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The cyclical behaviour of European bank capital buffers

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We would like to thank Antonello D'Agostino, Ari Hyytinen, Esa Jokivuolle, Juha Kilponen, Jukka Vauhkonen and Matti Virén as well as the audiences of the XXVIII Kansantaloustieteen Päivät 2006 and internal Bank of Finland workshops for their very useful comments and suggestions.

http://www.bof.fi

ISBN 952-462-298-X
ISSN 0785-3572
(print)

ISBN 952-462-299-8
ISSN 1456-6184
(online)

Helsinki 2006

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Discussion Papers 17/2006

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Abstract

Using an unbalanced panel of commercial, savings and co-operative banks for the years 1997 to 2004 we examine the cyclical behaviour of European bank capital buffers. After controlling for other potential determinants of bank capital, we find that capital buffers of the banks in the accession countries (RAM) have a significant positive relationship with the cycle, while for those in the EU15 and the EA and the combined EU25 the relationship is significantly negative. We additionally find fairly slow speeds of adjustment, with around two-thirds of the correction towards desired capital buffers taking place each year. We further distinguish by type and size of bank, and find that capital buffers of commercial and savings banks, and also of a sub-sample of large banks, exhibit negative co-movement. Co-operative banks and smaller banks on the other hand, tend to exhibit positive cyclical co-movement.

Key words: bank capital, bank regulation, business cycle fluctuations

JEL classification numbers: G21, G28

Pankkien pääomapuskureiden suhdannedynamiikka Euroopassa

Suomen Pankin tutkimus
Keskustelualoitteita 17/2006

Terhi Jokipii – Alistair Milne
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tässä työssä tarkastellaan pankkien pääomapuskureiden suhdannedynamiikkaa eurooppalaisten liike-, säästö- ja osuuspankkien muodostamassa ajanjakson 1997–2004 kattavassa vuositason paneeliaineistossa. Kun estimoitavassa mallissa kontrolloidaan muut mahdolliset pankin pääomaa määräävät tekijät, vaihtelevat pankkien pääomapuskureiden määrä estimointitulosten mukaan suhdanteita myötäillen uusissa Euroopan Yhteisön jäsenmaissa. Kaikkien 25 ja 15 vanhemman Euroopan Yhteisön sekä euroalueen jäsenmaat käsittävissä aineistoissa pankkien pääomapuskurien määrä ja suhdannevaihtelut korreloivat negatiivisesti. Pääomapuskureiden sopeutuminen tavoitetasolleen on lisäksi tulosten mukaan suhteellisen hidasta, sillä poikkeamista kaksi kolmasosaa korjaantuu vuoden aikana. Kun pankit luokitellaan tyypin ja koon mukaan, niin tulokset viittaavat siihen, että liike- ja säästöpankkien samoin kuin suurten pankkien pääomapuskurien muutokset ovat erisuuntaisia. Osuuspankkien samoin kuin pienten pankkien pääomapuskurit sen sijaan muuttuvat talouden suhdanteittain samansuuntaisesti.

Avainsanat: pankin oma pääoma, pankkien sääntely, suhdannevaihtelut

JEL-luokittelu: G21, G28

Contents

1 Introduction

Several instruments are used to regulate banking institutions, the most prominent taking the form of the capital requirement regulation. As imposed by the 1988 Basel Capital Accord and its subsequent amendments, the regulation requires that banks hold a minimum amount of capital equal to eight percent of its risk-weighted assets. An updated version of the Capital Accord, Basel II, will come into force in 2007 with the objective of bringing bank capital requirements more in line with actual risks. The move towards increased risk-sensitivity in the bank capital requirements under Basel II, has sparked a debate relating to a 'pro-cyclicality' issue, whereby capital requirements have the potential to amplify the business cycle. There have been widespread concerns that the Basel II regime will raise bank capital requirements in business cycle recessions, hence constraining bank lending and potentially leading to loan foreclosures and falls in loan collateral values.[1]

Much of the work analysing the extent to which the 'pro-cyclicality' issue may arise with the introduction of Basel II, has however failed to consider that most banks hold capital to a large degree in excess of that required by the regulators (see for example Berger and Udell, 1994; Berger, 1995; Kwan and Eisenbeis, 1997; Jackson, 1999; Furfine, 2000). This is clearly apparent in the data we use for this paper. Table 1, discussed in detail in Section 3, highlights the fact that on average, banks operating in Europe hold a capital ratio in the region of three percentage points above that required of them.

Recent empirical literature in this field has hence become concerned with under-standing the determinants of this excess capital under the current accord in an attempt to shed some light on the possible implications of the introduction of the new framework (see Ediz et al, 1998; Rime, 2001; Ayuso et al, 2004; Bikker and Metzemakers, 2004; Estrella, 2004; Lindqvist, 2004; Stoltz and Wedow, 2005). Many of these authors have concentrated on studying bank capitalization within a single country framework, the exception being Bikker and Metzemakers (2004), who perform a cross-country analysis on 29 OECD countries. A further gap in this literature stems from the inability of these studies to uncover significant evidence relating to capital buffer movements between different types or sizes of banks.

[1] See among others BCBS (2001), Borio et al (2001), Daníelsson et al (2001), DNB (2001) and ECB (2001).

Table 1. **Capital buffers by country (weighted by total assets)**

	1997	1998	1999	2000	2001	2002	2003	2004	avg
AT	0.72	2.09	2.09	1.96	2.89	2.63	3.08	3.10	2.32
BE	3.43	3.45	4.37	5.75	5.31	5.06	4.66	4.45	4.56
FI	4.03	2.49	4.01	1.38	1.68	2.53	10.97	11.20	4.79
FR	2.24	2.31	2.13	1.80	1.78	1.67	1.84	1.49	1.91
DE	1.96	1.89	2.46	3.00	2.79	2.85	4.41	4.37	2.97
GR	1.73	1.67	6.21	4.51	2.83	2.24	3.42	4.57	3.40
IE	3.02	3.54	3.23	3.05	3.05	4.95	6.82	5.54	4.15
IT	1.49	1.81	1.46	1.61	1.34	2.32	2.42	2.87	1.92
LU	4.87	4.07	4.26	4.07	3.94	3.75	4.88	2.47	4.04
NL	2.96	2.84	2.71	2.69	2.80	3.23	3.56	3.50	3.04
PT	2.66	1.86	2.35	0.98	1.23	1.62	2.04	2.21	1.87
ES	1.93	2.75	2.39	2.50	3.20	2.82	2.63	2.51	2.59
DK	2.29	2.22	2.62	1.75	2.24	2.43	2.79	2.23	2.32
SE	2.55	2.73	3.23	2.46	2.70	2.29	2.53	2.68	2.65
UK	1.70	1.47	1.89	2.37	1.50	0.96	0.92	0.85	1.46
CY	2.13	1.34	3.94	4.63	3.24	1.52	1.48	2.83	2.64
CZ	2.09	3.79	4.81	6.13	4.03	3.94	4.43	2.74	4.00
EE	3.23	8.57	10.55	7.53	6.84	6.55	5.18	4.01	6.56
HU	4.51	4.73	7.32	6.88	3.27	4.68	2.27	1.96	4.45
LAT	8.10	1.60	4.78	3.00	2.74	2.42	2.33	4.14	3.64
LIT	2.23	15.40	3.12	3.79	4.49	4.81	1.97	2.28	4.76
MAL	6.57	8.46	8.06	8.27	6.65	7.19	7.71	3.01	6.99
PL	2.32	2.18	4.84	5.36	6.33	5.67	5.76	7.67	5.02
SLK						5.36	10.14	12.05	9.18
SLV	8.06	6.10	5.49	6.71	6.03	8.09	6.29	6.04	6.60
EU25	3.20	3.72	4.10	3.84	3.45	3.66	4.18	4.03	3.77
EU15	2.51	2.48	3.03	2.66	2.62	2.76	3.80	3.60	2.93
EA	2.59	2.56	3.14	2.77	2.74	2.97	4.23	4.02	3.13
DK-SE-UK	2.18	2.14	2.58	2.19	2.15	1.90	2.08	1.92	2.14
RAM	4.36	5.80	5.88	5.81	4.85	5.02	4.75	4.67	5.14

Note: AT = Austria, BE = Belgium, DE = Germany, ES = Spain, FI = Finland, FR = France, GR = Greece, IE = Ireland, IT = Italy, LU = Luxembourg, NL = Netherlands, PT = Portugal, DK = Denmark, SE = Sweden, UK = United Kingdom, CY = Cyprus, CZ = Czech Republic, EE = Estonia, HU = Hungary, LAT = Latvia, LIT = Lithuania, MAL = Malta, PL = Poland, SK = Slovakia, SL =Slovenia.
* denotes figures equal to the un-weighted average of composite countries.

Ayuso et al (2004) concentrate on a panel of Spanish savings and commercial banks, finding a robustly significant negative relationship between the cycle and the buffer. This negative relationship justifies the concerns raised relating to the possibility of increased pro-cyclicality under the new Accord since banks don't appear to be accounting for mitigating risks during an economic upturn, building up capital buffers when it is cheaper and easier to do so. Lindqvist, (2004) estimates a similar model for Norwegian savings and commercial banks and find a similar negative effect. Bikker and Metzemakers (2004), analyse the buffer-cycle relationship for a set of OECD countries. Their analysis focuses on commercial banks only and uncovers a similar negative relationship. In their study on the buffer movements of German savings and co-operative banks over the cycle, Stoltz and Wedow (2005) separate their sample by type of bank. They find a similar negative effect to other authors in this field, but discover that the fluctuations appear to be stronger for savings banks than they are for commercial banks.

