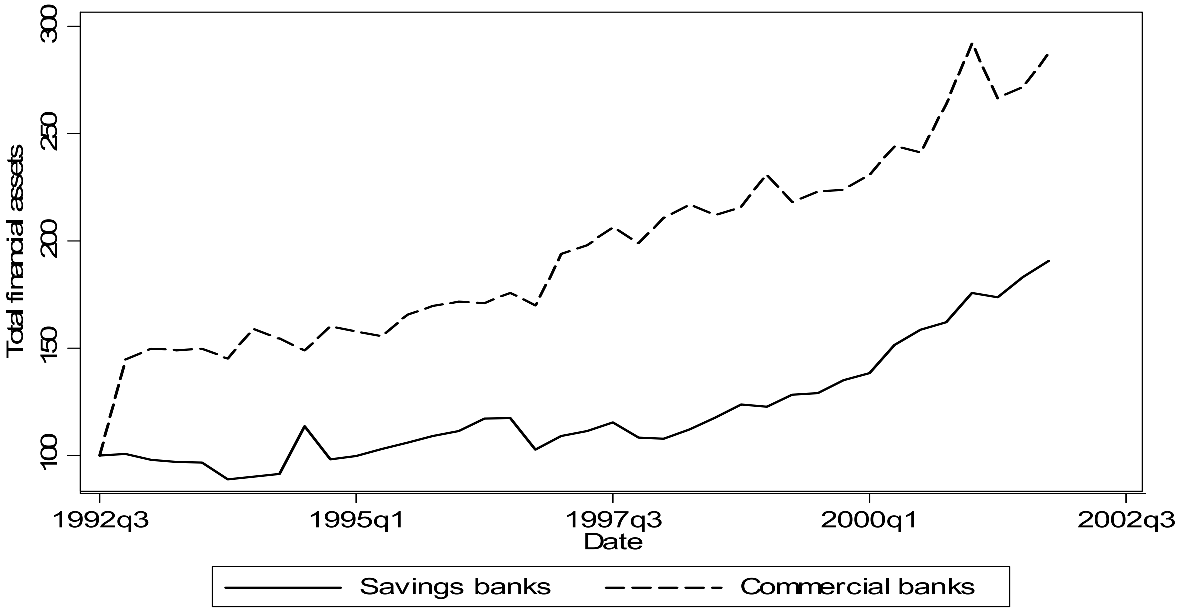
Figure 4 shows that unspecified loan loss provisions measured relative to risk-weighted assets largely follow the same pattern over time for the two groups of banks.

Figure 4. *Unspecified loan loss provisions relative to risk weighted assets, in per cent. Quarterly unweighted means*



Note: Assets are risk-weighted in accordance with Basel I rules.

Figure 5. *Banks' size measured by total financial assets incl. guarantees. Quarterly unweighted means*



From Figure 5 it is clear that, measured by total financial assets incl. guarantees, the average size of both bank types has increased over time. The increase is larger for commercial banks than for savings banks.

Empirical results

We estimate Eq. (1) for savings banks and commercial banks separately assuming random effects. This implies a time-invariant bank specific effect on the level of the buffer capital, while the slope coefficients, i.e. the estimated elasticities, are equal across banks within the two groups but may vary across the two groups. We use the Generalised Least Squares (GLS) Random-Effects Model procedure in STATA 7.0 (StataCorp (2001)). The Breusch and Pagan (1980) Lagrange multiplier test, which tests if the variance of the random component is zero, is applied to test the relevance of the random effects specification. To test the appropriateness of the random effects estimator applied, which assumes that the random effects and the regressors are uncorrelated, we apply the Hausman (1978) specification test. The estimation results for savings and commercial banks are given in Table 2 and Table 3 respectively.

According to the results in Table 2, the hypothesis of "no random effects" is clearly rejected, while the hypothesis of "no correlation between the random effects" in general is not. Model I and II, which both represent our most general model, differ with respect to the information set used, i.e., different empirical proxies for the price variable (PEC) are applied. In Model I, we use the predicted bank specific interest rate on subordinated debt lagged one period (PEC1), while in Model II, and in the remaining models, we use the β-coefficient (PEC2). In general, we do not find significant price effects when applying the first measure, and we therefore concentrate on the results from using the β-coefficient, i.e. PEC2. The poor results when using PEC1 may reflect that the generalisation from the relatively small number of savings banks included in the estimation of the interest rate on subordinated debt is not valid.

