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THE DETERMINANTS OF PORTUGUESE BANKS' CAPITAL BUFFERS*

Miguel Boucinha

Abstract

The purpose of the present paper is to shed some light on why Portuguese banks hold significant capital buffers above the required regulatory minimum, through the estimation of a dynamic panel data model.

The main findings are that the capital buffer is positively influenced by several broad risk measures, suggesting that the introduction of the more sensitive regulation in Basel II might not affect Portuguese banks' capital ratios as much as one could expect. Provisions and high and stable profitability are found to be substitutes for capital buffers, whereas larger banks seem to hold less excess capital. A negative business cycle effect is also found, and several other hypotheses are tested.

Keywords: Banking; Excess Capital; Risk; Panel Data

JEL: G21; G28; C23

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1. Introduction

Since the mid 1980's, there has been an increasing effort to decrease the distortionary effects of excessive regulation in the Portuguese banking sector, following the revolution and nationalization of Portuguese banks. However, it was not until the early 1990's that credit ceilings were abolished and deposit rates were fully liberalized. This period has also hosted full entry liberalization and the beginning of privatizations, which lasted until 1996. Hence, during the early 1990's, the Portuguese banking sector has met greater sophistication through market segmentation, risk differentiation and increased competition, which allowed for considerable efficiency gains.

In this context of decreasing direct controls on banks' conduct, capital adequacy regulation has become relatively more important. Hence, as established in the 1988 Basel Capital Accord (Basel I), each bank is required to hold at least 8% of its Risk Weighted Assets (RWA) in capital. However, most banks' solvency ratios are well above the regulatory minimum and a better understanding of the determinants of these capital buffers in the context of the present regulation may shed some light on the relevance and desirability of the more sophisticated and risk sensitive regulation proposed in Basel II[1]. On the other hand, it may make it easier to assess the factors underlying banks' solvency ratios.

This study is organized as follows: Section 2 discusses some hypotheses to be examined; section 3 summarizes previous empirical findings on the subject; section 4 presents the data; section 5 presents the model to be estimated; section 6 discusses estimation issues; section 7 presents the estimation results and section 8 concludes.

[1] For a discussion of the adoption of Basel II rules in Portugal, refer to Box 4.2 in Banco de Portugal's Financial Stability Report for 2006.

2. Hypotheses

The reasoning behind capital adequacy regulation is that banks should hold enough capital in order to assure that failure risk is minimal. This is important due to the negative externalities bank failures impose on their depositors and the potential for moral hazard in the behaviour of limited liability stockholders, but especially due to the possibility of generating systemic risk with severe effects to the real economy[2].

In this context, since the current solvency regulation is generally acknowledged to have poor risk sensitivity[3], one would expect banks with higher risk to hold higher capital buffers. On the other hand, the literature suggests that capital is a relatively expensive source of financing when compared to deposits or bonds[4]. Hence, banks' capital decisions reflect the trade-off between the benefits and the costs of holding excess capital (Milne and Whalley 2001).

One of the main benefits of holding high capital buffers is lower failure costs due to a decrease in the probability of failure. On the other hand, a decrease in the capital ratio below the regulatory minimum would imply extra supervisory scrutiny which would in turn decrease bank value. Furthermore, adjustments to the capital level bare direct costs, i.e. the transaction costs of issuing and repurchasing shares, as well as indirect costs from the signals they send to markets – issuing new shares may be interpreted as a signal that shares are overvalued[5]. Dietrich and Vollmer (2004) argue that banks use excess capital as a strategic tool which provides banks with increased bargaining power when renegotiating loans. In the context of asymmetric information, strong solvency ratios may also be interpreted as a signal of the bank's low probability of failure. Hence,

[2] For a comprehensive discussion on the relevance of financial stability see Crockett, A. (1997).
[3] See BCBS (1999).
[4] Check Myers and Majluf (1984).
[5] Cornett and Tehranian (1994) report statistically significant negative share price reactions to announcements of equity issues in the banking industry.

higher solvency ratios allow for better credit ratings, therefore decreasing the cost of financing and improving the bank's image. In the presence of liquidity constraints, banks may also hold excess capital in order to provide for unexpected investment opportunities.

According to the "too big to fail" hypothesis, larger banks feel that authorities would support them if they faced difficulties due to the important externalities and contagion risk their failure would pose. This moral hazard effect makes big banks willing to purchase less insurance against failure. On the other hand, if portfolio diversification increases with bank size and is not captured by the risk measures, larger banks are less likely to experience large drops in their capital ratios[6]. One may also consider the costs and benefits of screening and monitoring borrowers in order to better acknowledge their risk. If there are scale economies in screening and monitoring, one would expect larger banks to choose relatively more of these activities to the detriment of excess capital. As Alfon et al. (2004) remark, big banks may also be less liquidity constrained and/or have smaller costs in adjusting capital to optimum levels and thus issue comparatively more capital or debt on demand rather than hold large capital reserves.