In this paper, we define the capital buffer as the amount of capital banks hold in excess of that required of them by the national regulator and examine the degree to which co-movement exists between the buffer and the cycle. We split the banks in our sample by countries – so as to obtain EU25, EU15, EA, Denmark, Sweden and the United Kingdom (DK-SE-UK) and RAM (countries that joined the EU in May 2004) sub-samples – and by bank type and size – to investigate differences in the buffer-cycle relationship.

Our estimation results reveal substantial differences in capital buffer behaviour in the various sub-groups. We find that capital buffers of RAM banks appear to move together with the business cycle while the buffers of banks operative in the EU25, EU15, DK-SE-UK and EA samples rather exhibit negative co-movement. Breaking the sample down further by size and type of bank, we find additional distinctions. Here, capital buffers of commercial and savings banks, as well as those of larger banks appear to have a negative relationship with the cycle while those of co-operative banks and of smaller banks move together with the cycle. On the other hand, in almost all cases, we find a fairly slow speed of adjustment towards desired capital buffers.

The remainder of the paper is organized as follows. Section 2 gives a short overview of bank regulation. Section 3 discusses the motivation for holding excess capital, sets out the hypotheses we test, and describes our data including the various controls we introduce for the non-cyclical determinants of bank capital. Section 4 presents our specification and empirical results together with some robustness checks. Finally, section 5 concludes.

2 Bank regulation

The combination of the potential instability of banking institutions, their complex nter-connections, and their important facilitating role in the economy justifies the detailed regulation of the banking sector. Various different instruments have been adopted for the regulation of the banking sector, including: the government safety net, restrictions on asset holdings, capital requirements, chartering and bank examination, disclosure requirements, consumer protection and various remedies to promote competition (Greenbaum and Thakor, 1995; Freixas and Rochet, 1997; Mishkin, 2000).

Capital regulation is one of the key regulatory instruments, aimed at providing both a ‘buffer’ during adverse economic conditions, as well as a mechanism aimed at preventing excessive risk taking ex ante (Rochet, 1992; Dewatripont and Tirole, 1993). Borrowings (including deposits) generate contractual liabilities, which, if not paid when due, can result in bank failure. Thus the greater the proportion of a bank’s operations that are financed with capital funds contributed by its owners, the higher the chance that the bank will continue to be able to pay its obligations during periods of economic adversity.

Moreover, in a largely leveraged firm, owners are able to reap the gains of success while shifting losses to the lenders via limited liability. Consequently, incentives for risk taking are significantly increased.[2] Since banks often times have capital structures with substantial amounts of debt, the possibility of such risk shifting behaviour in this sector is particularly problematic. Incentives for such bank moral hazard are exacerbated by the bank safety net, since depositors and debt-holders who believe that they will be supported, have relatively little incentive to monitor bank portfolio risks.

Current capital regulation, as implemented by the Basel Accord of 1988, applies to all internationally active banks. Over 100 countries to date have adopted the rules, most of which additionally require locally active banks to adhere to them. The capital adequacy ratio is set equal to eight percent of the banks’ risk weighted assets, and acts as an indicator of the banks’ ability to absorb losses. The numerator of the ratio comprises total capital which is a combination of tier one and tier two capital. Tier one capital refers to the banks core capital, including equity and disclosed reserves and can absorb losses without a bank being required to cease trading. The ratio of the banks’ tier one capital to risk-weighted assets should be no less than four percent. Tier two capital on the other hand, relates to secondary bank capital, and includes items such as undisclosed reserves, general loss reserves and subordinated term debt. Tier two capital can

[2] For a more detailed discussion of the risk shifting phenomenon in banking and the role of capital requirement regulation in mitigating this, see; Milgrom and Roberts 1992; Greenbaum and Thakor, 1995 and Keeley, 1990.

absorb losses in the event of a winding-up and so provides a lesser degree of protection for depositors. The denominator of the ratio is obtained by multiplying assets by a pre-defined weighting coefficient.[3]

The capital regulation rules, as outlined above, are a minimum to be implemented by the individual supervisory authorities with the aim of creating a level playing field for market operatives, as well as for ensuring a sound and stable financial environment. Several of the supervisory authorities acting in the countries within our sample have, for various reasons, either set capital ratios above those recommended by the Accord, or, alternatively, supplemented the rules with a range of additional requirements. Table 2 presents the implementation of the minimum capital requirements adopted by the national regulators of the countries in our sample. Further individual country measures are outlined in Annex 1.

Table 2. **National Tier 2 capital Requirements**

Countries applying ratio above 8%			
	minimum required ratio	year of implementation	reason
UK	9%*	1979	
CY	8%	1997	
	10%	2001	changes in market structure
CZ	8%	1992	
EE	10%	1997	rapid growth of bank assets and a change in operating environment
HU	8%	1991	
LAT	10%	1997	
	8%	2004	
LIT	10%	1997	
	8%	2005	
MAL	8%	1994	
PL	8%	1992	
SK	8%	1997	
SL	8%	2002	

Note: *As explained in Appendix I, the FSA sets additional 'trigger' and 'higher target' ratios for UK banks resulting in higher levels of capital required by the regulators. For this reason in the study we apply a 9% requirement to UK banks active in the sample and calculate the buffer as capital above this level.
AT = Austria, BE = Belgium, DE = Germany, ES = Spain, FI = Finland, FR = France, GR = Greece, IE = Ireland, IT = Italy, LU = Luxembourg, NL = Netherlands, PT = Portugal, DK = Denmark, SE = Sweden, UK = United Kingdom, CY = Cyprus, CZ = Czech Republic, EE = Estonia, HU = Hungary, LAT = Latvia, LIT = Lithuania, MAL = Malta, PL = Poland, SK = Slovakia, SL = Slovenia.

[3] Under the Basel I Accord, four risk buckets are set: 0 per cent for claims on central governments; 20 per cent for claims on other banks; 50 per cent for loans secured by residential property and 100 per cent for claims on private sector. Further risk-weights are applied to off-balance sheet exposures.

Since its implementation in 1988, The Basel Accord has helped to strengthen the soundness and the stability of the international banking system as a result of the higher capital ratios that it required. The revised version of the Capital Regulations (Basel II), to be implemented by 2007, aims to bring the framework more in line with modern banking by becoming more risk-sensitive and representative of current risk management practices. There are several components to the new framework. First, it is more sensitive to the risks that firms face: the new framework includes an explicit measure for operational risk and additionally updates the existing weightings that exist against credit risk. Under the standardised approach, banks will be permitted to make use of external ratings by acknowledged ratings agencies; introducing differing weight coefficients for counterparties distinct from the set risk buckets defined under Basel I. Risk coefficients for enterprises under Basel II, will range between 20 and 150 percent depending on the risk involved.

The Accord further reflects improvements in firms' risk management practices, for example by the introduction of the internal ratings based approach (IRB) for credit risk. The IRB approach will allow firms to rely, to a certain extent, on their own internal estimations of default probabilities and of loss given default. Risk coefficients here have the potential to be even more risk sensitive than under the standardized approach, with coefficients ranging between 3 and 600 percent, depending on the perceived riskiness of the counterparty (BIS, 2002).

Much of the debate surrounding Basel II has focused on the potential cyclicality effects that could arise from the adoption of the new framework. Since one of the primary aims of the new Accord is to create a closer link between capital requirements and risks, it is clear that these requirements will subsequently become more dependent on the business cycle. In a cyclical downturn, when counterparties are more likely to be downgraded than upgraded, the resultant effect under the standardized approach could be a significant increase in the capital requirements to account for increased counterparty risk. Similarly, during an economic upturn, when rating agencies are likely to increase the number of upgrades made, the amount of capital required would be reduced. Since raising capital is costly, especially during an economic recession when profits are decreasing, banks might be forced to reduce their loan portfolio in a recession, so as to meet rising capital requirements. The subsequent credit squeeze would add to the downturn and further accentuate the cycle, creating an undesired effect on bank stability. Thus the management of bank capital buffers that we examine in the present paper becomes a critical determinant of the impact of bank capital regulation.

3 Hypotheses and data description

As our Table 1 indicates, banks hold far more prudential capital than that required by the regulators.[4] Capital buffers of banks within the EU15 vary from 1.87 per cent of risk-weighted assets in Portugal to 4.79 per cent in Finland with an average across the EU15 of 2.93 per cent. Buffers are also substantial in the accession countries where they range between 2.64 per cent in Cyprus and 6.99 in Malta. The average buffer for the RAMs is around 5.14 per cent which is considerably larger than for the other sub-samples.

Several reasons have been put forward to explain why banks hold excess capital (see for example Marcus, 1984; Berger et al, 1995; Jackson, 1999; Milne and Whalley, 2001; Milne, 2004). Banks generally will tend to assess their risks differently, for instance via the use of internal economic capital models. Appropriate bank-specific capital levels will therefore be set according to varying assumptions and levels of assumed risk appetites. Alternatively, banks may choose to hold excess capital in order to signal soundness to the market as a means to obtain funds quickly and at a lower rate of interest in the event of unexpected profitable investment opportunities.

Buffer capital can further act as a cushion, absorbing costly unexpected shocks, particularly if the financial distress costs from low capital, and the costs of accessing new capital quickly, are high. Furthermore, banks may hold capital as a security against the violation of the regulatory minimum (Marcus, 1984; Milne and Whalley, 2001; Milne, 2004). By holding capital as a buffer, banks' essentially insure themselves against costs related to market discipline or supervisory intervention in the event of a violation of the requirements. Finally buffer capital may be held in order to take advantage of future 'growth opportunities'. In the event of a substantial increase in loan demand banks with relatively little capital may lose market share to those that are well capitalised.

