Risk, capital buffers and bank lending:
The adjustment of euro area banks

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ABSTRACT

This paper estimates euro area banks' internal target capital ratios and investigates whether banks' adjustment to the targets affects their credit supply and securities holdings during the financial crisis in 2005–2011. Based on data on listed banks and country-specific macro-variables, a partial adjustment model is estimated in a panel context. The results indicate, first, that an increase in the riskiness of banks' balance sheets positively influences banks' target capital ratios. On the euro area level, we find banks' undercapitalisation in terms of Tier 1 capital ratio to be close to 2 percentage points in the middle of 2008. While median capital gaps diminish towards the end of 2011, the heterogeneity across individual banks increases. Second, the adjustment towards higher equilibrium capital ratios has a significant impact on banks' assets. The impact is more sizeable on security holdings than on loans, thereby suggesting a pecking order of bank assets for deleveraging.

1. INTRODUCTION

During the latest financial crisis, banks' core capital was often insufficient to cover impairment losses arising from both loan and securities portfolios. The increasing vulnerability of the banking sector and considerable pressures from markets, regulators and policy makers highlighted the necessity to strengthen banks' capital base and to reduce their exposure. While new stringent regulatory requirements for financial institutions call for higher capital levels (BIS, 2010a), banks usually operate above minimum regulatory solvency ratios with an additional capital buffer in order to minimise the risk of breaching the regulatory limit (ECB, 2007; Harding et al., 2013). This voluntary buffer, together with the regulatory capital, forms banks' internal capital. Target

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capital ratios are also entity specific and vary over time, partly reflecting banks' reaction to regulatory and market pressures. (Berger et al., 2008; Stolz and Wedow, 2011).

In the case of a capital shortfall, banks seek to close the capital gap and to reach their internal targets. They do so by increasing their core capital, adjusting their securities portfolios or decreasing their lending to the economy. In practise, the fastest ways to adjust to the new situation involve raising capital and selling off securities. As increasing core capital may be costly, especially during downturns when it is often needed to absorb losses, banks' adjustment to target capital ratios is likely to negatively affect their loan supply. The decreasing availability of credit and higher cost of financing for the economy at large, in turn, exert adverse effects on economic activity.[2] Hence, monitoring banks' capital gap and the implied deleveraging pressures is important for policy makers. Although deleveraging has been a popular topic since the financial crisis and although several policy measures, such as TARP and EU bank capitalisation exercises, have been implemented to avoid deleveraging, academic evidence of deleveraging in the euro area is still lacking.

This paper contributes to the literature by analysing the impact of the financial crisis on euro area banks. The analysis sheds light on two issues: First, what are the determinants of euro area banks' internal target capital ratios? Secondly, has the financial crisis affected euro area banks' balance sheets in general and banks' lending and security holdings in particular? Banks' internal targets are estimated on a bank-by-bank basis by using bank-level data on large and listed euro area banks, and the banking system's adjustment to target capital ratios is analysed by using capital targets and country-specific macroeconomic variables and by applying a partial adjustment model. The data period covers the latest financial crises starting from the first quarter of 2005, prior to the crisis, and extending to the last quarter of 2011.

Overall, several indicators are shown to have a positive impact on banks' internal target capital ratios. We find that a substantial part of the movement in internal targets arises from changes in banks' risks and earnings associated with the economic conditions. On an aggregate basis, we find undercapitalisation in terms of the Tier 1 capital ratio close to 2.0 percentage points (p.p.) in the middle of 2008. The negative gap prevails at the end of 2010 but vanishes towards the end of the estimation period. While median capital gaps diminish, the heterogeneity across individual banks increases. The estimations suggest that more than a half of the individual institutions do not have a capital shortfall in the beginning of 2011. At the same time, some weak banks continue to lack adequate capital. Similar results are obtained for the total capital ratio.

Turning to the impact of banks' adjustment to target capital ratios on assets, the estimates indicate that closing a 1 p.p. capital gap dampens loan growth by between 2.0 and 2.3 p.p. in the medium term. The impact on security holdings is found to be larger, approximately 5.8–7.1%, thereby suggesting a pecking order of bank assets for deleveraging.

The literature supports the analysis approach by showing that bank-specific factors are important in terms of capital levels and lending. In relation to solvency positions, large banks have lower capital ratios than smaller banks, while banks maintain higher ratios in countries with stringent capital requirements, active supervisors and effective corporate governance (Brewer et al., 2008). Further evidence is provided by Memmel and Raupach (2010), who indicate that banks with high asset volatility tend to have higher capital ratios. In addition to the importance of entity-specific characteristics, the speed of adjustment towards the desired capital level is shown to vary across institutions.[3] For instance, private commercial banks and banks with a high share of liquid assets adjust their capital ratios more quickly (Memmel and Raupach, 2010).

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[2]   See BIS, 2010b; Miles et al., 2010; Ötker-Robe et al., 2010.

[3]   See, for instance, Jokipii and Milne, 2008; Memmel and Raupach, 2010 and Brewer et al., 2008.

Banks' adjustment towards the desired capital levels may consequently have implications for banks' asset composition and lending activity.[4] Such an adjustment can be triggered, for instance, by new regulation, notably the Basel Accords. Empirical papers suggest that in the US, the Basel I regulatory framework led to slightly decreased lending (particularly with respect to business lending), and that the risk-based capital standards were a significant factor in explaining the credit crunch of the early 1990s.[5] In addition, using a structural model and data on large US commercial banks, Furfine (2000) indicates that changes in capital regulation influence banks' decision making, affect commercial loan portfolios and explain the decline in loan growth. Similarly, Basel II requirements are shown to increase the volatility of bank lending, especially for undercapitalised and less liquid banks (Jacques, 2008; Gambacorta and Mistrulli, 2004). Additionally, analysis regarding the Basel III regulations suggests that the increase in capital requirement could exert a negative impact on banks' lending volumes (BIS, 2010b).