3. Previous Empirical Findings

There is an extensive literature regarding banks' solvency. However, most of it regards US banks and capital ratios rather than excess capital. The literature on the determinants of European banks' capital buffers includes Stolz and Wedow (2005) for German banks, Ayuso et al. (2002a) and Ayuso et al. (2002b) for Spanish banks and Lindquist (2003) for Norwegian banks. To our knowledge there is no such work for Portuguese banks. A dynamic model is estimated in the first three papers, whereas Lindquist (2003) does not

[6] It is, however, important to note that Portuguese banks' capital requirements are already adjusted for diversification.

explicitly model for the persistence of the capital buffer, i.e. for adjustment costs in banks' level of capital.

The conclusions on the effect of risk on capital buffers vary somewhat between models. Ayuso et al. (2002a) find a negative influence of non performing loans on Spanish banks' capital buffer, which the authors expected since this is an ex-post risk measure. Ayuso et al. (2002b) also find evidence of a negative relationship between non performing loans and excess capital. However, they also find a negative impact of the loan growth rate (which may be interpreted as a measure of banks' willingness to increase portfolio risk) and a positive impact of the share of risk free assets to total assets. These results suggest the counter-intuitive interpretation that more risky banks tend to hold less insurance against default[7]. Lindquist (2003), using a more sophisticated measure of risk but a less sophisticated modelling approach, also finds a negative risk effect which the author did not expect. Stolz and Wedow (2005) find a positive relationship between banks' liquidity and excess capital, which the authors argue may be interpreted as a positive risk effect as they proxy liquidity by banks' holdings of shares and bonds, and capital buffers may be held in order to hedge for the corresponding market risk.

Ayuso et al. (2002a) and Ayuso et al. (2002b) find a negative effect of the price of insurance, proxied by banks' Return on Equity (ROE), in capital buffers. Lindquist (2003) finds the same result using the β-coefficient for the Norwegian banking industry as a proxy for the cost of excess capital, since it is a measure of the industry level risk premium. Being an industry level variable, this proxy has the obvious shortcoming of allowing for no cross-section variation. Stolz and Wedow (2005) find a negative

[7] Crocket, A (1997) presents potential explanations for this result, most of which are based on moral hazard in banks' behaviour and the potential for regulatory arbitrage.

relationship between banks' Return on Assets (ROA) and excess capital, suggesting that banks with high returns may use profits to increase capital and therefore need to hold smaller capital buffers as insurance.

The four papers find a negative relationship between the business cycle and capital buffers. From a regulator's perspective this may seem like a reassuring result as banks seem to protect themselves with higher excess capital during downturns, when loan default rates are higher. On the other hand, banks may increase excess capital during downturns through changes in their portfolio in order to reduce the risk weighted assets on which the regulatory minimum level of capital is based[8]. Hence, from a macroeconomic perspective, this behaviour may not be quite as desirable as it is likely to amplify rather than dampen business cycles, as during downturns firms are more likely to be denied credit (at a reasonable cost) which should increase bankruptcies. Stolz and Wedow (2005), Ayuso et al. (2002b) and Lindquist (2003) also find a negative effect of banks' size on excess capital.

Lindquist (2003) also finds a significant positive effect[9] of competitors' capital buffers which is interpreted as evidence of peer pressure as banks use solvency in order to signal the market of their credibility. However, this result must be interpreted with caution, since Lindquist (2003) does not include the lagged dependent variable in the model, which in the presence of persistence in capital buffers may make inference invalid[10].

[8] Furfine (2000) develops a structural dynamic model of a banking firm, finding evidence that US banks adjust their loan portfolios to capital shocks.
[9] In fact, the hypothesis that the corresponding elasticity equals one is not rejected.
[10] See Bond (2002), for instance.

4. The Data

Estimation in the present study is based on an unbalanced panel of yearly data from banks' financial statements reported to Banco de Portugal, Statistical Bulletins issued by Banco de Portugal and Reuters. Consolidated figures are used (except for banks that do not belong to any banking group and thus do not consolidate their data and variables for which data is only available on an individual basis[11]) as capital requirements are imposed at the consolidated group level. The dataset used for estimation covers 17 Portuguese banks from 1994 to 2004, though profitability data since 1993 was used. The choice of the period for analysis was made with the purpose of maximizing the number of observations while avoiding structural changes in the industry. Hence, by 1994 Portuguese banks had adapted to the regulatory framework developed in Basel I but by 2004 they had not yet started to adapt to the new Basel II rules. The first three observations of newly created banks were excluded in order to allow for some stabilization of their activity. Small banks specialized in investment banking were also excluded as they are likely to behave differently.

The capital buffer (BUF) is defined as the ratio between excess capital and the regulatory minimum. NPL1 is the ratio of non-performing loans overdue for less than one year to total loans and CREDG is the growth rate of total loans. PROV is the coverage ratio of non-performing loans by specific provisioning. ROE and ROA are each bank's Return on Equity and Return on Assets, whereas CF is banks' cash flow normalized by total assets. The variance of profits (VPROF) is the variance of banks' past ROA and is computed using profits from the previous three years to the current year in order to obtain a meaningful measure of volatility while minimising the loss of observations. For the same reason, profitability data since 1993 is used. STK is the

[11] For these variables, group level data is obtained by adding data for each of its members.

weight of volatile income financial assets in banks' total assets and MKTD is the ratio of market debt (total liabilities deducted of deposits) to total liabilities. TIER1 is the ratio of Tier 1 to total own funds. Banks' size (SIZE) is measured by the natural logarithm of total assets. PSIG is the change in the Lisbon Stock Exchange general index and is thus constant across banks. YGAP is a simple output gap measure obtained through the application of a Hodrick-Precott filter to the real output series.[12] Since this filter is known to have a poor fit for the first and the last observation, it was applied to an output series covering more years than the sample. YGAP is defined as the ratio of output gap to potential output. MERGER is a dummy variable equal to one when a bank has been involved in a merger. Ratios and growth rates are defined in percentage points.