In all these explanations buffers of prudential capital provide a cushion for absorbing shocks. For banks, the main source of such shocks relate to credit risk, principally uncertainty about borrowers ability to repay loans. The term credit risk covers both expected as well as unexpected losses. 'Expected losses' relate to the average anticipated loss likely to be incurred over a period, while 'unexpected losses' describes the distribution of losses around their expected level. The evolution of such risks can essentially be thought to be anti-cyclical in nature since during an economic downturn (upturn) the probability of default increases (decreases) with the increased volatility of asset returns while the expected loss increases (decreases). Similarly, unexpected losses also increase (decrease) during a recessionary (expansionary) period.

[4] Similarly large capital buffers are also held by US and Asian banks. See for example Peura and Jokivuolle (2004) for a tabulation of US capital buffers.

Drawing on this literature, we examine the following null hypothesis:

H_0 Under the Basel I Accord, business cycle fluctuations do not have an impact on the capital buffers of European banks.

This null hypothesis is compared with two alternative hypotheses (H_1):

H_1(a) Banks tend to increase capital relative to regulatory requirements in business cycle expansions and reduce capital in business cycle recessions ie capital buffers exhibits positive co-movement with the business cycle.

H_1(b) Banks tend to reduce capital relative to regulatory requirements in business cycle expansions and increase capital in business cycle recessions ie capital buffers move counter-cyclically.

Both of these alternative hypotheses are consistent with forward looking models of bank capital dynamics. Estrella (2004) examines the relationship between optimal forward looking capital buffers and deterministic cycles of loan losses. He finds that banks, subject to costs of capital adjustment, will build up capital buffers in anticipation of loan losses. Since loan losses themselves tend to lag the business cycle, this may mean that actual capital buffers are rising during cyclical downturns, essentially indicating negative cyclical co-movement.

Additionally, banks relying on credit ratings to gain access to capital markets may also need to raise their capital holdings to maintain their ratings during an economic downturn. For both these reasons banks may increase their desired bank capital buffers in economic downturns, hence leading to negative co-movements of capital buffers in relation to the cycle (H_1(a)).

On the other hand, as argued elsewhere in the literature (see among others Rajan, 1994; Borio et al, 2001; Crockett, 2001) risks during upturns may actually increase. During an economic boom, lenders continue to provide large amounts of credit while imbalances that will become responsible for the following recession continue to build up, increasing the possibility of unusually large losses. This rationale explains why desired capital buffers, as well as actual capital buffers, may move together with the cycle. (H_1(b)).

Our alternative hypothesis H_1(b) may also be the consequence of myopic bank behaviour. During an economic upturn, when risks are less likely to materialise and banks can safely hold less capital, they may underestimate risks and as a result expand their loan portfolios. In the subsequent economic downturn when risks materialize, the deficient capital buffers may then be unable to absorb shocks encountered from the possible rise in the number of write-offs and provisions. Banks then may have to resort to reducing their loan portfolio. Such a lack of capital build-up or inability to properly account for risks during and an economic upswing can be considered as short-sighted bank behaviour.

We also need to consider a number of other factors that influence the banks desired level of capital. Different banking institutions manage their capital differently due to their varying institutional characteristics. Differences that exist are largely a result of variations in ownership structures and their access to the capital market. A large body of literature examines the impact of different types of banks may have on the risk profile of institutions (see among others, Saunders et al, 1990; Gorton and Rosen, 1995; Esty, 1997; Salas and Saurina, 2002b).

Bank size could additionally play a role in the management of bank capital. Generally, unexpected losses can be due to purely random shocks or alternatively to 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. 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. This may however be due to a diversification effect as well. The argument here being that portfolio diversification will reduce the probability of experiencing a large drop in the capital ratio, and that diversification generally increases with size. A third argument relates to the 'too big to fail' hypothesis whereby large banks expect support from the government in the event of difficulties, while this is not, to the same degree, expected by small banks. For all these reasons we expect large banks to hold lower capital buffers.

Sample selection

To test our hypotheses we make use of an unbalanced panel data set consisting of eight years of annual bank balance sheet data obtained from the Bureau Van Dyck *Bankscope* database. Our sample includes data for commercial, savings and co-operative banks. In total, 468 banks are included in the sample, made up of 364 EA banks, 427 EU15 banks and 41 banks for the RAMs (the 10 accession countries that joined the European Union in 2005). All 25 European Union countries are represented in the sample.

The largest bank in the samples is *BNP Paribas*, with total assets of around EUR 906 bln at the end of 2004. The smallest bank, *Budapest Bank* in Hungary, has total assets amounting to just around EUR 1.5 million at the end of 2004. The distribution of banks in the sample is presented in Table 3, with the largest number of banks in France (103 banks) and Spain (70 banks) from the EU15 and in Poland (10 banks) for the RAMs. In order to deal with various incidents of large fluctuations in the level of the buffers over time, we cleaned the data by removing outlier observations of change in capital buffer, identified via graphical representation of the sample.[5]

Table 3. **Distribution of the sample**

	commercial banks	co-operative banks	savings banks	big banks (total assets > EUR37 billion in 2004)	small banks (total assets < EUR37 billion in 2004)	total
AT	12	8	6	4	22	26
BE	10		2	2	10	12
ES	23	3	44	8	62	70
FI	4		1	1	4	5
FR	55	42	6	13	90	103
DE	24	8	2	7	27	34
GR	12			1	11	12
IE	11			4	7	11
IT	30	13	11	10	44	54
LU	7			1	6	7
NL	18	1		5	14	19
PT	8	1	2	3	8	11
DK	13		2	5	9	15
SE	3	1	2	5	1	6
UK	41		1	9	33	42
CY	5				5	5
CZ	3				3	3
EE	2				2	2
HU	6				6	6
LAT	4				4	4
LIT	2				2	2
MAL	2				2	2
PL	9		1	5	5	10
SK	2			1	1	2
SLOV	5				5	5
EU25	311	77	80	85	383	468
EU15	271	77	79	79	348	427
EA	214	76	74	59	305	364
DK-SE-UK	57	1	5	20	43	63
RAM	40	0	1	6	35	41

[5] Only cleaned data is presented in the paper.

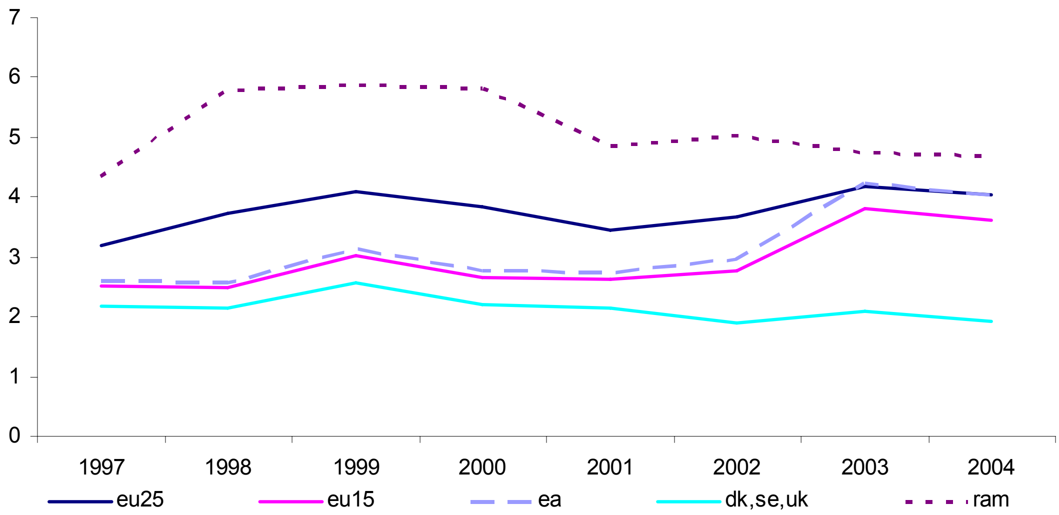
Our sample is further broken down by bank type distinguishing between commercial, co-operative and savings banks. We additionally differentiate between 'small' and 'large' banks by considering the median asset size in 2004 as our cut-off point. Here we consequently regard those banks with total assets over EUR 37 billion in 2004 as large. The sample distribution across countries, by type and size of bank, is presented in Table 3. Here we can see that the RAM sub-sample is essentially made up of small commercial banks, the exception being a single Polish savings bank, *Powszechna Kasa Oszczednosci Bank*. The EU15 and EA sub-samples are comprised of around 65 per cent of commercial banks, 15 per cent co-operative banks and around 20 per cent savings banks. Sweden has the largest percentage of 'large' banks (around 50 per cent), followed by Ireland (around 35 per cent). In the DK-SE-UK sub-sample 19 per cent of banks are 'large', similar to the proportion in the EU15 (16 per cent) and the EA (16 per cent).

Dependent and explanatory variables

Table 1 tabulates average capital buffers in our sample, by time and by country. Here the capital buffer is measured as the risk-weighted tier one capital ratio of the bank less the minimum requirement of the regulators, as summarised in Table 2. The individual country averages are obtained by weighting the buffer by the market share (total assets) of the individual banks. Interestingly, the data highlights several differences that exist in the buffer sizes between countries. Many of the smaller countries such as Finland, Belgium and Ireland have large buffers, in the region of around 4 per cent when compared to banks in larger countries such as France and Italy and the UK, where the buffers are around two percent above the required minimum. The individual country buffers further highlight the fact that RAM banks on average hold around far more capital than banks in the EU15 countries. This becomes more evident when we study the sub-sample averages additionally presented at the bottom of Table 1. The sub-sample figures are calculated as un-weighted averages of the composite countries.