In addition to changes in the regulatory environment, bank-specific factors influence the credit supply. Puri et al. (2011) study German banks that were affected by the US financial crisis and that endured heavy losses from the subprime exposures and show that these banks rejected relatively more loan applications and thus restricted their lending to a greater extent than less-exposed banks.[6] In a similar vein, Brinkmann and Horvitz (1995) indicate that the loan growth of poorly capitalised banks is lower than that of better-capitalised competitors owing to reductions in bank capital. Banks with binding capital constraints also seem to reduce lending more than other banks in reaction to unanticipated drops in capital (Hancock et al., 1995; Peek and Rosengren, 2000).[7] Furthermore, Spanish banks with weaker capital and liquidity ratios as well as European and US banks with low solvency ratios, large shares of market-based funding and non-interest income are shown to reduce lending to a greater extent than other banks. (Jimenez et al., 2012; Gambacorta and Marques-Ibanez, 2011)

An individual bank's response to changes in capital is also conditioned on the bank's size. The results of Puri et al. (2011) are particularly strong for smaller and more liquidity-constrained banks as well as for mortgage loans. Hancock and Wilcox (1998) also show that small banks decreased their portfolios considerably more than large banks in response to the decline in their own bank capital.

Lastly, banks' capital targets and financial institutions' adjustment towards these targets affect banks' lending (Francis and Osborne, 2009; Berrospide and Edge, 2010). By using partial adjustment models, estimates on banks' internal capital ratios and data on UK banks, Francis and Osborne (2009) show that banks with a surplus (shortfall) of capital relative to their target tend to record higher (lower) credit growth. Berrospide and Edge (2010) analyse US banks but find relatively modest effects of bank capital on lending. They indicate that factors such as economic activity and perceived macroeconomic uncertainty also play a role.

The rest of the paper is organised as follows. Section 2 presents the dataset together with stylised facts on developments in the euro area banking sector since 2005. The partial adjustment model and the estimation results are discussed in Section 3, while Section 4 concludes.

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[4] Disentangling the impact of supply factors (which may be driven by changes in capital requirements) from demand factors is nevertheless difficult, as both factors contribute to loan growth.

[5] See, for instance, Bernanke and Lown, 1991; Hancock et al., 1995; Berger and Udell, 1994; Berger et al., 1995; Wall and Peterson, 1995; Peek and Rosengren, 1995 and Brinkmann and Horvitz, 1995.

[6] Furthermore, Ivashina and Scharfstein (2010) show that banks that were more vulnerable to credit-line drawdowns, that were more reliant on short-term debt and that had limited access to deposit financing reduced their lending to a greater extent than their counterparts during the latest financial crisis.

[7] The existence of a negative link between the capital gap and lending has also been confirmed by theoretical models. For example, based on a static model, Thakor (1996) shows that capital requirements linked solely to credit risks raise the cost of lending relatively to alternative investments, thus increasing credit rationing and reducing aggregate demand.

2. DATA AND STYLISED FACTS

2.1. Bank data

Our dataset is based on the balance sheets and income statements of euro area listed banks available from Thomson Reuters Datastream. The dataset includes large and listed banks domiciled in Germany, France, Italy, Spain, Belgium and Austria. While some observations are available from 2003 onwards, our estimation period extends from the first quarter of 2005 until the fourth quarter of 2011 in order to ensure reasonable data coverage. Over the sample period, the total assets of the banks included in the sample constitute, on average, 60% of the total assets of credit institutions in the above-mentioned countries.[8]

Data are collected at the consolidated group level, including banks' foreign subsidiaries and branches. Although the majority of banks report balance sheets and income statements on a quarterly basis, some banks publish bi-annual data. In this case, missing quarterly observations are linearly interpolated in order to ensure a sufficiently large sample. Over the sample period only 10 percent of all observations consist of interpolated data, on average.

We extract information from Datastream on risk-weighted assets (RWAs), total assets, retained earnings, provisioning for loan losses, total investments[9] and net loans (that is, total loans excluding inter-bank loans). Data on these variables are subsequently used to compute bank-specific indicators that reflect the riskiness of the assets and earning capacity of the bank. To get the indicators, we divide the variables with total assets for each bank in the sample. Thus, the indicators include loan loss provisioning over total assets, total investments over total assets and risk-weighted assets over total assets (so called risk weights). Retained earnings over total assets is also calculated but we modify the indicator further and take quarterly growth for it. In addition, Datastream is used to obtain information on banks' return on equity (ROE) and solvency ratios[10], both the total capital ratio and the Tier1 capital ratio. ROE and capital ratios are in percentages.

In respect of balance sheets, the total assets of euro area listed banks increased from 2003 to 2008. However, the financial crisis interrupted this increasing trend in 2009, and total assets started to decline. For instance, total lending declined by approximately 5% per year in 2009 and 2010. While the mean ROE was relatively weak, banks' risk weights remained high in 2005–2001. (See Table 1 for summary statistics on several bank-specific variables.)

Table 1
Summary statistics of bank-specific variables used in the estimation (2005Q1–2011Q4), %

	Mean	Median
Return on equity (ROE)	8.67	9.92
Risk weight	64.50	67.41
Expected Default Frequency (EDFs)	0.68	0.10
Tier1 capital ratio	8.57	7.55
Total capital ratio	11.41	10.76

Note: Return on equity (ROE) as well as Tier 1 and total capital ratios are obtained directly from Thomson Reuters Datastream. Risk weight is calculated by dividing risk-weighted assets with total assets (both series obtained from Datastream). In case of missing quarterly observations, authors have interpolated the data. Expected default frequencies are from Moody's.

Source: Authors' computations based on Datastream and Moody's.

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[8]   Data on credit institutions are obtained from balance sheet items (BSI) statistics reported by the ECB. The possibility of using BSI data in our analysis is limited because it includes neither regulatory concepts, such as risk-weighted assets or solvency ratios, nor income statements. Moreover, BSI data are only available at the aggregated level for the euro area as a whole and euro area countries; thus information on individual banks is lacking. Given that the average for a country can reflect many individual combinations of bank-specific variables, bank-level data is necessary to analyse the adjustment of banks properly.