Descriptive statistics of the included variables are presented in Table 1 below and the correlation matrix is in the Appendix.

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
$BUF_{i,t-1}$	152	46.297	37.591	1.180	208.430
$NPL1_{i,t}$	152	1.046	0.942	0.000	7.076
$PROV_{i,t}$	148	65.626	15.407	0.000	100.000
$CREDG_{i,t}$	135	19.313	28.757	-51.660	148.769
$STK_{i,t}$	152	2.902	2.526	0.009	12.153
$SIZE_{i,t}$	152	15.425	1.598	11.561	18.122
$YGAP_t$	187	0.588	2.430	-2.378	4.392
$ROA_{i,t}$	162	0.873	1.437	-0.080	10.970
$CF_{i,t}$	152	2.197	2.260	0.100	17.050
$VPROF_{i,t}$	111	0.212	0.721	0.000	4.421
$PSIG_t$	187	11.627	23.895	-20.700	65.200
$PSIG*STK_{i,t}$	152	32.514	113.030	-180.393	792.372
$ROE_{i,t}$	152	9.186	6.490	-4.154	32.791
$TIER1_{i,t}$	152	74.982	13.722	50.000	100.000
$MKTD_{i,t}$	152	42.554	24.492	11.006	100.000
$MKTD*SIZE_{i,t}$	152	642.570	326.752	162.142	1363.399

NOTE: ROA covers the period 1993-2004 while the remaining variables cover 1994-2004

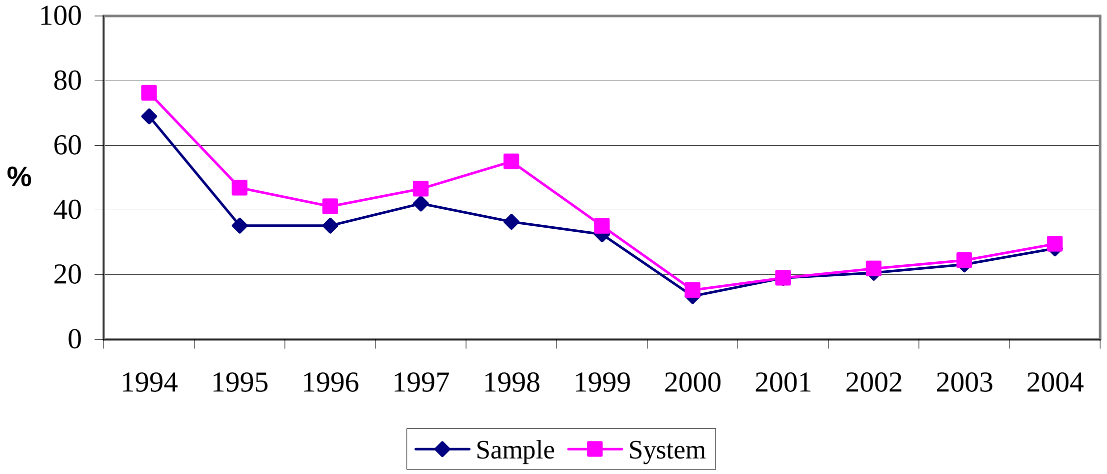
[12] The Hodrick-Prescott filter was implemented using the Stata command hprescott8.

Untabulated results indicate that the average capital buffer for the largest banks (4th quartile of total assets) is little above a third of the average buffer for the smallest banks in the sample (1st quartile of total assets).

As seen in Figure 1 below, the in-sample aggregate capital buffer tends to be lower than the banking system's actual capital buffer. This difference may be explained by the fact that the banks that were eliminated from the sample – newly created banks and institutions with very specific activities – tend to have abnormally high levels of excess capital.

From the beginning of the sample to the end of the past decade, capital buffers have declined as the economy recovered from the 1993 recession, credit accelerated and decreased exchange rate risk due to the adoption of the Euro was anticipated. Furthermore, there was an historical excess of capital in the Portuguese banking system, and rationalization of its use increased during this period. From the turning of the millennium, as capital ratios approached the regulatory minimum and economic growth slowed down, the banking system's aggregate capital buffer initiated a slow and steady recovery.