Figure 1 plots the evolution of our individual sub-sample capital buffers over the last eight years. In the EU15 capital buffers rose slightly between 1998 and 1999, but then increased substantially between 2002 and 2003. In the RAM countries capital buffers have behaved very differently, rising steadily from 1997 to 1998 before falling sharply between 2000 and 2001. Thereafter, the RAM buffer level continues on a slight downward trend and by 2004 is at a similar level to the EU15.

Figure 1. **Capital buffer development by sub-sample**



In Figure 2, we plot the evolution of capital buffers over time, for each sub-sample we distinguish between different bank types and bank sizes, and additionally include the aggregate sample output gap. Here we can see distinct differences in the levels of capital held for different banking types for each of the sub-samples. In particular, we see that capital buffers of co-operative banks behave very differently to those of commercial and savings banks. This is unsurprising considering large differences in ownership structure together with the fact that commercial and savings banks are profit maximizing. Moreover, the difficulty that co-operative banks face in increasing their capital base to match growth in business opportunities when compared to commercial and savings banks, can additionally affect the behaviour of their buffers over time.[6] We see that in the EU15, generally small banks tend to hold higher capital buffers than large banks which would be in line with the 'too big to fail hypothesis' as well as with the notion that smaller banks tend to experience greater difficulty in accessing the capital markets.

[6] Co-oparative banks cannot issue new shares and members prefer cash payments over retained earnings because there is no market for their ownership claims.

Figure 2. **Capital buffers by bank type and size (weighted by total assets)**

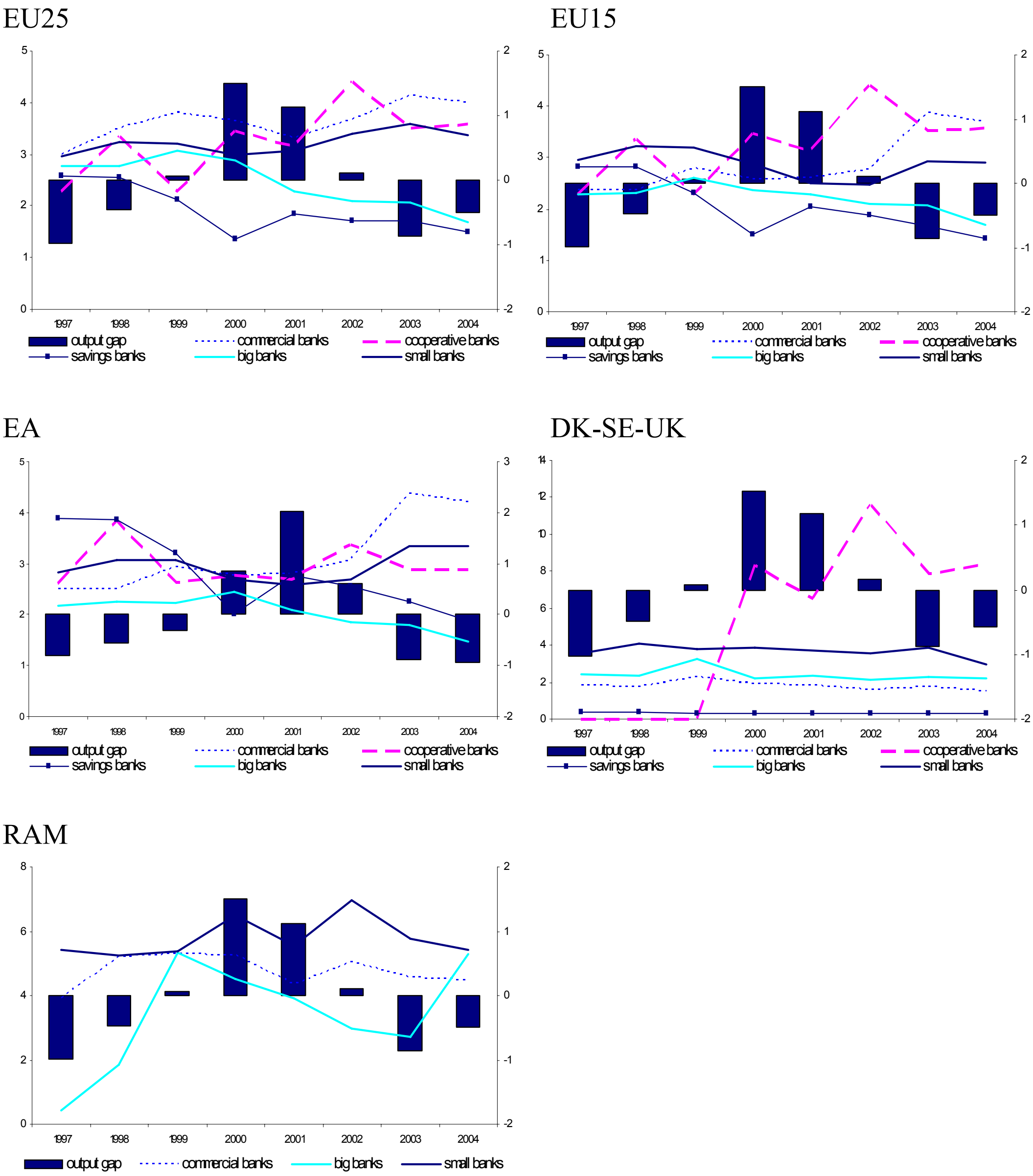


Table 4 provides definitions of the remaining variables used in our estimation. We employ two alternative measures of the business cycle, both constructed using GDP data from *Eurostat* for each of the 25 countries and for the EU25, EU15, EA, DKSEUK, and RAM country groupings. Our preferred cyclical indicator is the output gap, which we obtained by applying the Hoddrick-Prescott filter to the real GDP series. We also investigated the use of the real GDP growth rate as a measure of the business cycle. We report results using cycle variables measured both for individual countries and at a broader country-grouping level. In this paper we present results for the output gap variables only since the estimates using GDP growth differ to only a minor extent. Estimation results with the GDP series are available from the authors on request.

Table 4. **Description of variables adopted**

Variable	Description
Balance sheet variables	
buf	capital ratio-national regulatory minimum as per table 2
roe	return on equity
risk	ratio of non-performing loans to total loans
risk2	loan-loss provisions over total assets
size	log of total assets
profit	post-tax profit over total assets
Δloan	annual loan growth
net loans	loans over total assets
Business and economic cycle variables	
gdp	domestic and sub-sample GDP growth
output gap	HP filtered real GDP series

Our basic specification (model specification 1) includes several additional explanatory variables, in order to control for the various costs that are balanced in a banks capital management decisions: the cost of holding capital, the cost of failure and the cost of capital adjustment. These are the same three costs that appear in the theoretical model of bank capital management provided by Estrella (2004). The first of these costs relates to the *cost of holding capital* which is expected to be proportional to the level of capital of an operating bank. This cost arises because of the greater costs of equity capital funding, relative to deposits or debt. Theoretical analysis (see Myers and Majluf, 1984; Campbell, 1979) suggests that in the context of information asymmetries, equity is a more costly alternative to other bank liabilities. Equity may also be relatively disadvantaged because interest payments on debt are deducted from earnings before tax. We include the banks return on equity (ROE), the ratio of post-tax earnings to book equity, in order to capture the direct costs of remunerating excess capital. We therefore expect to observe a negative relationship between the capital buffer and the ROE variable.

The second cost is the *cost of failure*. Regulators constantly monitor banks' capital ratios C, ensuring that they do not fall below the regulatory minimum C* thus reducing the probability of bankruptcy and the costs associated with failure.[7] Here, when C = C* the bank is faced with the option of recapitalizing or liquidating. Higher levels of capital therefore reduce the risk of non-compliance

[7] So called losses of failure include the loss of charter value, reputational loss, and the legal costs of the bankruptcy process. (see Ancharya, 1996).

and the subsequent costs of failure which are directly proportional to absolute value of the negative net worth of the failing bank (Milne and Whalley, 2001).

The actual cost of failure can be considered as the loss of share value times the probability of failure. Since a banks' probability of failure is dependent on its risk profile, we proxy the cost of failure by adopting various measures of risk. As a first measure, we consider the ratio of non-performing loans to total loans (RISK) as per Ayuso et. al (2002). This is an ex post measure of the risks assumed by banks and is comparable to other measures adopted in the literature since banks with non-performing loans are obliged to make provisions for loan losses. We further include an alternative measure for risk as per Stoltz and Wedow (2005) and Lindquist (2004) whereby we consider the ratio of new net provisions over total assets (RISK2).[8] If banks set their capital in line with the true riskiness of their portfolios, then we would expect the relationship here to be positive.[9]

Size can have a significant impact on a banks' access to capital, and consequent target capital level. Furthermore, the size of a bank may play a role in determining the banks' risk level through its impact on investment opportunities and diversification possibilities. We include a SIZE variable which is proxied by the natural log of total assets. We might expect larger banks to hold smaller capital buffers as per the 'too-big-to-fail' hypothesis since they generally expect to be 'bailed-out' if they are faced with difficulties. Small banks on the other hand, might hold larger buffers due to their relative difficulty to access the capital markets, in which case the SIZE variable acts as a proxy for adjustment costs rather than the cost of failure.

