Bank capital, bank lending, and monetary policy in the euro area

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Abstract

This paper provides arguments and evidence in favour of the hypothesis that bank capital matters for euro area banks' loan response to a change in monetary policy. Bank-level panel data estimates for 1991-1999 show that the lending behaviour of the least-capitalised banks in France and Italy is more responsive to a change in monetary policy than that of better capitalised banks. The degree of capitalisation also matters for the monetary policy impact on lending of the key players in the German and euro area banking system. These findings suggest that the new Basle capital requirements can affect the monetary transmission channel through bank capital.

Keywords: bank capital; monetary policy; bank lending channel; bank balance sheet channel; panel data

JEL classification: C23; E52; G21

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I. Introduction

The way in which changes in monetary policy are transmitted into real economic activity has always been a topic of great interest to economists and monetary policy authorities. Consequently, the transmission mechanisms by which these effects occur have been extensively studied in macroeconomics. In the recent decade the so-called credit channel has received much attention in the monetary policy transmission debate (*de Bondt*, 2000, and *Angeloni et al.*, 2003). The credit channel focuses on the special role banks play in the financial system, arising from the fact that banks ameliorate asymmetric information problems between borrowers and lenders. Partly as a result of this role, banks have been the most important form of financial intermediation in the euro area and are the only source of access to external financing for a large number of borrowers. One consequence of the credit channel is that the general conditions of the banking sector and the specific characteristics of individual banks can have an impact on the monetary policy transmission.

The existence of a credit channel has therefore been typically examined on the basis of bank-specific data. The pioneering studies by *Kasyhap and Stein* (1995) for the U.S. and *de Bondt* (1999) for Europe initiated a myriad of further studies (*Favero et al.*, 1999, *Kasyap and Stein*, 2000, *Kishan and Opiela*, 2000, *Ehrmann et al*., 2001 and 2003, *Altunbaş et al.*, 2002, and *Gambacorta and Mistrulli*, 2003 and 2004). The main innovation of these studies is the additional role banks may play in the monetary policy transmission process. Banks grant credit to firms and households in addition to their role in supplying money. Hence, a smooth transmission of monetary policy critically hinges on the conditions of the banking sector. Indeed, when banking problems emerge they tend to have a substantial impact on the economy. Historical experience suggests that distressed banking systems leading to adverse credit conditions have been one of the most important sources of macroeconomic contractions for a large number of countries, such as Spain in the early 1980s, Scandinavian countries in the early 1990s, and Japan in the late 1990s.

Among the different characteristics of banking institutions, and partly as a result of market, technological, and regulatory forces, bank capital has become a major element influencing bank behaviour. The importance of bank capital derives from its influence on banks' risk-taking incentives, its role promoting efficient corporate governance of the banking sector and its influence on the competitiveness of banks (*Santos*, 2001). This has been widely recognised by regulators that have given bank capital an increasingly prominent role in prudential regulation. Empirical and theoretical studies analysing the impact of bank capital on bank behaviour have regained prominence in recent years in light of the proposed new Basle Accord on capital requirements (*Jackson*, 1999, and *Santos*, 2001).

This study explicitly focuses on whether the impact of monetary policy on bank lending depends on the degree of bank capitalisation. It examines the three largest banking systems in the euro area, i.e. Germany, France and Italy, and the largest banks in the euro area between 1991 and 1999. The motivation to examine the role of bank capital in lending and the monetary transmission mechanism is twofold. First, capital crunch stories gain in popularity during recessions, for instance during the U.S. downturn in the early 1990s. Second, bank capital is a hot topic in the context of revising the Basle minimum capital requirements. This debate in itself already suggests that bank capital is not irrelevant for bank lending.

Our main message is that the level of bank capital matters for the lending response of banks to a change in monetary policy. Lending of the least-capitalised banks in France and Italy is more responsive to a change in monetary policy than that of the better capitalised banks. Furthermore, the degree of capitalisation matters for the monetary policy impact on lending of the key players in the German and euro area banking system. The regression results also show that following a monetary tightening the least-capitalised banks have reduced their liquid assets and interbank lending more pronouncedly than other banks. Overall, the regression results suggest that loan supply effects from a bank lending channel, e.g., a forced decline in bank loans due to a decline in reservable bank liabilities following a monetary tightening, are partly mitigated by an active asset and liability management by banks in the form of reducing their securities portfolio and interbank lending. At the same time, a bank balance sheet channel via bank capital is found to be operative in the euro area. The latter transmission channel means that banks' loan responses following a change in monetary policy depend on their balance sheet positions, which, in turn, depends on the degree of capitalisation. This also implies that the introduction of the new Basle capital requirements can affect this bank balance sheet channel via its impact on capital constraints and the funding costs of banks.

The remainder of this paper is organised as follows. Section 2 reviews the theoretical studies on why bank capital might matter for bank lending and monetary policy. Section 3 highlights the empirical studies in this field of research. Section 4 introduces the empirical methodology and the data. Section 5 presents and discusses the empirical results. Section 6 provides concluding remarks. Appendix A sketches a theoretical model on why bank capital might matter for the impact of monetary policy on bank lending. Appendix B presents, as a robustness test, estimation results based on a different split of the sample along bank capital.