Figure 1. Evolution of Portuguese banks' Capital Buffers



5. The Model

Considering the small size of the available sample, which makes it impossible to estimate a comprehensive general model, the option was to estimate a parsimonious model and then test additional hypotheses on the initial specification presented below:

$$BUF_{it} = \beta_0 BUF_{it-1} + \beta_1 NPL1_{it} + \beta_2 PROV_{it} + \beta_3 CREDG_{it} + \\ + \beta_4 STK_{it} + \beta_5 SIZE_{it} + \beta_6 YGAP_t + \beta_7 MERGER_{it} + \delta + \eta_i + \varepsilon_{it} \quad (1)$$

where δ is a constant term, η_i is an unobservable variable that captures idiosyncratic features of each institution that are constant over time and $\varepsilon_{i,t}$ is a random shock

The lagged dependent variable is intended to capture capital buffers' persistence. As argued by Ayuso et al. (2002a) and Ayuso et al. (2002b), its coefficient may be interpreted as a measure of adjustment costs in capital buffers and its expected sign is thus positive. NPL1 is a credit risk measure that intends to capture the flow rather than the stock of non-performing loans, thus decreasing (but not fully eliminating) the ex-post character of this variable. Hence, β_1's sign should depend on how much lag it has. If it still measures ex-post risk, a negative sign is expected as banks where higher credit risk has materialized are expected to have lower excess capital. If, on the other hand, it is a forward looking risk measure, and since the current solvency regulation is known to have poor risk sensitivity, one would expect a positive sign as banks with higher credit risk should, *ceteris paribus*, be willing to purchase more insurance.

The coverage of non-performing loans by provisioning is expected to have a negative effect as banks that have already provisioned for more of their overdue credit should require smaller capital buffers. Provisions are thus imperfect substitutes for capital as they are intended to cover expected rather than unexpected losses.

The high credit growth observed during the sample period may have contributed to decrease capital buffers through a direct effect if banks have not anticipated this growth. On the other hand, one would expect a positive effect if banks anticipated high credit growth and responded to it with a precautionary excess capital increase. Furthermore, since an increase in granted loans is not expected to materialize immediately in an increase in non-performing loans, controlling for credit growth may be important for a correct interpretation of NPL1.

Banks with a higher weight of stocks in their total assets are expected to hold higher capital buffers as their assets should be more volatile. As argued above, both banks' size and the output gap are expected to have a negative impact on excess capital.

A negative coefficient on $MERGER_{i,t}$ would suggest mergers consume capital, whereas a positive sign could be explained by precautionary behaviour or simply by the acquisition of a strongly capitalised bank.

5.1. Additional variables tested

a) $ROA_{i,t}/CF_{i,t}$ and $VPROF_{i,t}$

High and stable earnings are expected to decrease the level of excess capital as profits are the first line of defence against unexpected losses.

b) $PSIG_t$

Good stock market performance should increase capital buffers as banks tend to choose these times to issue new capital and the value of banks' capital should increase due to the likely increase in listed banks' share price and the increase in profits from stock holdings. Hence, the hypothesis that the stock market effect is stronger for banks with a higher weight of shares in their assets is also tested.

c) $ROE_{i,t}$

Higher cost of capital, proxied by banks' Return on Equity (ROE), is expected to have a negative impact in capital buffers.

d) $TIER1_{i,t}$

Banks with a higher ratio of Tier 1 to total own funds are expected to require smaller capital buffers as this ratio may not fall below 50%. Hence, for banks close to the minimum, a negative shock to Tier 1 capital will have a higher impact in the capital ratio as Tier 2 capital will also decrease. Furthermore, banks close to the minimum allowed ratio should have higher capital adjustment costs as supplementary capital is cheaper and faster to issue than core capital. These effects should be reflected in capital buffers as they are not considered in the definition of the regulatory minimum capital.

e) $MKTD_{i,t}$

Higher weight of market debt (total liabilities deducted of deposits) in total liabilities is expected to positively influence capital buffers as, on the one hand, banks should hedge for the increased exposure to liquidity risk and to changes in market sentiment, and on the other hand, banks with higher market debt should target higher credit ratings as the price of issued bonds depends on the issuer's rating[13].

[13] The importance of rating targets had been acknowledged in Ayuso et al. (2002b) but, to our knowledge, had not been explicitly tested.

6. Methodology

The main advantages of using panel data are capturing both cross-section and time-series variation as well as allowing for meaningful inference using a sample with a relatively small number of cross-section observations over a short time period. Allowing for dynamics in the underlying process is relevant not only to infer on the persistence of the series but also to ensure that the estimates for other parameters are consistent.

In the estimation of dynamic models with a small number of time-series observations such as the ones described above, traditional estimation methods result in inconsistent estimates. Maximum Likelihood estimators may be inconsistent if the distribution of the initial conditions is miss-specified[14]. In fact, in panels with a small number of time-series observations, this estimator's attractive properties depend on quite strong and un-testable assumptions. Direct Ordinary Least Square (OLS) estimation would also result in inconsistent estimates as $BUF_{i,t-1}$ would be correlated with the error term $v_{i,t} = (\eta_i + \varepsilon_{i,t})$ due to the presence of time invariant individual effects. The Within Groups estimator solves for this source of inconsistency as it eliminates the fixed effects by transforming the variables into deviations from their means:

$$BUF_{i,t-1} - \frac{1}{T-1}\left(BUF_{i,1} + \ldots + BUF_{i,t} + \ldots + BUF_{i,T-1}\right) \qquad (2)$$

$$v_{i,t} - \frac{1}{T-1}\left(v_{i,2} + \ldots + v_{i,t-1} + \ldots + v_{i,T}\right) \qquad (3)$$

[14] See Bond (2002).