[9]   According to the data manual of Datastream, the series includes a bank's investments in securities such as government bonds, municipal bonds, securities under repo agreements, trading account securities and mortgage backed securities. Also securities that are available for sale are included.
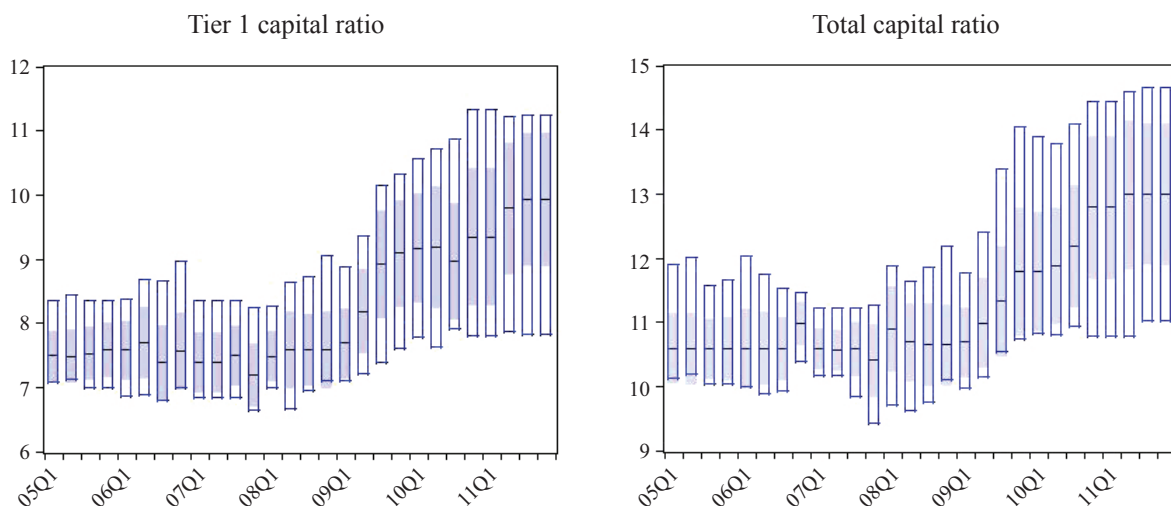
[10]   The solvency ratios are defined as regulatory Tier 1 (or total) capital over risk-weighted assets. Banks calculate these ratios according to supervisory regulations and Thomson Reuters Datastream collects the information from banks' annual and interim reports.

Turning to the solvency ratios, both the Tier 1 and the total capital ratios of listed euro area banks remained relatively stable from 2005 until the end of 2008. Since this time, the solvency ratios have started to increase (see Figure 1). Over the estimation period, the Tier 1 capital ratio stood at 8.6%, and the total capital ratio, at 11.4%, on average.

Looking at the distribution among the sample, the capital ratios of the banks in the sample were rather close to each other until the beginning of the financial crisis, while from 2009 onwards, the ratios have improved faster for the upper part of the distribution and for an average bank than for the lower part of the distribution. Nevertheless, throughout the sample period, the banks' ratios remained above the regulatory minimum, on average. Given the broadly stable risk-weighted assets from 2009 onwards, the increases in the banks' Tier 1 and total capital ratios were mainly driven by developments on the liability side of the banks' balance sheets. In addition to the new capital raised from market sources via the issuance of shares, the banks benefited capital injections from public authorities and resorted to internal capital accumulation in the form of retained earnings. Indeed, after having recorded losses in 2008, the listed euro area banks returned to profit in the second half of 2009. It is only towards the end of the sample period that the importance of reshuffling assets towards less risky exposures and deleveraging pressures increased.

Figure 1
Tier 1 capital ratio and total capital ratio for listed euro area banks (%)

Notes: Individual bank-level capital ratios are collected by the Thomson Reuters Datastream from banks' annual and interim reports. Banks calculate the ratios according to supervisors' regulations and definitions. A capital ratio is defined as the Tier 1 capital ratio or total capital ratio over risk-weighted assets. In case of missing quarterly observations, authors have interpolated the data. The horizontal line in the bars represents the median of the distribution, and the blue area, the 95% confidence intervals. The limits of the boxplots indicate the first and third quartiles of the distribution.

Source: Thomson Reuters Datastream and authors' calculations

2.2. Other data sources

In addition to the information on banks' financial statements, other statistical data sources are used to capture the riskiness of a bank's balance sheet, the bank's credit standards, loan demand factors and the macroeconomic conditions of individual countries. In the estimation, country-level data on different indicators and macro-variables are associated with each individual bank according to the location of the bank's headquarter.

First, we add expected default frequencies (EDFs) computed by Moody's for each bank in the sample. EDFs provide an estimate of the probability that a bank will default within one year, and therefore represent the market's perceived riskiness of the institution. From the beginning of the 2000s, the expected default frequencies of euro area listed banks have remained stable at a low

level, before increasing abruptly in the wake of the financial crisis. This holds both for the mean and the distribution measured at the inter-quartile range. The perceived risk increased to a greater extent for banks in the upper part of the distribution, namely the weakest banks, than for the strongest banks in the beginning of 2009.

Second, we include country-specific statistics on credit standards available from the Bank Lending Survey (BLS) compiled by the European Central Bank (ECB).[11] In this survey, the senior loan officers report on the importance of factors such as the perception of risks related to the industry- or firm-specific outlook, expectations regarding economic activity and the impact of changes in a bank's own funding conditions on the bank's credit standards applied while approving loans and credit lines to enterprises. Moreover, the loan officers share their views on the expected and actual loan demand by firms. Since the onset of the financial crisis, aggregate credit standards and expectations regarding loan demand have co-moved with the macroeconomic developments in the euro area. The credit standards tightened substantially in 2008−2009, while demand exhibited cyclical behaviour, increasing in 2005−2007 and declining during the crisis. The aggregate figures nevertheless mask any notable country differences.

Lastly, to control for macroeconomic conditions, the dataset includes quarterly macroeconomic variables for each country. Gross domestic product (GDP) is taken from Eurostat in nominal and real terms.[12] The annual growth in stock prices is calculated on the basis of the Euro Stoxx 50 index, reflecting the development of the 50 largest companies in terms of capitalisation, as available from Thomson Reuters Datastream.