II. Theoretical literature review

Two main theoretical motives appear in the literature on why bank capital might affect the monetary policy transmission process via bank lending: i) a bank lending channel and ii) a bank balance sheet channel. Both channels derive from failures of the Modigliani-Miller theorem for banks, but the nature of the failure is somewhat different in each case. In a Modigliani-Miller world of perfect capital markets, banks' lending decisions are independent of their financial structure. As banks will always be able to find investors willing to finance any profitable lending opportunities, the level of bank capital is irrelevant to lending, and thus to the monetary transmission mechanism.

Firstly, a *bank lending channel* assumes that monetary policy affects the liability side of bank balance sheets and that there are no perfect substitutes for bank loans, either on the asset side of bank balance sheets or on the liability side of borrowers (see, among many others, *Bernanke and Blinder*, 1988, *Gertler and Gilchrist*, 1993, *Bernanke and Gertler*, 1995, and *Trautwein*, 2000). According to this theory a monetary policy tightening results in a decrease in reservable liabilities, which in turn lead banks to reduce lending due to the fall in funding sources. In other words, a bank lending channel contends that after monetary policy tightening banks are forced to reduce their loan portfolio due to a decline in total reservable bank deposits.

It is questionable, however, whether or not monetary policy in practice directly affects bank liabilities. The indirect impact of a change in monetary policy on total bank liabilities is also not straightforward. Another critique of the bank lending channel is that banks can easily switch to alternative forms of financing, that is non-deposit sources of loan funding, for instance by issuing certificates of deposits, as first stated by *Romer and Romer* (1990). A final critique is that banks can liquidate assets other than loans, most likely liquid assets, for example by selling treasury securities to counteract a reduction of their liabilities

Implications of this bank lending channel are, and it should be born in mind that it is only here that bank capital is introduced, that monetary policy has distributional effects. For instance, poorly capitalised bank will only be able to issue certificates of deposits at very high costs. In this line, *Chami and Cosimano* (2001) argue that in the presence of imperfect competition in the banking industry, the marginal costs of external finance for banks increase, following a monetary policy tightening. Another distributional effect to offset a bank lending channel is that monetary policy is expected to have a relatively strong impact on banks with a small buffer stock of liquid assets, such as treasury securities, because these banks are less able to sell these when their deposit base shrinks. Monetary policy will also have a strong impact if households and firms are highly reliant on external finance for their financing needs because borrowers will be less able to resort to internal finance.

Secondly, a *bank balance sheet channel* assumes that monetary policy is among the factors that might affect the balance sheet or net worth position of banks and thereby bank lending. Following a monetary policy tightening, all other things being equal, banks' experience a decline in profits. This is because banks' assets typically have a larger duration than their liabilities. Consequently, banks experience a decline in profits following a monetary tightening, since a larger number of deposits than loan contracts would be renegotiated. Under this circumstance, for some banks, bank capital might become less than optimal either from a regulatory, market or bank's internal perspective (*de Bondt and Prast*, 2000). As there is an imperfect market for bank equity, these banks might be forced to restrain their lending to achieve their required capital position.

Similarly, from a regulatory perspective, capital requirements establish a minimum ratio of capital to risk weighted assets. With regulatory binding capital requirements, a bank cannot expand lending without raising additional capital, which for poorly capitalised banks could become prohibitively expensive in the short term. *Van den Heuvel* (2002a and 2002b) argues that the interest rate mismatch between bank assets and liabilities faced by banks is the key driver for changes in banks' balance sheet positions. This idea is based on *Froot and Stein* (1998), which show that bank's capital budgeting and risk management considerations should factor into the pricing of bank products the risks that cannot be easily hedged. Under the assumption that banks fail to fully hedge interest rate risk, a change in monetary policy affects the interest rate mismatch of banks. The change in the interest rate mismatch, in turn, has an impact on the value of bank capital and therefore on the supply of loans. In a dynamic framework, bank capital positions could also matter when capital is not regulatory binding, because banks are forward-looking and take into account the possibility of a market or regulatory restriction in the future. More generally, changes to bank profits, such as loan defaults indirectly induced by a restrictive monetary policy, can have an impact on bank lending.

Appendix A presents a theoretical model on why bank capital might matter for the monetary policy impact on bank lending in order to put our empirical results into a theoretical perspective.

III. Empirical literature review

U.S. studies tend to show a relationship between bank capital and loan growth and that the impact of monetary policy on the supply of loans depends on the degree of bank capitalisation. In contrast, euro area evidence analysing the transmission of monetary policy is rather inconclusive on whether bank capital matters for the impact of monetary policy on lending.