Table 2. *Estimation results for savings banks. Endogenous variable is* buf_{it}[a]

Variable	Model I	Model II	Model III	Model IV	Model V
const	1.766	-0.679	-0.038	0.169	0.064
	(2.62)	(-0.88)	(-0.20)	(1.29)	(0.87)
$risk_{it}$	-0.019	-0.037	-0.041		
	(-0.69)	(-1.34)	(-1.51)		
$pec_{i,t-1}$[b]	-0.053	-0.069	-0.066	-0.066	-0.069
	(-0.63)	(-6.71)	(-7.21)	(-7.18)	(-8.11)
$vprof_{i,t-1}$	-0.032	-0.064	-0.064	-0.063	-0.064
	(-2.51)	(-4.99)	(-4.96)	(-4.89)	(-5.02)
$cbuf_{i,t-1}$	0.544	1.075	0.978	0.960	1.000[c]
	(3.63)	(7.33)	(22.81)	(23.28)	
sup_t	0.105	0.032			
	(2.06)	(0.71)			
$gdpg_t$	0.002	-0.055	-0.052	-0.049	-0.063
	(0.08)	(-1.81)	(-1.92)	(-1.83)	(-2.80)
$uslp_{i,t-1}$	0.005	-0.002			
	(1.77)	(-0.60)			
$size_{it}$	-0.052	-0.021	-0.021	-0.020	-0.018
	(-5.29)	(-3.37)	(-3.26)	(-3.18)	(-3.03)
$trend_t$	-0.223	0.091			
	(-1.82)	(0.78)			
Q2	-0.029	-0.056	-0.056	-0.056	-0.057
	(-2.56)	(-4.67)	(-4.69)	(-4.71)	(-4.80)
Q3	-0.063	-0.046	-0.050	-0.051	-0.049
	(-5.12)	(-3.58)	(-4.44)	(-4.51)	(-4.41)
Q4	0.108	0.159	0.150	0.149	0.154
	(6.53)	(8.93)	(12.23)	(12.15)	(14.08)
R^2 : Within	0.263	0.269	0.268	0.267	0.136
Between	0.168	0.110	0.111	0.115	0.113
Overall	0.191	0.137	0.137	0.140	0.114
RE[d]	0.000	0.000	0.000	0.000	0.000
Hausman[e]	0.007	0.209	0.393	0.127	0.461

[a] t-values in parentheses. The number of observations is 3101, and the number of banks is 131.

[b] In Model I, we use the lagged predicted interest rate on subordinated debt which varies both over time and across banks. In Models II-V, we use the β-coefficient which is constant across banks.

[c] Restricted a priori.

[d] Breusch and Pagan (1980) Lagrange multiplier test. H_0 is no random effects. Prob>$\chi^2(1)$ is reported.

[e] Hausman's (1980) specification test. H_0 is zero correlation between the random effects and the explanatory variables. Prob>$\chi^2(5)$ is reported.

Models III-V are reductions of Model II. Although not being significant at the five per cent level in Table 2, the negative coefficient on the credit risk measure (RISK) is a robust result in our data. We therefore conclude that the buffer capital of Norwegian savings banks does not vary systematically – and certainly not positively - with the measure of credit risk. One may therefore expect a shift to a more risk sensitive capital regulation to affect Norwegian banks. As explained earlier, though, when evaluating the relationship between risk and buffer capital more generally, one should also take into account the effect of the variance on past profits (VPROF). Since banks can use retained profits to increase their buffer capital, a high variance implies that this option is highly uncertain. We find a significant negative coefficient on this variable, which means that banks with highly variable profits tend to have less buffer capital. It is therefore tempting to conclude that the buffer capital of Norwegian savings banks is adversely connected to risk. However, this negative relationship does not imply that high-risk banks are poorly capitalised relative to their level of overall risk. It may rather be the case that low-risk banks have "too much" capital, i.e. banks may evaluate and react very differently to risk. (Recall the relatively high average buffer capital of savings banks shown in Figure 1.)