3. ESTIMATION BASED ON A PARTIAL-ADJUSTMENT MODEL

Macroeconomic and bank-specific shocks affect banks' internal target capital ratios and banks' responses, which involve adjusting their asset management strategies, lending policies and securities holdings. This adjustment process is modelled with a partial adjustment model, which is developed in two separate steps.[13]

In the first step, we concentrate on the relationship between bank-specific characteristics and the target capital ratio. Risk indicators are used to estimate a target capital ratio for each entity, while controlling for the bank's capacity to generate income and accounting for certain structural characteristics, such as bank size. To account for risk, both market evaluation and bank accounting items are considered. Based on the estimated parameters, a bank's time-varying capital gap between the desired (unobserved and internal) target capital ratio and the actual (observed) capital ratio is then computed for each time period. In the second step, the adjustment of loans and securities is explained using the estimates on the bank's capital gap and variables related to the macroeconomic environment.

3.1. Estimating the target capital ratio

The first step focuses exclusively on the link between a bank's target capital ratio and the riskiness of the bank's balance sheet, the bank's earning capacity and the degree to which the bank is exposed to market discipline. Banks' internal time-varying target capital ratios, $k^*_{i,t}$, which are not known to the public, are modelled as a function of bank-specific risk indicators, $RISK_{i,t}$, and variables that capture the bank's capacity to accumulate income, $INC_{i,t}$ (see equation 1). Other

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[11]   For more information on the euro area BLS, see http://www.ecb.europa.eu/stats/money/surveys/lend/html/index.en.html.

[12]   More information on GDP data is available at http://epp.eurostat.ec.europa.eu/portal/page/portal/national_accounts/introduction.

[13]   Another option would be to model deleveraging process with the partial adjustment model. However, we concentrate on capital as we want to induce the impact of changing equity on banks' assets.

factors, such as market pressures, the bank's business model, the bank's strategy and specificities of the market in which the bank operates, are included in α_i.

$$k_{i,t}^* = \alpha_i + \theta_1 RISK_{i,t} + \theta_2 INC_{i,t} \tag{1}$$

Owing to market frictions and adjustment costs, it takes several periods for banks to adjust from their current capital levels towards their internal targets. Hence, a partial adjustment model is applied to describe how a bank closes the gap between its capital ratio in the previous period, $k_{i,t-1}$, and its internal target capital ratio, $k_{i,t-1}^*$. This process is presented in equation (2): the observed change in publicly disclosed capital ratio, $\Delta k_{i,t}$, is a function of the gap between the internal target and (observed) capital ratio ($k_{i,t-1}^* - k_{i,t-1}$) in the previous period. This gap is closed at speed λ, which lies between 0 and 1. In addition, an error term, $\varepsilon_{i,t}$, captures idiosyncratic shocks during the adjustment.

$$\Delta k_{i,t} = \lambda(k_{i,t-1}^* - k_{i,t-1}) + \varepsilon_{i,t}, \quad 0 < \lambda < 1 \tag{2}$$

Substituting (1) into (2) and rearranging the expression gives equation (3).

$$k_{i,t} = \lambda \alpha_i + (1 - \lambda)\, k_{i,t-1} + \lambda\theta_1 RISK_{i,t-1} + \lambda\theta_2 INC_{i,t-1} + \varepsilon_{i,t} \tag{3}$$

The equation (3) is estimated using the panel of euro area listed banks over 2005Q1–2011Q4 period, constituting 28 quarters per bank. The estimations are run with two-stage least squares (TSLS) method with cross-sectional fixed effects for both regulatory solvency ratios (Tier 1 capital ratio and total capital ratio) as the dependent variable.[14] We apply the TSLS estimation method because standard OLS estimation may arguably suffer from endogeneity bias.[15]

By construction, the first lag of capital ratio is incorporated as an explanatory variable to account for a bank's lagged adjustment and it is expected to correlate positively with the capital ratio. Regarding the risk and income indicators, we also include the first lags of these variables in the equation (3). Several combinations of explanatory variables are tested to account for the different channels that affect the target capital ratio. Indicators referring to a bank's income capacity include return on equity (ROE) and retained earnings over total assets. The coefficients are expected to be positive, as a bank's earnings support the capacity to accumulate capital through retention.[16] To reflect the riskiness of a bank, we consider indicators based on balance sheet items, namely, loan loss provisioning over total assets and total investments over total assets, as well as indicators based on the market's view of the bank's situation, i.e., expected default frequency (EDF) and log-odds EDFs.[17] For all of these indicators, risk is expected to exert a positive impact on the target capital ratio, as a bank with riskier balance sheet should have a higher capital buffer to cover its exposures.[18]

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[14] For more information on the estimation method, see Baltagi (2008).

[15] With endogeneity, the idiosyncratic shocks captured by the error term, $\varepsilon_{i,t}$, are correlated not only with dependent variable (target capital ratio) but also with explanatory variables related to banks' income capacity and riskiness. Such a bias makes estimated OLS coefficients biased and inconsistent.

[16] In principle, profitability ratios may also exert a negative impact on the capital ratio since they also reflect the implicit cost of capital, in that part of the profits are paid out to stakeholders. However, as banks usually keep part of their profits as retained earnings, we expect higher net income to result in a higher capital ratio.

[17] Log-odds ratios, LOR, are calculated as LOR = log((EDF)/(1−(EDF))).

[18] However, credit risk and market perceptions may exhibit pro-cyclical behaviour. For instance, loan losses tend to increase during economic downturns, depleting banks' capital position and solvency ratios. Moreover, EDFs started to increase only at the beginning of the financial crisis. Hence, these indicators may be negatively correlated with capital ratios. The first lags of capital ratios are introduced in the regressions to reduce the impact of cyclicality.

The TSLS method requires instrumental variables. We instrument explanatory variables ($k_{i,t-1}$, $RISK_{i,t-1}$ and $INC_{i,t-1}$) with their corresponding second and third lags ($k_{i,t-2}$, $k_{i,t-3}$, $RISK_{i,t-2}$, $RISK_{i,t-3}$, $INC_{i,t-2}$ and $INC_{i,t-3}$).[19] The idea in using the lagged values of explanatory variables is that they are less likely to be influenced by current shocks. Theoretically, we have good reasons to expect that these instruments perform well. From the statistical perspective, instruments are judged to be valid when they are relevant and exogenous. The selected lags are indeed relevant as each of the exogenous variables ($k_{i,t-1}$, $RISK_{i,t-1}$ and $INC_{i,t-1}$) is strongly correlated with its corresponding second and third lag. As for instrument exogeneity, we can use the Sargan J-test. This test for overidentifying restrictions indicates that the instruments are valid in all our specifications and the test statistics is reported with the results.