However, the estimator will still be biased for small T as $-\frac{BUF_{i,t}}{T-1}$ in (2) will be correlated with $v_{i,t}$ in (3) and $-\frac{v_{i,t-1}}{T-1}$ in (3) will be correlated with $BUF_{i,t-1}$ in (2)[15].

Application of OLS after taking first differences of the variables would still yield inconsistent estimates as the regressor $\Delta BUF_{i,t-1} = BUF_{i,t-1} - BUF_{i,t-2}$ would be correlated with the error term $\Delta\varepsilon_{i,t} = \varepsilon_{i,t} - \varepsilon_{i,t-1}$. This problem may, however, be solved by using Two-Stage Least Squares (TSLS) with instrumental variables that are both correlated with $\Delta BUF_{i,t-1}$ and orthogonal to $\Delta\varepsilon_{i,t}$, as proposed by Anderson and Hsiao (1981).

Arellano and Bond (1991) build on this approach by developing an asymptotically efficient estimator in a General Method of Moments (GMM) framework, using an instrument matrix of the form:

$$Z_i = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ BUF_{i,1} & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & BUF_{i,2} & BUF_{i,1} & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & BUF_{i,3} & BUF_{i,2} & BUF_{i,1} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots \end{bmatrix} \qquad (5)$$

Where rows correspond to the first-differenced equations for periods t=3,4,…,T for individual i.

However, as Arellano and Bover (1995) remark, in the presence of persistence in the dependent variable, lagged levels produce weak instruments for differences. Nevertheless, assuming lagged differences are uncorrelated with the fixed effects, one may explore additional moment conditions by estimating level equations using lagged

[15] See Nickel (1981) for details.

differences as instruments. This is the intuition behind System GMM proposed in Blundell and Bond (1998) and which basically consists in estimating a system of both difference and level equations using lagged levels to instrument differences and lagged differences to instrument levels. System GMM thus allows for increased efficiency, especially when the dependent variable is persistent, which is likely to be the case with capital buffers[16].

There are one and two-step versions of this estimator. While the two-step version is asymptotically more efficient, its standard errors are known to be severely downward biased in finite samples[17]. Hence the finite sample two-step covariance matrix correction developed in Windmeijer (2005) is used.

Table 2. Instruments Used

Variable	Instrument	Underlying Assumption
$BUF_{i,t-1}$	$BUF_{i,t-2}$	Pre-determined
$NPL1_{i,t}$	$NPL1_{i,t-2}$	Endogenous
$PROV_{i,t}$	$PROV_{i,t-2}$	Endogenous
$CREDG_{i,t}$	$CREDG_{i,t-2}$	Endogenous
$STK_{i,t}$	$STK_{i,t-2}$	Endogenous
$SIZE_{i,t}$	$SIZE_{i,t-2}$	Endogenous
$ROA_{i,t}$	$ROA_{i,t-2}$	Endogenous
$CF_{i,t}$	$CF_{i,t-2}$	Endogenous
$VPROF_{i,t}$	$VPROF_{i,t-2}$	Endogenous
$ROE_{i,t}$	$ROE_{i,t-2}$	Endogenous
$TIER1_{i,t}$	$TIER1_{i,t-2}$	Endogenous
$MKTD_{i,t}$	$MKTD_{i,t-2}$	Endogenous
$PSIG_t$	$PSIG_t$	Exogenous
$YGAP_t$	$YGAP_t$	Exogenous
$MERGER_{i,t}$	$MERGER_{i,t}$	Exogenous

[16] The correlation matrix in the Appendix presents a correlation of around 0.8 between $BUF_{i,t}$ and $BUF_{i,t-1}$.

[17] See, for example, Bond and Windmeijer (2002).

Table 2 summarises the instruments used and the underlying assumption on the correlation of each regressor with the error term. Conservative assumptions[18] have been made since they are relevant to the validity of the conclusions and not testable.

The use of too many instruments relative to the number of cross-section observations is known to overfit endogenous variables, thus creating biased estimates. Hence, rather than using all available lags to instrument each variable, regressions were first estimated using one lag. The number of lags was then increased and the specification with the highest p-value for the Hansen J test of overidentifiyng restrictions was chosen. To further address this problem the instrument matrix Z_i in (5) was collapsed by adding into:

$$Z_i' = \begin{bmatrix} 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & \cdots \\ BUF_{i,1} & 0 & 0 & \cdots \\ BUF_{i,2} & BUF_{i,1} & 0 & \cdots \\ BUF_{i,3} & BUF_{i,2} & BUF_{i1} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix} \qquad (6)$$

implying the use of one instrument for each variable and lag distance, rather than one instrument for each time period, variable and lag distance.

7. Estimation Results

Table 3 presents Blundell-Bond two-step finite sample covariance matrix corrected System GMM estimates for the model presented in section 5 and a reduced model (1.A). Estimation was carried out in Stata 8.0 using the xtabond2 routine developed in Roodman (2005).

[18] Ayuso et al. (2002b), for instance, assume exogeneity of bank size.