The negative risk effect is consistent with the results in Kim, Kristiansen and Vale (2001). They find a negative relationship between the buffer capital and interest rate margins. If interest rate margins reflect, i.e. increase with, risk, their results imply that the buffer capital is negatively related to risk – as evaluated by the banks. Ayuso et al. (2002) also find a negative relationship between the capital buffer and their risk measure. However, they argue that a negative sign was expected, because their risk measure is interpreted as an ex post measurement of risk assumed by the individual institution.

For Models II-V we find a significant negative price effect (PEC). Hence, we find support for the insurance explanation for the buffer capital. We find a very strong competition effect, and the elasticity of a bank's buffer capital with respect to an increase in the buffer capital of its competitors (CBUF) is not significantly different from one. This strong market discipline effect supports the hypothesis that excess capital serves as an instrument, which the bank is willing to pay for, in the competition for unsecured deposits and money market funding. The banks probably use excess capital as a signal of its solvency or probability of non-failure to the market.

In general, we do not find a significant effect of supervisory monitoring (SUP) on the buffer capital of savings banks. Hence, for this segment of the banking industry, our results do not support the conclusion in Furfine (2001). The negative relationship between economic growth (DGDP) and buffer capital is consistent with the argument in Berger et al. (1995) that banks hold excess capital to be able to exploit unexpected investment opportunities. However, this is not a very strong conclusion, since the buffer capital may vary systematically with growth due to changes in banks' capital rather than assets. We do not find a significant effect of unspecified loan-losses provisions (USLP) on the buffer capital of savings banks.

We find, however, a clear negative size (SIZE) effect, which, as explained earlier, may be due to several factors. A higher level of monitoring and screening in large banks due to scale economies in these activities may reduce the need for buffer capital as an insurance. The negative size effect may also come from a diversification effect not captured by the measure of credit risk (RISK). A third explanation is related to the too-big-to-fail hypothesis. The estimated Models II-V do not include a significant trend effect. We find, however, systematic seasonal variation in the buffer capital, as suggested by the significant coefficients of the quarterly dummy-variables (Q2-Q4). The estimated quarterly effects imply that banks scale down their buffer capital over the three first quarters of the year. The explanation to this pattern is that savings banks use retained profits to adjust their capital, and this is basically done in the fourth quarter when the financial statement is revised. According to the estimated model, the buffer capital increases by more than 1½ percentage point from the third to the fourth quarter.

The results for commercial banks are less clear cut. We use a general to specific modelling strategy, and, to some degree, the reduced model depends on the route taken in the reduction process. Less robust conclusions for the commercial banks than for the savings banks are probably due to the much smaller cross-sectional dimension of the sub-sample with commercial banks. One may therefore argue in favour of a combined regression, i.e. a regression based on all data for both groups of banks. However, because savings banks dominate in the combined regression, these results are very close to those given in Table 2.

In Table 3, we summarize the main differences across competing models for commercial banks. Again, we find that the hypothesis of "no random effects" is clearly rejected, while the hypothesis of "no correlation between the random effects" in general is not. As in Table 2, Model I and Model II correspond to our most general model, but they differ with respect to the price variable applied. In contrast to savings banks, we generally find a positive price effect for commercial banks. This probably reflects some incidental co-movement of the data.

According to the estimated interest rate equations (see the Appendix), the interest rate on subordinated debt largely follows the risk-free interest rate, i.e. the interest rate on 10-year government bonds. The buffer capital of commercial banks and this risk-free interest rate happens to follow a very similar pattern over our estimation period, and this explains the positive price elasticity.

To avoid the problem described above, we exclude the price variables from our model. The results from this strategy are given in Models III-V. In Model III, an attempt is made to include price effects without including a price variable that largely follows the same trend as the risk-free interest rate. We estimate the model for the buffer capital including the bank specific explanatory variables of the interest rate equation, i.e. we include a variable that measures the four-quarter average of losses relative to assets (LOSSASS). The second bank specific variable, i.e. size, is already included in the model. Again, we find a positive relationship between the buffer capital and the variable intended to represent the price. This result may help us understand the mechanisms driving the buffer capital of commercial banks, however. The positive relationship between previous losses to assets and the buffer capital suggests that commercial banks put much effort into rebuilding the buffer capital after a period of losses independent of price. Remember that commercial banks in general have a much smaller buffer capital than savings banks. Although we do not find a negative price effect or a positive effect of the variability in profits, the positive losses-to-assets effect may represent both an insurance effect and a market discipline effect. We conclude that commercial banks seem to follow a very simple insurance rule, i.e., conditional on variables in the model which represent other explanations and motivations for why banks hold capital buffers, banks tend to keep a relatively stable capital buffer and rebuild this buffer when experiencing losses.