The results for the target capital ratio measured with the Tier 1 capital ratio are presented in Table 2. Overall, the estimated coefficients are in line with our a priori expectations. The lagged dependent variable has a positive sign and is statistically significant, consistent with a partial adjustment model that assumes some delay in the closure of the capital gap.

Regarding the income indicators, return on equity (ROE) and quarterly change in retained earnings over total assets exert positive effects on capital ratios, although the coefficients are not statistically significant. This positive (but not significant) correlation between profitability and solvency ratios is in line with the results of Berrospide and Edge (2010), who report that the bank holding companies tend to increase capital when profits, measured with return on assets, rise. The lack of significance for the coefficient may reflect the fact that the income indicators also reflect banks' cost of capital, as mentioned by Francis and Osborne (2009).

Table 2
Determinants of the target Tier 1 capital ratio

	Equation 1	Equation 2	Equation 3	Equation 4
Lagged capital ratio	0.86 [0.03]***	0.83 [0.03]***	0.77 [0.03]***	0.86 [0.03]***
Change in retained earnings over total assets	0.07 [0.07]	0.03 [0.07]	0.03 [0.06]	.. ..
Provisioning over total assets	1.32 [0.40]***	.. ..	.. ..	1.38 [0.40]***
Expected default frequency (EDF)	.. ..	0.08 [0.02]***	.. ..	.. ..
Log-odds EDFs	.. ..	.. ..	0.15 [0.02]***	.. ..
Change in return on equity	.. ..	.. ..	.. ..	0.01 [0.01]
Constant	1.05 [0.21]***	1.35 [0.23]***	2.94 [0.38]***	1.09 [0.22]***
Number of observations	756	728	728	756
Cross-section	27	26	26	27
Sargan J-test statistics	5.81	4.98	2.57	3.70

Notes: The estimation period covers 2005:1−2011:4. Standard deviations are reported under the point estimates in brackets. (*), (**), and (***) indicate statistical significance at 10%, 5%, and 1%, respectively. The Sargan J-statistic indicates the validity of the model. The critical value for the Sargan J-test is 40.11 (38.89), with 27 (26) degrees of freedom at a significance level of 5%. As test statistics is below the critical value, null hypothesis of valid instruments can be accepted.

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[19]   In addition, cross-section fixed dummies also serve as instruments.

Turning to the risk indicators, increasing risk is shown to have a positive effect on banks' internal targets, inducing the institutions to strive for higher capital levels. The ratio of loan loss provisions over total assets is statistically significant and positively correlates with the Tier 1 capital ratio.[20] Meanwhile, the ratio of total investments over total assets, another measure of risk, exhibits a positive relationship with the Tier 1 capital ratio. This relationship is not significant at the 10% level, however. In addition, expected default frequencies (EDFs) are significantly and positively related to the solvency ratios. This result can be interpreted to indicate markets' ability to recognise that a bank's risks call for a higher capital position in the future. Markets' perceptions regarding a bank's riskiness and need to raise more capital to cover its risk exposure are subsequently reflected in the bank's internal target.

The results obtained for the Tier 1 capital ratio also apply to the total capital ratio to a large extent (see Table 3). In both cases, the lagged dependent variable and indicators for risk enter the equations with positive signs. Overall, the positive relationships between the target capital ratios and the various risk indicators confirm the view that banks with high risk in their balance sheets also orient themselves towards high capital levels.

Table 3
Determinants of the target Total capital ratio

	Equation 1	Equation 2	Equation 3
Lagged capital ratio	0.67 [0.05]***	0.60 [0.05]***	0.52 [0.06]***
Change in retained earnings over total assets	0.15 [0.13]	0.09 [0.13]	0.10 [0.13]
Provisioning over total asset	2.03 [0.76]***	.. ..	.. ..
Expected default frequency (EDF)	.. ..	0.18 [0.04]***	.. ..
Log-odds EDFs	.. ..	.. ..	0.28 [0.04]***
Constant	3.59 [0.51]***	4.50 [0.59]***	7.34 [0.90]***
No. of observations	756	728	728
Cross-section	27	26	26
Sargan J-test statistics	15.11	10.26	6.41

Notes: The estimation period covers 2005:1–2011:4. Standard deviations are reported under the point estimates in brackets. (*), (**), and (***) indicate statistical significance at 10%, 5%, and 1%, respectively. The Sargan J-statistic indicates the validity of the model. The critical value for the Sargan J-test is 40.11 (38.89), with 27 (26) degrees of freedom at a significance level of 5%. As test statistics is below the critical value, null hypothesis of valid instruments can be accepted.

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[20]   Berrospide and Edge (2010) and Francis and Osborne (2009) also show that larger charge-off rates and provisions support higher capital ratios.
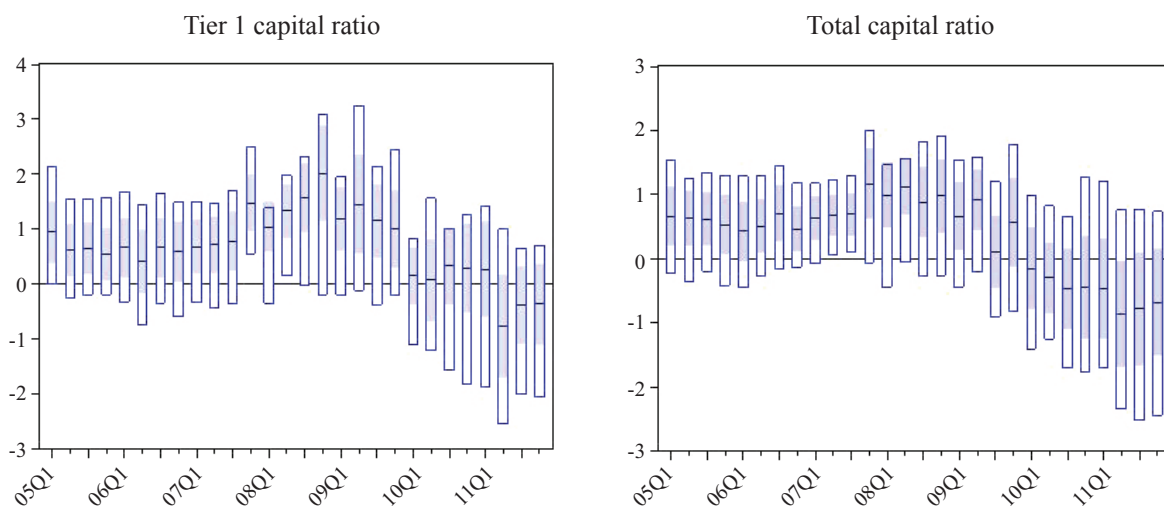
3.2. Deriving the capital gap