Table 3. Estimation Results

Variable	Model (1)	Model (1.A)
$BUF_{i,t-1}$	0.260 (0.98)	0.396 (1.84)*
$NPL1_{i,t}$	-11.478 (-1.64)	-8.196 (-1.43)
$PROV_{i,t}$	-1.125 (-2.07)*	-1.013 (-2.49)**
$CREDG_{i,t}$	0.249 (0.78)	
$STK_{i,t}$	11.457 (1.97)*	16.315 (2.03)*
$SIZE_{i,t}$	-20.989 (-2.69)**	-21.193 (-4.49)***
$YGAP_{t}$	-2.372 (-2.92)***	-2.089 (-2.73)**
$MERGER_{i,t}$	-6.440 (-0.60)	3.136 (0.39)
CONST	409.801 (2.55)**	387.258 (4.88)***
Hansen	0.695	0.705
AR (1)	0.050	0.054
AR (2)	0.958	0.652
F	0.000	0.000

NOTES: t-statistics are reported in parenthesis.
***, ** and * indicate statistical signifficance at the 1%, 5% and 10% confidence level, respectively, in a two-tailed t-test.
p-values are reported for the Hansen, AR(1), AR(2) and F tests

The Hansen J test of overidentifying restrictions is not significant in any of the specifications above, which means that there is no evidence that the instruments used are invalid. AR (1) and AR (2) are the application of the autocorrelation tests developed in Arellano and Bond (1991) to check for first and second order autocorrelation in the residuals of the differenced equations. The fact that there is evidence of first order but not second order autocorrelation implies that the model is well specified in levels, as expected. Furthermore, the F-test for the null hypothesis that all coefficients equal zero is safely rejected in both models.

Since the coefficient in $CREDG_{i,t}$ is not found to be statistically significant, this variable is eliminated from the regression and analysis is focused in the reduced model (1.A)[19].

[19] Even though the coefficient on the lagged dependent variable is not signifficant when credit growth is controlled for, it is relevant in models that do not include $CREDG_{i,t}$. This variable, on the other hand, has not shown to be signifficant even in specifications that do not include $BUF_{i,t-1}$.

Capital buffers are found to be persistent as the coefficient in $BUF_{i,t-1}$ is significant and positive, thus presenting evidence in favour of the adjustment cost hypothesis. There is statistically weak evidence of a negative relationship between $NPL1_{i,t}$ and excess capital, which may suggest that this variable does not fully eliminate the ex-post character of the outstanding stock of non-performing loans or that credit risk is not a relevant determinant of banks' capital buffers. This may be because the regulatory capital ratio already adjusts enough to cover the extra credit risk (which is unlikely) or because the precautionary effect of increasing capital buffers to cover credit risk is cancelled by the moral hazard and regulatory arbitrage effects described in Crocket, A. (1997) that actually lead more risky banks to hold less excess capital.

The negative coefficient in $PROV_{i,t}$ presents evidence in favour of the hypothesis that provisions are a substitute for capital buffers. The fact that banks with a higher weight of stocks in their total assets seem to hold higher capital buffers suggests that banks with higher exposure to market risk choose to hold more excess capital in order to cover for the excess risk not considered in the regulatory minimum requirements. As expected, a significant size effect is also found. However, no statistically significant effect of mergers is found, suggesting that mergers and acquisitions have not taken place at the expense of the overall system's capital.

Finally, as documented in the literature, a negative relationship between the output gap and capital buffers is found, which conveys that banks tend to cover the extra risk in cycle downturns with excess capital but also that the lending cycle may be pro-cyclical.

7.1. Additional Hypotheses

Since the variance of profits is a broad risk measure, the hypothesis that banks with higher and more stable profits require smaller capital buffers is tested on a model that does not include other risk measures. For increased robustness, income is measured both by ROA and by cash flow. Qualitatively, the conclusions are the same, confirming that banks with higher and less variable income do in fact tend to hold less excess capital. However, the coefficient in $ROA_{i,t}$ is statistically weaker than the one in $CF_{i,t}$. The F-test for the hypothesis that both the coefficient in profitability and the one in profit volatility are zero is significant at 10% in model (a.1) and at 1% in model (a.2).

Table 4.1 Additional Hypotheses - Profitability, Stock Market Growth Rate

Variable	Model (a.1)	Model (a.2)	Model (b.1)	Model (b.2)
$BUF_{i,t-1}$	0.748 (11.76)***	0.675 (7.82)***	0.396 (1.92)*	0.358 (2.67)**
$NPL1_{i,t}$			-1.632 (-0.25)	-5.589 (-1.31)
$PROV_{i,t}$			-0.986 (-2.32)**	-0.640 (-1.24)
$STK_{i,t}$			14.501 (1.99)*	11.586 (1.68)
$PSIG_t$			0.215 (2.24)**	-0.667 (-0.74)
$PSIG*STK_{i,t}$				0.374 (1.08)
$ROA_{i,t}$	-3.316 (-1.17)			
$CF_{i,t}$		-3.274 (-2.14)**		
$VPROF_{i,t}$	8.614 (3.37)***	4.972 (2.10)*		
$SIZE_{i,t}$	-4.252 (-0.95)	-9.230 (-1.93)*	-15.896 (-3.24)***	-15.925 (-3.31)***
$YGAP_t$	-2.233 (-3.31)***	-2.001 (-3.29)***		
$MERGER_{i,t}$	-6.662 (-0.91)	-5.123 (-0.92)	-3.799 (-0.43)	6.127 (0.45)
CONST	79.960 (1.15)	166.078 (2.09)*	299.725 (3.26)***	284.566 (3.51)***
Hansen	0.513	0.695	0.557	0.529
AR (1)	0.023	0.020	0.046	0.061
AR (2)	0.896	0.983	0.469	0.209
F	0.000	0.000	0.001	0.001