In contrast to the results for the savings banks, Table 3 shows that for commercial banks we have a robust positive effect of supervisory scrutiny (SUP) on the buffer capital. Hence, an increase in the activity by the supervisory authorities, i.e. an increase in the number of on-site inspections, increases the buffer capital of commercial banks. Although not always significant, we generally find a negative GDP-growth effect. With the same reservation as for the savings banks, one may argue that this supports the hypothesis that banks hold excess capital to exploit unexpected investment opportunities. The negative third quarter (Q3) seasonal effect is very robust.

Table 3. *Estimation results for commercial banks. Endogenous variable is* buf_{it}[a]

Variable	Model I	Model II	Model III	Model IV	Model V
const	0.429	-4.028	1.027	-4.895	-2.182
	(0.16)	(-2.96)	(1.03)	(-4.47)	(-1.56)
$risk_{it}$	0.228	-0.033			-0.723
	(0.80)	(-0.16)			(-3.65)
$pec_{i,t-1}$[b]	1.181	0.048			
	(2.12)	(0.75)			
$vprof_{i,t-1}$	-0.026	-0.050			
	(-0.68)	(-1.30)			
$cbuf_{i,t-1}$	0.004	-0.007			
	(0.12)	(-0.21)			
sup_t	0.926	0.966	0.765	0.970	0.858
	(2.32)	(2.56)	(2.20)	(3.09)	(2.17)
$gdpg_t$	-0.095	-0.206	-0.327		
	(-0.47)	(-1.10)	(-1.81)		
$uslp_{i,t-1}$	-0.162	-0.167		0.171	
	(-8.42)	(-8.57)		(8.90)	
$size_{it}$	-0.029	-0.020	-0.089		-0.116
	(-1.03)	(-0.81)	(-2.55)		(-2.57)
$trend_t$	1.042	0.638		0.719	
	(3.12)	(2.18)		(3.51)	
$lossass_{i,t-1}$			0.065		
			(1.81)		
Q2	-0.045	-0.039			
	(-0.56)	(-0.45)			
Q3	-0.231	-0.170	-0.158	-0.151	
	(-2.62)	(-2.05)	(-2.25)	(-2.38)	
Q4	-0.031	0.013			
	(-0.37)	(0.16)			
R^2 : Within	0.355	0.312	0.067	0.306	0.106
Between	0.229	0.226	0.276	0.130	0.268
Overall	0.249	0.257	0.204	0.147	0.125
RE[c]	0.000	0.000	0.000	0.000	0.000
Hausman[d]	0.969	0.278	0.108	0.300	0.130

[a] t-values in parentheses. The number of observations is 300, and the number of banks is 16.

[b] In Model I, we use the lagged predicted interest rate on subordinated debt which varies both over time and across banks. In Model II, we use the β-coefficient which is constant across banks.

[c] Breusch and Pagan (1980) Lagrange multiplier test. H_0 is no random effects. Prob>$\chi^2(1)$ is reported.

[d] Hausman's (1980) specification test. H_0 is zero correlation between the random effects and the explanatory variables. Prob>$\chi^2(5)$ is reported.

For the other explanatory variables in Model III-V the sign is generally robust across different specifications, but the significance of each variable depends on the vector of explanatory variables included. We generally find a negative credit risk (RISK) effect, and although not significant in all alternative specifications, we conclude that the buffer capital of commercial banks does not increase with credit risk. Hence, banks with a higher credit risk probably run a higher risk of approaching or falling bellow the minimum capital requirement than banks with a low credit risk. We generally find a negative relationship between buffer capital and unspecified loan loss provisions (USLP), which suggests that commercial banks may use unspecified loan loss provisioning as an alternative to building up buffer capital. If a bank sees problems ahead, by increasing unspecified loan loss provisions rather than the buffer capital, it is less likely to be criticised by the shareholders for not increasing its lending. As for savings banks, we find a negative size (SIZE) effect for commercial banks. The trend (TREND) effect is generally positive, i.e., there is a positive trend in the buffer capital of commercial banks that cannot be explained by the other variables included in the model.