Based on the estimated equations for the Tier 1 capital ratio and the total capital ratio, target capital ratios ($k_{i,t}^*$) are computed for each individual bank by making use of the estimated parameters of equation (3) in equation (1).[21] The capital gap, $GAP_{i,t}$, for each individual bank i at time t is subsequently derived as follows:

$$GAP_{i,t} = 100 * \left(\frac{k_{i,t}^*}{k_{i,t-1}} - 1 \right) \tag{4}$$

where $k_{i,t}^*$ represents the bank's target capital ratio at time t and $k_{i,t-1}$ is the bank's actual capital ratio at time t–1. Equation (4) thus presents the deviation of a bank's actual capital ratio in period t–1 from the target at time t in terms of the Tier 1 capital ratio and total capital ratio. A positive (negative) value of the capital gap represents a capital shortfall (surplus) relative to the long-run target capital ratio.

Figure 2
Estimates of the capital gap for the banks in the sample (percentage points)

Notes: The latest observation is 2011Q4. The capital gap is expressed in terms of percentage points (i.e., the needed capital over risk-weighted assets). A positive value indicates a capital shortfall, indicating that banks' actual capital ratio is below the target. The horizontal line in the bars represents the median of the distribution, and the blue area, the 95% confidence intervals. The limits of the boxplots indicate the first and third quartiles of the distribution.
Source: Authors' calculations.

Figure 2 presents the capital gap (expressed in percentage points, i.e., the needed capital over risk-weighted assets) and its distribution across euro area banks over time. The gap regarding the Tier 1 capital ratio is presented on the left-hand side, and the gap regarding the total capital ratio, on the right-hand side. Comparing the two set of results, the gaps estimated for both capital ratios are quite similar. At the beginning of the estimation period, both capital gaps are positive, indicating that the banks lag behind their internal targets. The analysis thus suggests that the banks' capital is not adequate to cover the risks that they are accumulating in their balance sheets. In economic terms, this outcome is logical, as low levels of equity help banks to obtain high short-term ROE and thus profitability, which is lucrative for investors. Implicit government guarantees and moral hazard may have further facilitated the omission of prudent standards. The gaps subsequently start to widen as risks materialise, loan losses increase and the financial crisis

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[21]   Thus, the target capital ratios are bank-specific and vary over time.

deepens in 2007–2008, reaching their highest point of approximately 2.0% in the middle of 2008. From then onwards, the capital gaps start to slowly narrow as the banks are forced to recapitalise.

While the median gap based on the total capital ratio becomes negative in the beginning of 2010, the median gap based on the Tier 1 capital ratio remains positive until the first quarter of 2011. Although median capital gaps diminish towards the end of 2011, variation across banks increases and high heterogeneity between banks remain in the euro area banking sector. While some weak banks continue to lack adequate capital, the estimations suggest that more than a half of the individual institutions do not have a capital shortfall in the beginning of 2011. This result is important since banks with a capital shortfall cannot expect banks with a capital surplus to compensate for their deficit at the sector level. Hence, the situation may be more adverse than the mean capital gap suggests.

3.3. Estimating the adjustment towards the target capital ratio

Banks have several possibilities to close their capital gap by adjusting the liability side or asset side of their balance sheets. However, in practise, the fastest way for a bank to balance its capital position is to issue new equity, to increase retained earnings or to reduce the amount of its loans and the size of its portfolio. However, as issuing equity can be costly during the time of a crisis, we assume in this paper that the adjustment operates mainly through deleveraging.

Thus, in the second step of the estimation, we use the obtained capital gap as an explanatory variable while controlling for macro-variables. A dynamic panel model is estimated for two different balance sheet items, $item_{i,t}$, namely, the total loans and total securities (see equation 5). The estimations are run with two-stage least squares (TSLS) method with cross-sectional fixed effects.

$$\Delta\log(item_{i,t}) = \beta_0 + \beta_1 Gap_{i,t-1} + \beta_2 \Delta\log(GDP_{j,t-1}) + \beta_3 X_{j,t-1} + \beta_4 \Delta\log(item_{i,t-1}) + \varepsilon_{i,t} \qquad (5)$$

We specify the model in growth rates as we are interested in the implications of capital gaps on banks' balance sheets. The explained variables, loans and security holdings, are expressed in terms of quarterly change. And the explanatory variables are also expressed in growth rates or depict a change between two subsequent time periods. The specification also takes into account non-stationary of the variables.

Regarding the capital gap of a bank, $Gap_{i,t-1}$, we use the two alternative variables based on the target Tier 1 capital ratio and the target total capital ratio.[22] In both cases, the capital gap, measured as the difference between the bank's target and actual capital ratio, is expected to have a negative impact. If the capital ratio of a bank is below its target, the gap is positive (see equation 4), and the growth in the balance sheet items should be adversely affected since banks partly deleverage to increase their solvency ratios.

To control for macroeconomic conditions, the annual growth rate of gross domestic product ($GDP_{j,t-1}$) is also included in the model. The variable refers to the economic activity in the country j in which the bank i's headquarter is located.[23] GDP growth is expected to have a positive impact on asset growth and loan growth.

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[22]   We use equations 1 and 2 in Table 1 to calculate the Tier 1 capital gap. Similarly, when deriving the capital gap for the total solvency ratio, equations 1 and 2 in Table 2 are used. These equations incorporate the changes in retained earnings over total assets, expected default frequencies (EDFs) and loan loss provisioning over total assets as explanatory variables.