The final costs are the *costs of adjustment of capital*. Considering financing under asymmetric information, costs in this sense are incurred when banks are forced to make use of external funds to add to existing internal capital (see for example Myers and Majluf, 1984). Such a cost mechanism provides motivation for holding higher levels of capital as a way of mitigating costs of remuneration. If the bank lets its internal funds fall too far, it is faced with the choice between cutting highly rewarding investments or incurring high costs of external finance. In order to capture these adjustment costs, we include the lagged dependent variable BUF_{t-1}. We follow Estrella (2004) by assuming the costs of adjusting capital are quadratic. With this specification higher adjustment costs would result in a higher coefficient of the lagged dependent variable, signifying a slower speed of adjustment. We expect the coefficient to be positively signed.

In a further specification (model specification 2) we include some *additional balance sheet variables*, to further control for the determinants of bank capital.

[8] As the results for RISK are broadly in line with those obtained for RISK2, we present only those for RISK2 since more observations are available for this variable.

[9] Banks may vary significantly in their willingness to take risk. This measure therefore can be assumed to uncover information on bank type. Any further idiosyncratic time-invariant component in the banks risk profile would be captured by the μ component of the residual term of Equation 2.

The size of a banks' profit can have an effect on bank capital in either a positive or a negative fashion but are considered an important source of capital financing, affecting the cost of adjustment. Since retained earnings are usually employed as a means to increase the capital cushion, a positive relationship would be evident. High profits on the other hand can similarly reflect high contract values and hence the need to consistently generate high profits. Consequently, capital buffers are increased through retained earnings implying a negative relationship between the buffer and the generation of profits (see Whalley and Milne, 2001). We therefore include post tax profits over total assets a measure of PROFIT with an ambiguous anticipated sign.

Finally, we further include the level of bank loans (NET LOANS) which acts to further reflect the risk profile of the bank since banks themselves could vary their capital buffers according to the risk profile of their loan portfolio. A larger number of loans with respect to total assets are likelier to reflect a riskier profile; the expected sign is therefore positive. We additionally incorporate annual loan growth (ΔLOAN) as a proxy for credit demand (Ayuso et al, 2004). Despite this variable being the interaction between credit supply and demand, it nevertheless serves as a proxy for credit demand since the main potential credit supply constraint (the capital requirements) is not binding in our sample. ie capital buffers are always positive. Moreover, since an increase in loan supply implies an increase in capital requirements, which in a context whereby the adjustment of capital (BUF_{t-1}) is costly, is likely to result in an increase in capital buffers.

4 Specification and estimation results

Building on previous literature (see among others Ayuso et al, 2004; Estrella, 2004), we test the hypotheses detailed in Section 3 through the use of a partial adjustment framework whereby we assume that banks aim to hold their respective optimum capital buffers. The specification takes the following form

$$\Delta BUF_{ijt} = \delta(BUF^{*}_{ijt} - BUF_{ijt-1}) + u_{ijt} \tag{4.1}$$

Here i = 1,2,…,N is an index of countries j = 1,2,…,J_i and index of banks within each country and t = 1,2,…, T_{j_i} is the index of time observation for bank j in country i. u_{ijt} is the error term that can be decomposed as the sum of two components, a random country specific component μ_i, plus a pure bank idiosyncratic component ε_{ijt}.

$BUF_{ijt}(BUF^{*}_{ijt})$ is equal to the (optimum) capital buffer of bank i in country j at time t. The proportionate adjustment towards the desired capital buffer in each period here is captured by δ. If $\delta = 1$, then adjustment is instantaneous while if $\delta = 0$ then there is no adjustment.

BUF^{*}_{ijt} however cannot be observed, and is therefore approximated by a variety of variables that serve to capture the factors affecting the optimal capital structure.[10] The empirical model to be tested therefore becomes

$$BUF_{ijt} = \alpha KK_{ijt} + \gamma KF_{ijt} + (1-\delta)BUF_{ijt-1} + \beta CYCLE_{t} + u_{ijt} \qquad (4.2)$$

Here KK_{it}, KF_{it} and denote the cost of holding capital and the cost of failure as discussed in Section 3. The reported coefficients on the lagged dependent variable are estimates of 1–δ ie the closer the estimated coefficient on the lagged dependent variable is to 0 the faster the speed of adjustment.

Since we estimate dynamic models, including the lagged endogenous variable, we employ the two-step generalized method of moments (GMM) procedure of Arellano and Bond (1991) estimator. The methodology assumes no autocorrelation in the u_{ijt} and uses the entire set of lagged BUF_{it} as instruments. We also include two to four lags of our other principal explanatory variables (RISK and ROE) as instruments in order to avoid correlation with u_{ijt}. The number of instruments chosen in each model was the largest possible, for which the Sargan J-statistic for over-identification restrictions was still satisfied. We additionally apply the Newey-West correction for heteroskedasticity and autocorrelation consistent covariances to further adjust the t-values for additional heteroskedasticity and autocorrelation.

Estimation results for country groups

We estimate two variations of our model. The results are presented in Table 5 for the total EU25 sample and our five sub-sample country groups. Our first model (labelled model specification 1) employs ROE, RISK, and SIZE, as controls for the costs of capital management. Estimation results are presented with both the domestic and the broad cycle (EU25) measures of the output gap.

[10] For a theoretical derivation and explanation of this model, see Ayuso et al 2004 or Estrella, 2004.

Table 5. **Two-step GMM estimates**

	EU25				EU15			
	Model specification 1		Model specification 2		Model specification 1		Model specification 2	
Cycle variable	domestic output gap	EU25 output gap	domestic output gap	EU25 output gap	domestic output gap	EU15 output gap	domestic output gap	EU15 output gap
buf_{t-1}	0.38	0.33	0.41	0.36	0.41	0.38	0.34	0.33
	(3.22)***	(3.49)***	(3.54)***	(4.56)***	(4.91)***	(4.88)***	(4.71)***	(4.81)***
roe	-0.05	-0.05	-0.04	-0.05	-0.06	-0.05	-0.08	-0.07
	(1.79)*	(1.90)*	(1.81)**	(1.31)*	(5.61)***	(5.58)***	(1.36)*	(2.29)**
risk	58.58	50.86	77.85	52.28	38.21	31.14	59.65	56.26
	(3.20)***	(2.50)***	(3.54)***	(3.17)***	(2.62)***	(2.27)***	(3.99)***	(3.54)***
size	-6.67	-6.39	1.31	-0.21	-6.17	-6.25	-0.54	-1.36
	(4.24)***	(3.85)***	(0.66)	(0.13)	(3.72)***	(4.05)***	(0.22)	(0.56)
profit			177.09	165.09			243.18	236.96
			(4.10)***	(3.77)***			(4.64)***	(4.42)***
cycle	-0.74	-0.24	-0.52	-0.28	-0.33	-0.43	-0.26	-0.17
	(4.66)***	(2.01)**	(4.74)***	(2.50)***	(4.86)***	(3.90)***	(3.72)***	(4.62)***
Δloan			-0.03	-0.03			-0.02	-0.01
			(3.25)***	(4.60)***			(2.60)***	(2.30)**
net loans			0.00	0.00			-0.02	-0.04
			(1.72)	(1.45)			(0.92)	(0.46)
Sargan	24.90	25.29	25.19	24.79	22.76	23.52	29.09	27.18
	(0.89)	(0.88)	(0.88)	(0.90)	(0.75)	(0.53)	(0.69)	(0.69)
a(1)	-2.67	-2.22	-2.94	-2.73	-2.08	-2.04	-2.16	-2.18
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
a(2)	-0.85	-0.99	-1.04	-0.17	-1.30	-1.29	-1.25	-1.29
	(0.69)	(0.32)	(0.30)	(0.86)	(0.39)	(0.69)	(0.45)	(0.65)

	EA				DK-SE-UK			
	Model specification 1		Model specification 2		Model specification 1		Model specification 2	
Cycle variable	domestic output gap	EA output gap	domestic output gap	EA output gap	domestic output gap	EU25 output gap	domestic output gap	EU25 output gap
buf_{t-1}	0.47	0.42	0.33	0.31	-0.70	-0.09	-0.13	-0.23
	(4.65)***	(3.93)***	(3.82)***	(3.47)***	(2.59)***	(3.87)***	(5.33)***	(13.55)***
roe	-0.05	-0.05	-0.12	-0.12	-0.04	-0.01	-0.02	-0.08
	(1.62)**	(1.31)*	(1.23)	(1.23)	(1.98)***	(1.14)	(0.82)	(4.92)***
risk	37.38	35.12	78.58	80.37	-60.25	-89.77	-56.37	-67.61
	(2.37)***	(2.17)**	(5.38)***	(5.38)***	(3.41)***	(7.44)***	(3.40)***	(3.34)***
size	-6.11	-6.55	0.59	-0.37	-5.61	-7.06	7.34	8.70
	(3.18)***	(3.41)***	(0.22)	(0.14)	(5.21)***	(7.75)***	(3.77)***	(4.42)***
profit			319.37	323.67			78.38	151.82
			(5.30)***	(5.71)***			(3.30)***	(5.78)***
cycle	-0.25	-0.03	-0.13	-0.06	-0.75	-0.57	-0.77	-0.61
	(3.47)***	(4.21)***	(1.71)***	(3.16)***	(8.61)***	(14.81)***	(11.35)***	(8.99)***
Δloan			-0.02	-0.02			-0.00	-0.08
			(2.19)**	(2.01)**			(3.37)***	(8.28)***
net loans			-0.05	0.07			0.07	0.08
			(0.96)	(1.06)			(2.65)***	(3.45)***
Sargan	24.13	27.58	22.20	23.81	30.38	30.97	24.81	26.57
	(0.64)	(0.23)	(0.58)	(0.61)	(0.87)	(0.42)	(0.36)	(0.64)
a(1)	-2.28	-2.25	-2.12	-2.09	-1.25	-1.29	-0.89	-0.89
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
a(2)	-1.65	-0.80	-1.04	-1.57	-1.29	-1.32	-1.53	-1.57
	(0.56)	(0.45)	(0.67)	(0.56)	(0.26)	(0.71)	(0.82)	(0.75)