4. Conclusions

Using unbalanced bank-level panel data for Norway, we estimate a model for banks' buffer capital. Buffer capital is defined as the ratio of excess capital to risk-weighted assets. We focus on the following issues: i) Whether excess capital depends on the risk profile of the banks' portfolios with focus on credit risk, ii) Whether excess capital acts as an insurance against falling below the regulatory minimum capital-ratio, iii) Whether banks use excess capital as a signal, i.e. a competition parameter, and relative capital buffers matter, iv) Whether a supervisory discipline effect is present, and v) Whether the buffer capital depends on economic growth.

We estimate the model separately on two sub-groups of the banks, i.e. on savings banks and commercial banks. The motivation for this split is that they probably behave differently, and the level of the buffer capital is in general much higher for savings banks than for commercial banks.

The results for savings banks suggest that there is a negative relationship between their buffer capital and risk. The effect of credit risk is not significant, but we find a significant negative effect of the variance of previous profits, which is interpreted as a broad risk measure. This is a rather thought-provoking result. However, it does not necessarily imply that high-risk banks are poorly capitalised, and may rather reflect that low-risk banks have “too much” capital. It is interesting that banks seem to evaluate and react differently to risk. We find a negative price effect on the buffer capital for savings banks, which supports the hypothesis that banks use buffer capital as an insurance against costs related to market discipline and supervisory intervention if they approach or fall below the regulatory minimum capital-ratio. Furthermore, an elasticity of approximately one on the buffer capital of competitors supports the assumption that banks use the buffer capital as a signal to the market of solvency and probability of non-failure. With the reservation that banks may adjust their capital rather than their assets, a negative relationship between the buffer capital and growth is consistent with the assumption that banks hold excess capital to exploit unexpected investment opportunities. There is a systematic variation in the buffer capital with bank size, and large banks tend to hold a smaller buffer than small banks.

For commercial banks, the results are less clear-cut and robust, which is probably due to the much smaller cross-sectional dimension of this sub-sample. Irrespective of the choice of empirical proxy, we generally find a positive price elasticity for commercial banks. This is probably due to incidental co-movement of the data along the time dimension, and we therefore exclude the price variables from the model, implicitly assuming no price effects on the buffer capital of commercial banks. Although not always significant, we generally find a negative credit-risk effect. As for savings banks, we therefore conclude that the buffer capital of commercial banks does not increase with credit risk. Hence, the introduction of Basel II is likely to affect both savings and commercial banks. We find evidence of a supervisory discipline effect, and increased monitoring by the supervisory authorities increases the buffer capital of commercial banks. Although not always significant, we generally find a negative GDP-growth effect and a negative size effect, as we also found for savings banks. For both groups of banks we find that the buffer capital follows a systematic seasonal pattern, and supervisory authorities should concentrate not only on quarter to quarter changes in capital ratios but also on year to year changes. A negative relationship between buffer capital and unspecified loan loss provisions suggests that commercial banks use unspecified loan loss provisioning as an alternative to building up buffer capital. Our interpretation of the positive relationship between previous losses to assets and the buffer capital is that commercial banks put much effort into rebuilding the buffer capital after a period of losses. Commercial banks seem to follow a relatively simple insurance rule, i.e., conditional on variables in the model which represent other explanations and motivations for why banks hold capital buffers, banks tend to keep a relatively stable capital buffer and rebuild this buffer when experiencing losses.

Although we find interesting similarities, there are important differences with respect to the behaviour of the buffer capital across the two groups of banks. This supports the chosen strategy to analyse savings banks and commercial banks separately. More analyses are needed, however, to understand better how banks evaluate risk and adjust to risk more generally.

Appendix

The empirical variables

BUF is the capital buffer measured as the "excess-capital to risk-weighted assets" ratio. Capital and risk-weighted assets are calculated in accordance with Basel I.