[23]   The combination of the bank-specific capital gap with country-specific macro-variables reflects the lack of publicly available data that would enable us to consider the geographical dispersion of exposure at the institutional level. Nonetheless, internationally active banks may not be affected by the developments in the home country alone. Still, an individual bank's capital gap is defined at the bank group level, representing a group's capital shortfall/surplus in relation to its overall risk position (including foreign lending).

Other exogenous variables ($X_{j,t-1}$) are incorporated to account for either supply or demand channels. First, we include information from the ECB bank lending survey. In the survey, banks reply to questions concerning the perceived changes in loan demand and questions on banks' own credit standards (indicating supply factors). Loan demand is expected to correlate positively with loan growth, while a tightening (easing) of credit standards is expected to dampen (increase) loan growth and thus to correlate negatively with loan growth. Second, we include stock prices to reflect the overall financing conditions of the economy. Stock prices are expected to correlate positively with the explained variables. Lastly, the dynamic model also includes the lagged growth rate of dependent variable ($item_{i,t-1}$) as well as an error term.

Regarding the instrumental variables, we use the second and third lags of the explanatory variables ($Gap_{i,t-1}$, $GDP_{j,t-1}$ and $X_{j,t-1}$) as instruments.[24] However, the lags for the total loans and total securities ($item_{i,t}$) are not included in the instrument list. As the lagged values of explanatory variables are less likely to be influenced by current shocks, they are expected to perform well. Indeed, based on the statistical examination, the instruments are valid as they are relevant and exogenous.

The results for the estimations on balance sheet adjustments are presented in Table 4 (where the capital gap is calculated on the basis of the Tier 1 capital ratio) and Table 5 (where the capital gap is based on the total capital ratio). The left-hand side of the tables presents the adjustment effect for net loans, while the right-hand side of the tables contains the results for the adjustment of securities portfolio.

Starting with the adjustment of net loans, the capital gap enters the estimations with a negative sign, as expected, and is statistically significant in explaining the development of the loan portfolio. Moreover, GDP growth and loan demand by non-financial corporations (NFCs) are found to be significant in explaining loan growth. The credit standards applied by banks on loans to NFCs appear to exert a negative impact on loans, reflecting the adverse effect of tightening the credit supply; however, this effect is not statistically significant.

The estimated adjustment based on the Tier 1 capital ratio target seems to be somewhat higher than that based on the total capital ratio target. This result reflects the distinct composition of the capital on which capital ratios are based. While Tier 1 capital is more narrowly defined and mainly contains equity capital, which is more readily usable to absorb losses, total capital includes also other capital-like instruments. When risks materialise, Tier 1 equity capital acts as a first line of defence and is more severely affected, as it buffers against losses. Therefore, the capital gap between the target Tier 1 capital ratio and the actual Tier 1 capital ratio induces larger changes in a bank's balance sheet than the capital gap between the target and the actual total capital ratios.

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[24]   In addition, cross-section fixed dummies also serve as instruments.

Table 4
Balance sheet adjustments based on the Tier 1 capital gap

	NET LOANS	SECURITIES
Capital gap	-2.78 [1.66]*	-8.2 [3.35]**
Lagged nominal GDP growth	0.44 [0.17]***	0.14 [0.13]
BLS credit demand NFCs realised	0.07 [0.02]***	.. ..
Annual growth in stock prices	.. ..	0.09 [0.05]**
Lagged explained	-0.31 [0.16]**	-0.41 [0.17]**
Constant	6.60 [2.06]***	11.01 [4.00]***
Long run impact of the capital gap	-2.126	-5.816
No. of observations	624	648
Cross section	26	27

Notes: The estimation period covers 2005Q1 to 2011Q4. Standard deviations are reported under the point estimates in brackets. (*), (**), and (***) indicates statistical significance at 10%, 5%, and 1%, respectively. Net loans exclude interbank loans. NFCs stand for non-financial corporations. Two dots mean that the variable was not used in the model. For the calculation of long-run impact, see footnote 25.

Turning to the adjustment of securities portfolios, a bank's capital gap (i.e., a shortfall of capital with respect to the bank's target), exerts a negative and significant impact on the bank's securities portfolio. Although GDP fails to be statistically significant, its coefficient remains positive. Banks are likely to rely more on market prices than on demand indicators in deciding on their investment portfolios. Indeed, the annual growth of stock prices positively correlates with a bank's securities portfolio, possibly reflecting that swift changes in the market environment and investor expectations positively influence a bank's decision to invest in securities.

Overall, the estimates suggest that the capital gap plays an important role in explaining loans offered within the euro area banking sector throughout the estimation period. Compared to a situation in which banks' actual capital ratios do not deviate from the target, a 1-percentage-point capital shortfall is estimated to reduce loan growth by 2.0 to 2.3 percentage points over the long term.[25] Given that at the trough of the financial crisis, the capital gap is estimated to have reached 2 p.p., banks' adjustment to a higher target capital ratio could have decreased loan growth by more than 4% in cumulated terms.

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[25] The long-run impact is computed by dividing the short-term coefficient of the capital gap (β_1) by the dependent variable's speed of adjustment (λ), which is defined as ($1 - \beta_4$). (See Francis and Osborne, 2009). While the speed of adjustment (λ) is fixed in this set-up, it would be possible to experiment with time and bank-specific adjustment speed. This is, however, beyond the scope of this paper.

Table 5
Balance sheet adjustments based on the total capital gap

| | NET LOANS | | SECURITIES |
	Equation 1	Equation 2	Equation 1
Capital gap	-2.93 [1.23]**	-2.74 [1.05]***	-10.00 [4.04]**
Lagged annual growth in real GDP	.. ..	0.66 [0.25]***	.. ..
Lagged nominal GDP growth	0.61 [0.24]**	.. ..	0.12 [0.15]
BLS credit demand NFCs realised	0.06 [0.02]**	0.08 [0.02]***	.. ..
Annual growth in stock prices	.. ..	.. ..	0.13 [0.05]**
Lagged explained	-0.29 [0.16]*	-0.33 [0.17]*	-0.42 [0.19]**
Constant	5.09 [1.05]***	4.98 [0.98]***	5.61 [2.02]***
Long run impact of the capital gap	-2.262	-2.061	-7.050
No. of observations	648	648	648
Cross section	27	27	27

Notes: The estimation period covers 2005Q1 to 2011Q4. Standard deviations are reported under the point estimates in brackets. (*), (**), and (***) indicates statistical significance at 10%, 5%, and 1%, respectively. Net loans exclude interbank loans. NFCs stand for non-financial corporations. Two dots mean that the variable was not used in the model. For the calculation of long-run impact, see footnote 25.