	RAM			
	Model specification 1		Model specification 2	
Cycle variable	domestic output gap	EU25 output gap	domestic output gap	EU25 output gap
buf_{t-1}	0.32 (10.90)***	0.34 (16.94)***	0.09 (2.81)***	0.15 (5.99)***
roe	-0.04 (1.33)*	-0.04 (3.38)***	-0.15 (0.52)	-0.01 (0.04)
risk	41.39 (1.38)*	44.39 (1.64)**	107.72 (2.96)***	150.57 (5.17)***
size	-9.34 (12.10)***	-10.45 (9.21)***	11.42 (1.70)*	12.23 (2.31)**
profit			85.44 (3.46)***	131.02 (3.95)***
cycle	0.03 (1.92)**	0.52 (4.65)***	0.12 (2.48)**	0.14 (2.78)***
Δloan			-0.10 (2.76)***	-0.11 (3.69)***
net loans			-0.01 (0.04)	-0.02 (0.37)
Sargan	22.75 (0.65)	20.65 (0.86)	21.09 (0.57)	27.53 (0.78)
a(1)	-1.91 (0.00)	-1.86 (0.28)	-1.78 (0.00)	1.70 (0.00)
a(2)	0.74 (0.65)	-0.98 (0.42)	-0.85 (0.76)	0.86 (0.66)

Note: Dependent variable is BUF_{it}. Other variables as defined in Table 3.
T-values presented in parentheses a(1) and a(2) represent first and second order residual tests.
*, **, *** denote significance at the ten, five and one per cent levels of significance respectively.

For the case of the EU25, EU15, EA and DK-SE-UK samples, we find a negative significant relationship between the capital buffer and each of the output gap variables. These findings support our H_1(a) hypothesis of negative cyclical co-movements in capital. The largest effect is seen for the DK-SE-UK sample, where the capital buffer decreases on average around 0.75 percentage points on a one percentage point rise in the domestic cyclical variable.

These findings are broadly in line with previous literature. Ayuso et al (2004) Lindqvist (2004) and Stoltz and Wedow (2005) find a similar negative relationship between bank buffers and the cycle variables for German, Spanish and Norwegian banks respectively. These findings can additionally be compared to those of Bikker and Metzemakers who conduct a cross-country analysis of bank capital buffers for 29 OECD countries. Their OECD sample can in some respects be considered to be similar to our EU25 sample in that it includes both RAM and original member state countries. While they do uncover a negative relationship, they find that cyclical effects are fairly limited.

The RAM sample returns opposite results. Here we find a significant positive relationship between the buffer and the cycle variables. This finding is in line with our H_1(b) hypothesis of pro-cyclicality and would tend to suggest forward-looking or prudent bank behaviour. Here we see a significant decrease in the capital buffer variable of 0.03 and 0.50 percentage points for a one percentage point rise in the domestic and the broad output gap respectively.

The coefficient on ROE, our proxy for the cost of capital, returns a significant negative coefficient, as expected, in each of the sub-sample estimations. The coefficients are essentially uniform across sub-groups, suggesting that the direct effects of such costs on bank capital are similar between European countries.

RISK2 (loan loss provisions over total lending) is highly significant and positive for four of the five sub-samples. This suggests that banks with relatively risky portfolios generally do hold more capital For the case of DK-SE-UK, the RISK2 coefficients are negative and significant. This counterintuitive finding is in line with some of the other literature in this field (Ayuso et al, 2004; Lindqvist, 2005).

The SIZE coefficients are consistently and significantly negative. This finding is as expected and consistent with several explanations of buffer capital. Larger banks may hold less capital because they anticipate state support (the 'too big to fail hypothesis'). This finding is also consistent with the presence of scale economies in screening and monitoring, ie larger banks are more transparent, can access capital markets with less cost, and therefore require less excess capital held as insurance against risk. Finally, the negative SIZE coefficient is consistent with the notion that smaller banks are less diversified than their larger counterparts and therefore hold higher levels of buffer capital. The SIZE coefficients are generally uniform across sub-groups with slightly larger coefficients for the RAM countries.

Finally, the cost of adjusting capital, captured by the lagged endogenous variable, is positive and significant in almost all cases. This finding is in line with the view that the costs of capital adjustment are an important explanation of the holding of large capital buffers. The coefficients are largely uniform across sub-samples, which would indicate that the costs of adjustment are largely consistent between countries, corresponding to a rate of adjustment towards desired capital of around 66 per cent per annum. However we find that the coefficients are negative for the DK-SE-UK sub-sample, which is inconsistent with a costly adjustment model of bank capital management.

Table 5 presents further estimation results for a second model (model specification 2), adding several further balance sheet variables to our baseline model (model specification 1). Our principal finding here is that the inclusion of these additional variables, leaves the relationship between the output gap and bank capital buffers largely unchanged. Both the domestic and the broad output gap remain negatively related to the buffer variable in the EU25, EU15, EA and DK-SE-UK sub-samples. The effect continues to be largest for the DK-SE-UK sub-sample predicting that a one percentage point fall in either the domestic or the broad output gap would result in a 0.77 and 0.61 percentage points fall in desired capital. Similarly for the RAM banks, the relationship between the capital buffer and the cycle remains positive and significant. These findings confirm the robustness of the results obtained via the estimation of the baseline model above.

The coefficient on the proxy for the cost of holding capital (ROE) and the speed of adjustment (the coefficient on the lagged dependent variable) are also broadly unchanged from those reported for model specification 1. The coefficients for the RISK proxies are now larger while the coefficient on the SIZE variable is smaller and no longer significant. For the DK-SE-UK and RAM sub-samples the coefficient has become positive and significant.

The new PROFIT variable for all sub-samples is positive and highly significant; indicating that retained earnings seem to be used to increase the capital cushion. The effect is noticeably larger for the EA sample when compared to the other sub-samples. The expected negative sign for the NET LOANS variable is found for the EU15, EA and RAM sub-samples, however the coefficients are broadly insignificant. The DK-SE-UK sample returns a highly significant positive coefficient. Considering the ΔLOAN variable, for all sub-samples, we find the parameter to be highly significant, with a negative sign as expected. This finding suggests that a contemporaneous increase in loan demand substantially reduces the capital buffer.

We have estimated a variety of other specifications, including subsets of the explanatory variables reported in Table 5. In all cases the relationship between the capital buffer and the output gap is very similar to that which we report here, and hence, for brevity results these results are not reported.

Estimation results for sub-groups of types and sizes of banks

Table 6 reports further versions of these estimation results, for sub-groups of banks, distinguishing commercial, savings and co-operative banks and also large and small banks. We report estimates only for the EA15. This is because the RAM sub-sample consists only of small commercial banks and RAM banks appear to behave so differently from those in the EA15. Considering commercial and savings banks, we find that for savings banks the co-movement with the cycle remains negative, but for co-operative banks the relationship is very different with a positive relationship evident between the cycle and capital buffers. The results for savings banks are more significant than for commercial banks, suggesting that the negative relationship reported in Table 5 is largely driven by savings banks.

Table 6. **EU15 two-step GMM estimates by type and size of bank**

	Commercial banks		Co-operative banks		Savings banks	
Cycle variable	domestic output gap	EU25 output gap	domestic output gap	EU25 output gap	domestic output gap	EU25 output gap
buf_{t-1}	0.30 (3.90)***	0.31 (4.27)***	-0.01 (0.30)	0.01 (0.43)	-0.04 (1.50)*	-0.07 (2.99)***
roe	-0.03 (1.48)*	-0.03 (1.35)*	-0.02 (0.60)	-0.06 (1.41)*	-0.22 (5.37)***	-0.20 (4.99)***
risk	27.34 (2.03)**	26.93 (2.08)**	149.11 (3.17)***	207.13 (2.59)***	-59.21 (2.33)***	-71.92 (2.62)***
size	2.16 (1.00)	0.47 (0.22)	-47.16 (12.85)***	-47.52 (5.70)***	-12.96 (0.81)	8.35 (0.63)
profit	151.69 (3.55)***	149.24 (3.32)***	157.41 (6.00)***	105.86 (1.93)**	432.59 (6.16)***	378.29 (5.52)***
cycle	-0.37 (1.33)*	-0.48 (2.64)**	0.18 (2.18)**	0.17 (0.79)	-0.33 (3.26)***	-0.30 (3.60)***
Δloan	-0.03 (5.23)***	-0.02 (4.05)***	0.14 (7.95)***	0.14 (3.41)***	0.11 (1.25)	-0.01 (0.14)
net loans	0.02 (1.00)	0.00 (0.06)	-0.36 (8.53)***	-0.37 (5.72)***	-0.24 (1.97)*	-0.08 (0.70)
Sargan	32.34 (0.94)	32.98 (0.85)	25.67 (0.86)	26.97 (0.81)	30.37 (0.94)	28.78 (0.85)
a(1)	-1.98 (0.00)	-2.03 (0.00)	-1.70 (0.00)	-1.89 (0.00)	-1.67 (0.00)	1.29 (0.00)
a(2)	-1.19 (0.74)	-1.22 (0.90)	-1.69 (0.96)	-1.26 (0.76)	-1.46 (0.83)	-1.42 (0.98)