RISK represents the 'risk profile' of banks' assets. We measure this as the bank-specific bankruptcy probability of limited liability firms with bank loans. In the calculations, firms are weighed in accordance to the volume of their bank loans. Hence, this risk measure reflects that loss given default varies across firms. We have access to predicted bankruptcy probabilities of all limited liability firms in Norway from a bankruptcy prediction model developed at Norges Bank, see Bernhardsen (2001). In addition, we have the volume of bank loans of each firm. We cannot match these firm data directly with the banks, however, since we do not have information on the borrower-lender identity. To overcome this shortcoming of the data, we calculate industry and county specific bankruptcy probabilities as weighted averages across firms with bank loans in each county and industry. The volume of bank loans of each firm is used as weights. (The county×industry matrix has dimension 19×58.) By matching available information on industry and county for each loan in banks' portfolios and the industry- and county-specific bankruptcy probabilities, we are able to calculate bank-specific bankruptcy probabilities. Since firm-specific bankruptcy probabilities are calculated using annual account data, we define this as the fourth quarter bankruptcy probability and interpolate linearly between these observations.[8]

PEC is the price of excess capital. This price is not observable, and we apply two alternative empirical proxies. The true price of excess capital is likely to vary across banks, and an attempt is made to calculate bank-specific prices. (An alternative to the proxies applied in this paper is to calculate the market value of banks' equity as suggested in Hughes, Mester and Moon (2001).)

PEC1: The predicted interest rate on subordinated debt. In our data, we have access to the implicit interest rate that banks pay on subordinated debt. The nominator and denominator are not fully consistent, however, resulting in a systematic measurement error that affects the

[8] The bank-specific bankruptcy probabilities are provided to us by Olga Andreeva, see Andreeva (2003) for more details.

level of the implicit interest rate. (We have 328 observations on savings banks and 287 observations on commercial banks.) As long as the ratio of subordinated debt to equity is below the maximum ratio defined by the capital regulation, one can argue that this interest rate is a good proxy for the marginal price of excess capital. Using the sub-sample of banks with subordinated debt, we regress this interest rate on variables that reflects (i) the risk-free interest rate, (ii) the banking industry-specific risk premium, and (iii) the bank-specific risk premium. The interest rate equation is given below.

$$PEC1_{it} = \tau_0 + \tau_1\, IGB10_t + \tau_2\, \beta_t + \tau_3\, SIZE_{it} + \tau_4\, LOSSASS_{it} \qquad \text{(A1)}$$

IGB10 is the interest rate on 10-year government bonds and represents the risk-free interest rate; β is the risk premium of investing in the Norwegian banking industry as compared to the Oslo Stock Exchange All Share Index. See PEC2; SIZE and LOSSASS are defined below; SIZE and LOSSASS is assumed to capture the bank-specific risk premium. Our conclusion from this exercise is that the interest rate on subordinated debt depends on the risk-free interest rate, the β-coefficient and bank size. The size effect is negative, implying that small banks pay a higher interest rate than large banks. In addition, for savings banks, the interest rate on subordinated debt depends significantly on the losses-to-capital variable. We use the estimated models for savings banks and commercial banks to predict the interest rate on subordinated debt for all banks in our sample. Finally, these predictions are used as a proxy for the price on excess capital in the regression of the buffer capital. The results from estimating Eq. (A1) are given in Table A1.

Table A1. *Estimation results for the interest rate on subordinated debt. Endogenous variable is $PEC1_{it}$*

	Savings banks		Commercial banks	
Variable	Coefficient	t-value	Coefficient	t-value
Const	0.000[1]		0.000[a]	
$IGB10_t$	0.306	20.20	0.271	15.99
β_t	0.002	1.88	0.002	2.00
$SIZE_{it}$	-4.96e-10	-2.73	-1.70e-10	-3.13
$LOSSASS_{it}$	0.688	2.80	0.000[a]	
DUM92			0.013	5.44
Root MSE	0.007		0.008	

[a] Restriction supported by the data.

PEC2: This is the β-coefficient, calculated in accordance with the Sharpe-Lintner capital asset pricing model (CAPM), as a proxy. See Sharpe (1964) and Lintner (1965). Not all banks are listed on Oslo Børs (Oslo Stock Exchange), however, and the trading in the hybrid capital instrument of savings banks is in general relatively small. We, therefore, calculate the β-coefficient for the Norwegian banking industry and use this common risk premium measure as a proxy for the price on excess capital. We use the following formula to calculate the β-coefficient on a quarterly basis[9]:

$$\beta_t = Cov[R_B , R_M]_t / Var[R_M]_t, \qquad (A2)$$

where R_B is the daily return on the bank index at Oslo Børs and R_M is the daily return on the Oslo Børs All Share Index. Both R_B and R_M are return indices where it is assumed that dividends are reinvested.