NOTES: t-statistics are reported in parenthesis.
***, ** and * indicate statistical signifficance at the 1%, 5% and 10% confidence level, respectively, in a two-tailed t-test.
p-values are reported for the Hansen, AR(1), AR(2) and F tests

Tests for the relevance of the growth of the PSI General stock market index were conducted on a specification which does not include the output gap as stock market performance is strongly correlated with the business cycle[20]. Statistically significant evidence of a positive effect of stock market performance in capital buffers was found, suggesting that banks tend to choose times of good stock market performance to issue new capital or that during these periods the value of banks' capital is boosted by the likely increase in listed banks' share price and the increase in profits from stock

[20] Check the correlation matrix of the variables in the Appendix.

holdings. These conclusions must, however, be interpreted with care, as the result may be spurious if changes in $PSIG_t$ do not cause changes in $BUF_{i,t-1}$ but, on the other hand, changes in the output gap cause changes both in capital buffers and in stock market performance[21]. If it is true that the positive impact of $PSIG_t$ in $BUF_{i,t-1}$ is related to impacts in profits from banks' holdings of stocks, one would expect the effect to be larger for banks with a higher weight of stocks in their total assets. The positive but not statistically significant coefficient in $PSIG*STK_{i,t}$ provides weak evidence for this hypothesis.

Table 4.2 Additional Hypotheses - Cost of Capital, Weight of Tier 1 Capital in Total Capital, Weight of Market Liabilities in Total Liabilities

Variable	Model (c)	Model (d)	Model (e.1)	Model (e.2)
$BUF_{i,t-1}$	0.359 (2.68)**	0.377 (2.75)**	0.374 (2.59)**	0.365 (2.67)**
$NPL1_{i,t}$	-8.725 (-1.43)	-8.440 (-2.00)*	-8.295 (-2.14)**	-3.778 (-0.70)
$PROV_{i,t}$	-1.010 (-2.55)**	-1.103 (-3.34)***	-1.111 (-2.88)**	-0.983 (-3.49)***
$STK_{i,t}$	8.364 (1.89)*	15.681 (2.88)**	14.824 (2.99)***	17.850 (4.18)***
$ROE_{i,t}$	-0.119 (-0.05)			
$TIER1_{i,t}$		-0.524 (-0.44)		
$MKTD_{i,t}$			0.542 (1.04)	-4.495 (-1.18)
$MKTD*SIZE_{i,t}$				0.354 (1.33)
$SIZE_{i,t}$	-15.700 (-2.49)**	-24.077 (-2.41)**	-20.241 (-5.86)***	-36.963 (-2.75)**
$YGAP_t$	-1.650 (-2.72)**	-1.917 (-3.07)***	-1.817 (-2.81)**	-1.435 (-2.18)**
$MERGER_{i,t}$	-3.249 (-0.25)	5.693 (0.44)	5.743 (0.56)	1.635 (0.15)
CONST	324.365 (2.93)***	477.204 (1.99)*	358.870 (6.53)***	582.475 (3.17)***
Hansen	0.507	0.862	0.798	0.942
AR (1)	0.040	0.021	0.044	0.032
AR (2)	0.524	0.664	0.585	0.497
F	0.000	0.000	0.000	0.000

NOTES: t-statistics are reported in parenthesis.
***, ** and * indicate statistical signifficance at the 1%, 5% and 10% confidence level, respectively, in a two-tailed t-test.
p-values are reported for the Hansen, AR(1), AR(2) and F tests

No significant effect of the cost of capital, proxied by ROE, was found. This may be related to the fact that the cost of capital is an adjustment cost to the capital buffer, since these costs are already taken into consideration through the inclusion of the lagged

[21] In fact, a regression of $PSIG_t$ on a constant and $YGAP_{t-1}$ yields a significant coefficient on $YGAP_{t-1}$ whereas a regression of $YGAP_t$ on $PSIG_{t-1}$ does not, suggesting that the business cycle determines stock market performance but the opposite is not true.

dependent variable. Furthermore, $ROE_{i,t}$ is measured in book-values whereas the true cost of capital is related to the market value of banks' return on equity[22].

The negative but statistically weak effect of the ratio of Tier 1 to total capital provides weak evidence for the hypothesis presented in 5.1 d). Weak evidence is also found for the hypothesis that banks with a higher ratio of market to total debt hold higher capital buffers. Furthermore, this effect seems[23] to be present only in the 94% larger banks.

Given the small sample size, it is reassuring to note that the sign and significance of most coefficients remains stable across a wide range of specifications[24]. The effect of NPL1, however, is not robust to the different specifications, suggesting that either banks do not adjust their capital buffers to credit risk or this variable is still a poor proxy for expected credit risk. Possible differences between domestic and foreign owned banks were also investigated through the inclusion of a dummy variable. However, this feature has not shown to be relevant.