	Big banks		Small banks	
Cycle variable	domestic output gap	EU25 output gap	domestic output gap	EU25 output gap
buf_{t-1}	0.53 (7.88)***	0.55 (7.67)***	0.15 (2.56)***	0.11 (2.72)***
roe	-0.11 (3.71)***	-0.11 (3.42)***	-0.08 (1.91)**	-0.08 (1.85)*
risk	71.46 (2.44)**	78.40 (2.73)***	40.57 (2.11)**	41.89 (2.18)**
size	-10.56 (5.03)***	-9.85 (4.59)***	12.91 (7.52)***	7.72 (2.02)**
profit	275.46 (4.45)***	268.66 (4.19)***	233.53 (3.33)***	-0.00 (3.32)***
cycle	-0.52 (2.14)**	-0.72 (1.65)*	0.14 (3.57)***	0.09 (2.67)***
Δloan	-0.04 (10.70)***	-0.04 (10.65)***	0.00 (0.07)	-0.00 (0.16)
net loans	0.05 (2.97)***	0.04 (2.45)***	-0.06 (1.60)*	-0.07 (1.82)*
Sargan	24.93 (0.89)	27.16 (0.80)	29.73 (0.65)	23.56 (0.66)
a(1)	-2.15 (0.00)	-3.26 (0.00)	-1.29 (0.00)	-1.39 (0.00)
a(2)	-1.96 (0.80)	1.03 (0.76)	-1.52 (0.86)	-1.55 (0.76)

Note: Dependent variable is BUF_{it}. Other variables as defined in Table 3.
T-values presented in parentheses a(1) and a(2) represent first and second order residual tests.
*, **, *** denote significance at the ten, five and one per cent levels of significance respectively.

This finding can help explain the relationship between our results and those of other researchers. Stoltz and Wedow (2005) present evidence for German banks finding that the relationship between the buffer and the cycle variable is stronger for savings banks than it is for co-operatives. The cross-country study of Bikker and Metzemakers (2004) finds that the cyclical effects appear to be limited. This finding is in line with our results since they focus their estimations on commercial banks only. Ayuso et al (2004) consider only savings and commercial banks in their study and find a robustly significant negative relationship. Their study does not however analyse bank type effects separately.

The ROE variable coefficients are very similar to those reported in Table 5. The coefficient is noticeably more significant amongst savings banks than it is for co-operative or commercial banks. This finding tends to indicate that the cost of holding excess capital appears to be most significant for co-operative banks when compared to savings and commercial banks.

The RISK coefficient remains positive and significant for both commercial and co-operative banks in all three sub-samples, while it is negative for savings banks. The sizes of the coefficients are notably larger for co-operative banks. The SIZE variables are negative and significant for co-operative banks while they are largely insignificant for the other bank types.

For all three sub-samples, the BUF_{t-1} variable is positive and highly significant for commercial banks, while it is very small (and significant) for savings banks and insignificant for co-operative banks. This suggests that adjustment costs are most important for commercial banks.

Turning to the comparison by bank size, also reported in Table 6, a positive and significant relationship appears to exist between the capital buffers of small banks and output gap variables, while the relationship is negative and significant for large banks. The coefficients on the ROE variable are little changed from those obtained for the initial total sample estimations. The coefficients are negative and highly significant for both small and large banks.

The RISK coefficients remain positive and significant for both small and large banks, while the coefficients vary for the SIZE variables. For small banks we find positive and significant coefficients, while the coefficients for large banks are negative and significant. Taken together these results suggest a hump shaped relationship with the largest capital buffers found amongst middle sized banks. This is in line with the hypothesis that the very largest banks generally feel themselves protected by the government safety net as per the 'too-big-to-fail' hypothesis. These results warrant further investigation.

The estimated cost of adjusting capital (the coefficient on BUF_{t-1}) is significant for both large and small banks. The coefficient is somewhat lower for small banks suggesting that adjustment costs play a larger role in the case of large banks.

To summarise, our estimations by both size and type of bank provide evidence that the capital buffers of both small and co-operative banks tend to have a positive relationship with the output gap variables. On the other hand we find negative co-movement with the cycle for commercial banks, savings banks, and large banks.

Robustness tests

We complete our analysis by examining the presence of individual national effects that could arise from various country-specific characteristics relating to the legal, regulatory, structural, or tax and accounting framework. A simple way to test, and control for these conditions, is to create a country-specific dummy variable (D_i) for each country. The inclusion of these dummies transforms equation (4.2) into the following

$$\begin{aligned} BUF^*_{ijt} = {} & \alpha KK_{ijt} + \gamma KF_{ijt} + (1-\delta)BUF_{ijt-1} + CYCLE_t + \xi_1 D_{1t} + \xi_2 D_{2t} \\ & + \ldots + \xi_{(I-1)} D_{(I-1)t} \end{aligned} \tag{4.3}$$

As it turns out, there are no significant fixed country dummy variables in our regressions, indicating that all the national effects are already captured by our chosen specifications.

The inclusion of dummy variables however does not allow for dynamic analysis and therefore are restrictive in their explicative power. As a further robustness check we re-estimate our model, including both the broad and the domestic cycle components among the regressors. The idea here is that the domestic cycle could capture dynamic national effects that are not depicted by the broad EU25 cycle. We would expect this effect to be particularly relevant for those countries outside EMU that, in principle, are more likely to have a business cycle dynamics different from the core EMU countries. The modified equation can now be presented as

$$BUF^*_{ijt} = \alpha KK_{ijt} + \gamma KF_{ijt} + (1-\delta)BUF_{ijt-1} + \beta GPCYCLE_t + \lambda NCYCLE_{it} + u_{ijt} \tag{4.4}$$

Where GPCYCLE and CNCYCLE denote the sub-group and the individual national cycle variables respectively. We find that for both the DK-SE-UK and the RAM samples, we are able to detect significant additional effects from the domestic cycle variable, indicating that national effects beyond those captured by the individual country dummies exists (Table 7). In the case of the DK-SE-UK and the RAM country grouping, we find that both the EU25 and the domestic output gap are significant at the five percent level. This suggests that national effects, as captured by the individual country business cycle variables, are important for the countries making up the DK-SE-UK and RAM sub-samples. These effects appear to have a significant impact on the movements and fluctuations of capital buffers of these countries.

Table 7. **Robustness checks: country effects**

	EU25	EU15	EA	DK-SE-UK	RAM
buf_{t-1}	0.25 (2.73)***	0.26 (2.81)***	0.22 (2.47)**	-0.21 (2.65)***	0.10 (2.59)***
roe	-0.03 (1.21)	-0.04 (1.29)*	-0.06 (1.29)*	-0.05 (1.78)*	-0.04 (0.82)
risk	50.13 (2.67)***	52.11 (2.62)***	62.21 (3.12)***	114.64 (6.22)***	96.54 (2.32)***
size	-0.15 (0.96)	-1.22 (0.42)	-0.75 (0.85)	6.97 (1.99)**	7.11 (1.45)*
profit	76.29 (2.89)***	156.21 (3.22)***	168.57 (2.99)***	124.06 (3.02)***	85.12 (2.93)***
cycle: broad	-0.16 (1.28)*	-0.37 (1.62)*	-0.21 (2.16)**	0.10 (2.04)**	0.13 (2.62)***
cycle: domestic	-0.05 (0.72)	-0.11 (0.96)	-0.25 (1.06)	0.15 (2.55)**	0.05 (1.96)**
Δloan	-0.03 (4.60)***	-0.01 (2.30)**	-0.05 (1.98)**	-0.06 (1.99)**	-0.08 (3.69)***
net loans	0.00 (1.45)	-0.04 (0.46)	0.02 (1.00)	-0.01 (0.55)	-0.02 (0.37)
Sargan	25.56 (0.68)	21.45 (0.85)	22.63 (0.92)	25.66 (0.67)	1.70 (0.00)
a(1)	-1.46 (0.00)	-1.22 (0.00)	-1.01 (0.00)	-1.47 (0.00)	0.86 (0.66)
a(2)	-1.04 (0.72)	1.03 (0.96)	-0.96 (0.63)	2.14 (0.74)	1.15 (0.99)

Note: Dependent variable is BUF_{it}. Other variables as defined in Table 3.
T-values presented in parentheses. a(1) and a(2) represent first and second order residual tests.
*, **, *** denote significance at the ten, five and one per cent levels of significance respectively.

We are also concerned with a further econometric problem. Moulton (1990) has highlighted a potential problem associated with measuring the effect of market or public policy variables on micro units by merging aggregate data with micro observations. The problem stems from the possibility that random unobservable characteristics within clusters can lead to a downward bias in the estimation of standard errors and a subsequent over-statement of statistical significance. In the cross-sectional example reported by Moulton, standard errors on aggregate variables are biased upwards by a factor of around three.

Several methods have been proposed to deal with this problem, the most common being 'robust-cluster' adjustment of standard errors available in Stata. Unfortunately we have been unable to carry out this adjustment, since the adjustment is only available for the estimation of a static panel regression with random effects. The option to adjust our preferred dynamic fixed-effects regression models is not available. We instead present two alternative calculations in order to assess the magnitude of the resulting bias in the standard errors on our aggregate cyclical variables. First, following Moulton (1990), we make use of an equation for the true covariance matrix in an OLS cross-section containing only aggregate group variables (equation (4.4) from Moulton)

$$C = \sigma^2 (X'X)^{-1} [1 + (m-1)\rho] \tag{4.5}$$

In this special case the magnitude of the covariance bias depends upon the number of observations within each group (m) and the correlation of residuals within groups (ρ). As Moulton acknowledges, this formula does not provide an exact measure of the bias in standard errors when there are a mixture of aggregate and individual regressors, or when the group size varies between groups but 'it often provides a reasonably good numerical approximation' (Moulton (1990), page 335) and indeed he shows that this formula works well for the particular case he investigates, a wage regression using cross-sectional data from United States.