VPROF is the variance of each bank's profit calculated on past observations.

CBUF is the competitors' average capital buffer. We split the banks into two groups, i.e. savings banks and commercial bank.

SUP represents supervisory scrutiny. Two alternative measures are applied: (i) SUP(N) is the number of employees at the beginning of each year at the Norwegian Banking, Insurance and Securities Commission (BISC). (ii) SUP(I) is the annual number of on-site inspections by BISC divided by four. The results are robust to the choice of empirical variable, and we present the results with SUP(I) in the paper.

GDPG denotes the four quarter growth rate of Mainland-Norway's gross domestic product, i.e. excluding oil, natural gas and shipping. Measured in per cent.

SIZE is total financial assets incl. guarantees and represents bank size.

USLP is unspecified loan loss provisions relative to risk-weighted assets.

[9] Help from Johannes Skjeltorp with the calculations is highly appreciated.

TREND is a simple deterministic trend variable.

LOSSASS is the previous four quarter moving average of losses relative to capital.

Qj, j=2, 3, 4, are quarterly dummy variables that are one in quarter j and zero elsewhere.

Table A2 and A3 give the correlation matrix of the variables used in the regressions for savings banks and commercial banks respectively. All variables are on logarithmic form. The largest correlation coefficients between the explanatory variables are found for savings banks between size and vprof and cbuf and trend, i.e. between bank size and the variance of cumulative profits and between competitors' average buffer and the trend. In addition, for both bank groups, we find some correlation coefficients in the range 0.4-0.5, which may cause some problems with multicollinearity.

Table A2. *The correlation matrix of the variables used in the regression, savings banks*[a]

	buf_{it}	$pec2_t$	$vprof_{i,t-1}$	$risk_{it}$	$cbuf_{t-1}$	sup_t	$gdpg_t$	$size_{it}$	$uslp_{i,t-1}$	$trend_t$
buf_{it}	1.000									
$Pec2_t$	0.042	1.000								
$vprof_{i,t-1}$	-0.285	-0.016	1.000							
$risk_{it}$	0.160	0.053	-0.161	1.000						
$cbuf_{k,t-1}$	0.178	0.247	-0.003	-0.161	1.000					
sup_t	0.001	-0.038	0.015	-0.007	-0.018	1.000				
$gdpg_t$	0.117	0.123	-0.013	0.084	0.536	-0.208	1.000			
$size_{it}$	-0.357	-0.041	0.810	-0.166	-0.111	0.037	-0.071	1.000		
$uslp_{i,t-1}$	0.011	-0.070	0.158	0.133	-0.174	0.022	-0.100	0.205	1.000	
$trend_t$	-0.187	-0.207	-0.001	-0.198	-0.935	0.039	-0.471	0.118	0.186	1.000

[a] The variables are on logarithmic form. Based on 3101 observations.

Table A3. *The correlation matrix of the variables used in the regression, commercial banks*[a]

	buf_{it}	$pec2_t$	$vprof_{i,t-1}$	$risk_{it}$	$cbuf_{t-1}$	sup_t	$gdpg_t$	$size_{it}$	$uslp_{i,t-1}$	$trend_t$
buf_{it}	1.000									
$Pec2_t$	-0.018	1.000								
$vprof_{i,t-1}$	-0.279	-0.006	1.000							
$risk_{it}$	0.023	0.120	-0.234	1.000						
$cbuf_{k,t-1}$	-0.279	0.265	-0.021	0.097	1.000					
sup_t	0.115	-0.042	-0.023	-0.075	0.466	1.000				
$gdpg_t$	-0.153	0.123	-0.013	0.138	0.007	-0.199	1.000			
$size_{it}$	-0.382	-0.032	0.406	-0.185	0.036	0.026	-0.005	1.000		
$uslp_{i,t-1}$	-0.322	0.058	-0.149	0.330	0.037	-0.041	0.064	0.344	1.000	
$trend_t$	0.248	-0.189	0.032	-0.244	-0.315	-0.005	-0.465	-0.076	-0.067	1.000

[a] The variables are on logarithmic form. Based on 300 observations.

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