8. Conclusions

The main purpose of this study was investigating which factors determine Portuguese banks' capital buffers, through the estimation of a dynamic panel data model.

Observed persistence in capital buffers suggests that there are relevant adjustment costs in banks' excess capital. On the other hand, high and stable profits and provisioning were found to be substitutes for capital buffers.

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[22] It is, however, impossible to compute banks' market value return on equity, as there are no estimates for most Portuguese banks' market value of equity.
[23] Evidence for this fact is once again weak as the hypothesis that both $MKTD1_{i,t}$ and $MKTD*SIZE_{i,t}$ are zero may not be rejected.
[24] In fact, estimation by Generalized Least Squares assuming Random Effects – the methodology used in Lindquist (2003) – provided the same qualitative results.

A statistically weak and not robust negative credit risk effect was found, suggesting that the credit risk proxy used does not fully eliminate the ex-post character of the proxies used in the literature. The intuitive and reassuring result of a positive risk effect was found for broad measures of asset risk and for the weight of market liabilities. Hence, banks seem to cover for higher market risk with more excess capital.

Weak evidence for the hypothesis that rating objectives have a positive effect on capital buffers, which had been previously discussed in the literature but not explicitly tested, was found. Weak evidence of a positive effect of stock market changes was also found.

The hypothesis that larger banks hold less excess capital was confirmed, as was a negative business cycle effect which means that banks protect themselves when higher credit risk materializes, but also that their credit policy may amplify economic cycles.

These findings allow for a better understanding of the factors underlying changes in Portuguese banks' capital buffers as well as assessing their likely reactions to changes in regulation. For instance, the fact that banks already seem to adjust capital buffers to risk and business cycles, suggests that the impact on banks' capital ratios of the more risk sensitive regulation proposed in Basel II may not be as large as feared, since it is likely that some of the volatility observed in capital buffers is transferred to capital requirements. The estimated impacts must not, however, be expected to hold in the future, as the new regulatory framework is likely to cause a structural break.

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10. Appendix

Correlation Matrix of Variables Included in Estimation

	$BUF_{i,t}$	$BUF_{i,t-1}$	$NPL1_{i,t}$	$PROV_{i,t}$	$CREDG_{i,t}$	$STK_{i,t}$	$SIZE_{i,t}$	$YGAP_t$	$ROA_{i,t}$	$CF_{i,t}$	$VPROF_{i,t}$	$PSIG_t$	$PSIG*STK_{i,t}$	$ROE_{i,t}$	$FPB_{i,t}$	$MKTD_{i,t}$	$MKTD*SIZE_{i,t}$	$MERGER_{i,t}$
$BUF_{i,t}$	1.000																	
$BUF_{i,t-1}$	0.799	1.000																
$NPL1_{i,t}$	0.029	0.014	1.000															
$PROV_{i,t}$	-0.398	-0.377	-0.040	1.000														
$CREDG_{i,t}$	-0.136	0.030	0.033	0.134	1.000													
$STK_{i,t}$	0.228	0.169	-0.067	-0.203	-0.083	1.000												
$SIZE_{i,t}$	-0.402	-0.388	-0.356	-0.031	-0.051	0.337	1.000											
$YGAP_t$	-0.188	-0.047	-0.159	-0.057	0.267	-0.029	0.080	1.000										
$ROA_{i,t}$	0.386	0.294	0.240	0.137	-0.064	0.444	-0.331	-0.160	1.000									
$CF_{i,t}$	0.330	0.227	0.417	0.165	-0.012	0.371	-0.410	-0.176	0.893	1.000								
$VPROF_{i,t}$	0.282	0.230	0.191	0.157	-0.075	0.300	-0.306	-0.060	0.829	0.655	1.000							
$PSIG_t$	0.197	0.137	0.103	0.170	0.068	-0.060	-0.027	-0.613	0.023	0.006	-0.060	1.000						
$PSIG*STK_{i,t}$	0.317	0.212	0.080	0.026	-0.057	0.220	0.036	-0.529	0.186	0.157	0.110	0.738	1.000					
$ROE_{i,t}$	0.127	0.078	0.141	0.040	-0.037	0.323	0.069	-0.013	0.611	0.472	0.400	0.067	0.063	1.000				
$FPB_{i,t}$	0.373	0.392	0.139	-0.084	0.159	0.015	-0.582	-0.041	0.296	0.316	0.203	0.064	0.023	-0.085	1.000			
$MKTD_{i,t}$	0.367	0.215	-0.025	0.004	-0.180	0.267	-0.152	-0.208	0.429	0.465	0.288	-0.088	0.096	0.162	0.035	1.000		
$MKTD*SIZE_{i,t}$	0.266	0.122	-0.129	-0.028	-0.191	0.329	0.080	-0.180	0.308	0.327	0.187	-0.111	0.084	0.134	-0.112	0.969	1.000	
$MERGER_{i,t}$	-0.139	-0.026	0.138	0.002	0.283	0.139	0.151	0.100	-0.057	0.010	0.006	-0.112	-0.185	-0.035	-0.017	-0.086	-0.054	1.000

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