The applicability of this formula is slightly less obvious in our case, because we have (unbalanced) panel data. The 'groups' in our case are the individual countries j. In our data (see Table 3) the average number of banks in each country (ie m in the Moulton formula) ranges between 4 (for the RAM countries) to 21 (in SE, DK, UK) and 30 (in the EA).

We further assess the extent to which our results are affected by this clustering problem by estimating a static random-effects version of our model, allowing us to then apply the 'robust-cluster adjustment' to the standard errors. For purposes of comparison we compare these estimates with those from a static fixed-effects version of our model as well as our preferred dynamic fixed effects model.

We find that for each variable, without the 'robust cluster adjustment', the standard error in the static regression using either fixed or random effects are very similar. We find that using the 'robust-cluster adjustment', the standard error changes increases by on average by around 20 per cent for each variable within each sub-sample. This suggests that, while clustering of errors is an issue for our results, it does not totally overturn the significance of our results.

Table 8 summarises all these calculations. Column 2 reports estimated within group cross-sectional correlation of residuals for the different data sets, in our preferred dynamic model. Column 3 reports the corresponding within group cross-sectional correlation for residuals from the static regressions (with fixed effects). Columns 4, 5 and 6 report the standard errors obtained for the static regression using fixed effects, random effects and the 'robust-cluster' adjustment respectively. The standard errors correspond to the cyclical variable. Column 7 reports the observed change in the standard error once the 'robust-cluster' adjustment has been performed. The adjustment of standard errors in the static random effects model is relatively small, ranging from 11 per cent in the RAM to 27 per cent in the EU25 estimates. The within group residual correlation in the three models is similar, suggesting that the required adjustment of standard errors in our preferred dynamic model is not radically different.

Table 8. **Robustness checks: within-group correlation summary**

		Dynamic	Static				
	Avg. no of banks per country	within group avg	within group avg (fixed effects)	fixed effects	random effects	Robust cluster adjustmen t	s.e percentag e change
Column #:		(1)	(2)	(3)	(4)	(5)	(6)
EU25	19	0.03	0.04	0.09	0.09	0.06	27.59
EU15	28	0.02	0.03	0.09	0.09	0.07	25.27
EA	30	0.02	0.03	0.09	0.09	0.08	17.39
DK-SE-UK	21	0.03	0.04	0.16	0.16	0.13	23.17
RAM	4	0.04	0.06	0.21	0.21	0.19	11.43

	Moulton formula	
	coeff. variances downwar d bias	s.e downwar d bias
Column #:	(7)	(8)
EU25	1.72	1.31
EU15	1.81	1.35
EA	1.87	1.37
DK-SE-UK	1.80	1.34
RAM	1.18	1.09

Note: The static case refers to results obtained by running the regression without the inclusion of the LDV. The dynamic case refers to our equation (4.2). Within-group correlations are obtained by calculating an average correlation coefficient of individual bank correlations within each country.

We additionally report the expected coefficient variance downward bias and the standard error downward bias in columns 8 and 9 of Table 8 respectively. They show that generally in our samples, the t statistics are on average going to be biased upward by a factor of around 1.29. When we multiply this factor by the t statistics obtained in Table 5 we find that the change is around 20 to 30 per cent for the EU25, EU15, EA and DK-SE-UK sub-samples, while slightly lower, around 8 per cent for RAM. This finding is broadly in line with the change that we obtained using the 'cluster-robust' adjustment reported in Table 8. We therefore conclude that our sample is affected to only a small extent by the problem of residual clustering identified by Moulton (1990).

5 Conclusions

This paper examines the relationship that exists between European bank capital buffer fluctuations and business cycle variations over the last eight years. Much of the empirical literature in this field has focussed on examining the determinants of bank capitalization within a single country. Our research is cross-country and centred on the comparison of different sub-sample groups of countries.

We build an unbalanced panel of 486 banks, using annual balance sheet data between 1997 and 2004. Controlling for various probable determinants of capital buffer movements, we analyse the remaining impact that the cycle variables appear to have. We find that for the EU25, EU15, EA and DK-SE-UK sub-samples, a significant negative relationship between the capital buffers of banks and the output gap exists. This finding is in line with the existing literature in this field and provides further cause for concern relating to the potential 'pro-cyclical' impact that the introduction of the new Accord will have on the amplification of the business cycle. For the RAM banks ie those in the 10 accession countries that joined the EU in 2004, our results indicate that capital buffers co-move positively with the output gap. The results suggest that the introduction of Basel II might have a stronger impact on capital management in the EU15 countries than in the RAMs.

We further break the sample down, distinguishing between both type and size of bank. Our findings indicate that capital buffers of large banks, and of commercial and savings banks, appear to behave in a similar fashion to the sample as a whole, co-moving negatively with the output gap ie declining in recession. On the other hand the capital buffers of small banks and of co-operative banks co-move positively with the cycle, rising in recession.

While these results are striking, they are limited by the restricted data available. Furthermore, as indicated by Figure 2, it is apparent that much of the buffer movements of the RAM banks has occurred during the first half of the sample period. Therefore, when more data on these countries becomes available, further research into the degree to which capital buffer decisions of RAMs are converging to become more like the other EU members would be beneficial.

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Appendix

Additional country-specific regulatory measures

EU15

All of the countries in the EU15 sample have chosen to implement the BIS minimum of eight per cent as the requirement for internationally active banks. However, in addition to this, as discussed below, several countries have supplemented these rules with alternative measures to ensure soundness and stability.

Spain

In Spain, due to the concern of the Banco de Espaňa regarding the ability of Spanish banks to keep up with potential credit losses latent in the expansion of lending activity, capital requirement regulations were supplemented in June 2000 by a 'dynamic provisioning' system. The idea of the provisioning was based on the notion that funds are set against loans outstanding in each accounting time period, in line with and estimate of expected long-run losses. Essentially, the idea is to build up a provision during good times which is subsequently drawn from during bad times. The provision will increase when actual losses for one year are lower than expected, and is used against specific provisions in years when losses are higher than expected. The provisioning system therefore acts to smooth out cyclicality impacts of specific provisions on the profit and loss account.

The statistical provision is calculated using a bank's own internal method[11], or alternatively, via a standard method recommended by the Banco de Espaňa. The standard method classifies exposures into six different categories, depending on their degree of riskiness, and each category is allocated a weight coefficient.[12] The total provision is then equal to the sum of the requirements for all six categories. It is therefore unsurprising, as seen in Table 1, that the capital buffers of Spanish banks have remain relatively unchanged (around 3.6 per cent) since the implementation of the dynamic provisioning in June 2000.

United Kingdom

In addition to the basic requirements set out by the Basel Accord, the UK Financial Services Authority (FSA) various additional requirements are implemented to assure the safety and soundness of the banking sector. First, sets

[11] The regulator must verify that the model adopted characterizes a suitable means to measure and manage credit risk.
[12] The coefficients range from 0 for zero risk exposures to 1.5 for high risk exposures.

two separate requirements for each bank: a ‘trigger ratio’ and a ‘higher target ratio’. The ‘trigger ratio’ serves as a minimum ratio which will generate regulatory intervention if infringed. The ‘target ratio’ serves as a warning signal and as a cushion of capital acting to prevent the accidental breach of the ‘trigger ratio’. The gap between the ‘target’ and the ‘trigger’ ratio acts as a buffer in that regulatory pressure is exerted when the capital ratio falls below the ‘target’ but drastic regulatory action is only enforced in the event of a violation of the ‘trigger ratio’. These ratios are bank specific and are based on the supervisors perception of the degree of riskiness of the banking institution. Banks deemed by the supervisor to be more (less) risky is required to hold higher (lower) levels of capital. Consequently, most UK banks are required to hold capital in excess of those specified by the EU directive. For the purpose of our estimations, we calculate the capital buffer for UK banks based on an assumed nine per cent minimum, since we are unable to obtain individual bank-specific requirement data.

RAMS

Banking policy for developing or transition economies generally tends to differ from that adopted for more developed markets. Since a stable financial system is vital for economic growth, the key questions for policy-makers in this context relate to the specific methods of bank regulation and supervision that can strengthen financial system regulation and supervision in order to promote more efficient and robust financial systems. Considering the largely varying degrees of development as well as the distinct differences that exist between the ram economies in terms of banking sector structures, it is unsurprising that the minimum capital adequacy ratio required of financial market operatives has varied across countries throughout our sample period.

Table 1 highlights the minimum ratios adopted in each of the ram countries. In Estonia and Cyprus, regulatory capital ratios have recently been tightened from eight to ten per cent of risk weighted assets to account for changes in market structure. In 1997, the Estonian authorities cited rapid growth of banks assets and changes in their operational environment as the main reasons for its higher regulatory ratio. In 2001, Cyprus raised its capital adequacy ratio to account for the increase in securities market activity. Latvia and Lithuania on the other hand both recently reduced their required ratios from ten to eight per cent effective from January 2005[13].

[13] The ten per cent regulatory minimum continues to be effective for AB VB Mortgage Bank in Lithuania.

In Poland, while banks are required to hold no more than the eight per cent regulatory minimum, 15 per cent is the requisite ratio for banks in their first year of operation, and 12.5 per cent in the second year.

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