Based on the estimations, the long-run elasticity of securities portfolios is higher than that of net loans. The estimated long-term elasticity for securities varies by approximately 5.8–7.1 percentage points, well above the corresponding elasticity for loans. This result supports the view that, since the onset of the financial crisis, euro area banks have deleveraged their assets along a "pecking order", reducing securities holdings to a greater extent than the loan supply. This finding can be explained by several factors. First, as the maintenance of customer relationships is an important part of the prevailing banking business model, credit institutions would be reluctant to jeopardise important client relationships by refusing to roll-over existing loans or to grant new ones. Second, the banking sector has received support via a number of government schemes that include conditions to maintain a minimum level of credit growth to the private sector. Third, loans are typically rather illiquid assets, and shedding existing loans from the balance sheet is difficult, particularly during a crisis when the securitisation and syndication markets are at a standstill.

3.4. Robustness

As a robustness test, the second-step estimations are run by defining all the explanatory variables in levels.[26] These estimations confirm the previous results, revealing the capital gap, GDP, credit supply, demand factors and stock prices as significant variables. Moreover, the long-term impact on securities portfolios is again found to be more pronounced than that on net loans, with a long-term impact of approximately 3.4 for securities and 2.4−2.8 for net loans.

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[26]   In this case, instead of equation 5, we estimate the following equation: $item_{i,t} = \beta_0 + \beta_1 Gap_{i,t-1} + \sum_{j=1} \delta_{1,j} GDP_{t-j} + \sum_{j=1} \delta_{2,j} X_{t-j} + \varphi item_{i,t-1} + trend + \varepsilon_{i,t}$.

Our estimates suggest that the deleveraging of loans is relatively stronger in the euro area than in the UK or in the US, as the estimated impact found in this paper is more pronounced than that reported by Berrospide and Edge (2010) and Francis and Osborne (2009). The former authors find that a 1-percentage-point increase in the capital ratio of US banks leads to an increase of 0.7−1.2 percentage points in annualised loan growth in the long term, while the latter authors suggest that the total effect of changes in the regulatory requirements of UK banks is approximately 1.2 percentage points. The differences in the results may be partly explained by the different estimation periods. Francis and Osborne (2009) use British data from 1996 to 2007, and Berrospide and Edge (2010) analyse the 1992Q1−2009Q3 period in the US, while we examine the years of the financial crisis, during which most of the deleveraging took place in the euro area.

In addition, although our estimation methodology broadly follows that of Francis and Osborne (2009) and Berrospide and Edge (2010), some differences remain. Francis and Osborne (2009) implement GMM to estimate the target capital ratio in the first step and use OLS with fixed effects in the second step, as there is no lagged dependent variable in the second-step equations. Berrospide and Edge (2010) estimate OLS with fixed effects for both steps. We apply TSLS with fixed effects in both steps.

4. CONCLUDING REMARKS

Operating above minimum capital requirements, banks maintain an additional capital buffer, which, together with the regulatory requirements, composes banks' internal capital target. Occasionally, banks' actual capital ratios may differ from their internal targets, leading to a capital surplus or deficit vis-à-vis the target. If a bank's capital position constitutes a deficit, pressures to close its capital gap and to increase its solvency ratios may trigger an adjustment process. To restore its capital ratios, the bank may reduce lending or otherwise adjust its balance sheet. Indeed, the recent financial crisis has highlighted the importance of financial intermediary characteristics and equity capital as determinants for the provision of credit to borrowers. As a continuous flow of credit is of vital importance to maintain investment and real activity, banks' capital gap and implied deleveraging pressures are important issues for the conduct of monetary policy.

In this paper, we have estimated a partial adjustment model in a panel context using various indicators to examine the impact of risk in a bank's balance sheet on the bank's internal target capital ratio and to determine the implications of closing the capital gap on the bank's lending and securities holdings. Our paper adds to the literature by concentrating on euro area banks and by providing evidence on the impact of deleveraging pressures during the latest financial crisis, while previous studies have disentangled the effects in the US and UK banking sectors over different time periods, during which such pressures may have been more difficult to detect.

We provide empirical evidence that the internal capital targets play a significant role in the adjustment of euro area banks. Based on the estimates, we find undercapitalisation in terms of the Tier 1 capital ratio close to 2.0 p.p. in the middle of 2008, and the negative gap remains at the end of 2010. Movement in internal target capital ratios arises from changes in banks' risks and earnings, although the estimated range of the impact remains large. Only from 2010 onwards, the capital gaps start to narrow as the banking sector is slowly recovering from the crisis. The heterogeneity across banks nevertheless remains considerable. The results for the total capital ratio are similar.

As our results show bank undercapitalisation in relation to banks' risks and earnings just before the onset of the latest financial crisis, the new Basel III capital and liquidity requirements as well as new macroprudential policy measures seem well-placed. The purpose of these new regulatory initiatives is to strengthen banks' capital and liquidity positions, improve the quality of the capital and decrease bank leverage. All these measures should reduce the vulnerability of

the banking sector and improve financial stability, making the occurrence of financial crisis less frequent.

The undercapitalised banks tend to restrict the provision of loans to the economy, as the relatively higher cost of bank equity leads banks to deleverage in order to reach their target capital ratios. Regarding the banks efforts to close the capital gap, we find evidence for significant impact on lending in the euro area. The estimates indicate that closing a 1 p.p. capital gap dampens loan growth by between 2.0 and 2.3% in the long-term. Given that at the trough of the financial crisis, the capital gap is estimated to have reached 2 p.p., banks' adjustment to a higher target capital ratio could have decreased loan growth by more than 4% in cumulated terms. Compared to loans, the impact on security holdings is found to be more pronounced and to be approximately 5.8−7.1%. The results thereby suggest that euro area banks have deleveraged their assets along a pecking order.

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