From a monetary policy perspective, *Kishan and Opiela* (2000) show that in the U.S. bank capital matters for the impact of monetary policy on the supply of loans. In parallel to this literature, a number of related studies analyse the impact of bank capital regulation on banks' lending behaviour in the early 1990s. *Peek and Rosengren* (1995a and 1995b), *Brinkmann and Horvitz* (1995), *Berger and Udell* (1994) and *Hancock and Wilcox* (1993, 1995, and 1998) argue that low bank capital levels and the introduction of risk-based capital requirements explain the severity of the 1990-1992 U.S. credit crunch. For instance, *Peek and Rosengren* (1995a) find for the U.S. that loans from banks with explicit regulatory bank capital enforcement actions shrunk at a significantly faster rate than loans from those banks without such enforcement. Another study by *Peek and Rosengren* (1995b) finds empirical support for a capital crunch, whereby poorly capitalised institutions reduce lending more than their better-capitalised peers, indicating an independent role for credit supply.

Turning to euro area evidence, a bank-level panel data study by *de Bondt* (1999) finds for five euro area countries some evidence in favour of a bank lending channel. The impact of monetary policy on bank lending behaviour depends generally on bank size and bank liquidity. *Favero et al.* (1999) investigate the response of banks in Germany, France, Italy and Spain to the monetary tightening during 1992. Although they find no evidence of a bank lending channel in any of the countries, French banks were found to have used their excess capital to maintain lending levels. *Ehrman et al.* (2001 and 2003) show that, in contrast to bank liquidity, neither capitalisation nor bank size play a role in distinguishing banks' lending behaviour in euro area countries. They explain the absence of bank size and capitalisation effects by arguing that a low degree of informational asymmetries exits in the euro area compared with the U.S. The role of the government, relationship banking, banking networks, as well as the historically low number of bank failures in euro area countries may have contributed to a reduction in information frictions. Bank-level panel data estimates for the euro area and for Germany and France by *Altunbaş et al.*

(2002) show little evidence of a lending channel via either bank size or capital strength. In contrast, *Gambacorta and Mistrulli* (2003 and 2004) find evidence for Italy in favour of a bank lending as well as a bank balance sheet channel. Using quarterly data for the period 1992-2001, they show that well-capitalised Italian banks shield their lending from monetary policy shocks comparably better than other banks as they have easier access to non-deposit fund raising. They also find evidence that co-operative Italian banks whose balance sheets are characterised by a large maturity mismatch between assets and liabilities and therefore a substantial interest rate mismatch show relatively strong monetary policy effects.

IV. Methodology and data

The methodology considered is similar to the frameworks used by previous bank-level panel data studies. The main contribution of this paper is the explicit focus on the loan impact of the degree of capitalisation irrespective of bank size. As shown in the previous section, the empirical findings for euro area countries suggest that different bank size categories might not be an appropriate bank-specific factor to examine the impact of monetary policy on bank lending.

We note that it is difficult to empirically distinguish between the traditional interest rate channel and the bank lending and balance sheet channel. The credit channel mainly depends on the financial situation of lenders and borrowers and the substitution between bank loans and other sources of debt finance, such as commercial paper (*Kashyap et al.*, 1993 and 1996). The latter substitution, however, rarely took place before 1999 in euro area countries, with the exception of France (*de Bondt and Lichtenberger*, 2003). Indeed, bank loans are the only source of external finance for households and almost exclusively for euro area non-financial corporations during the period under review. The corporate bond market in the euro area has only become a deep and broad market since the introduction of the euro (*de Bondt*, 2002). It would be warranted to match bank data with individual information on credit risk and the financial position of borrowers, for instance via the use of data from credit registers, to disentangle further between on the one hand the interest rate channel and on the other hand the bank lending and balance sheet channel. Our focus is, however, more limited. Following *Kishan and Opiela* (2000), we examine the possible effect that banks' capital positions might have on bank lending. Hence the only main assumption needed here is that the reaction of loan demand across banks does not differ substantially among borrowers along the degree of bank capitalisation.

Using individual bank-level data, the growth in bank loans (*LOAN*), is regressed on the current period and lagged values of changes in the short-term interest rate (*STIR*), deposits (*DEPO*), bank securities holdings (*SECU*), interbank lending (*INTERB*), the growth of the gross domestic product (*GDP*), and the lagged change in bank lending. Due to the inclusion of lags of the dependent variable, this study employs the GMM estimator suggested by *Arellano and Bond* (1991). This ensures efficiency and consistency of our estimates, provided that the instruments are adequately chosen to take into account the serial correlation properties of the model. The estimated empirical model is a dynamic version of equation

(19) and read as follows, with index *i* referring to bank *i*, t to period *t* and (1) to a one-period lag of the respective variable.

$$\Delta LOAN_{it} = \alpha_i + \beta_1 \Delta STIR_{it} + \beta_2 \Delta STIR(1)_{it} + \beta_3 \Delta DEPO_{it} + \beta_4 \Delta DEPO(1)_{it} + \beta_5 \Delta SECU_{it} + \beta_6 \Delta SECU(1)_{it} + \beta_7 \Delta INTERB_{it} + \beta_8 \Delta INTERB(1)_{it} + \beta_9 \Delta GDP_{it} + \beta_{10} \Delta GDP_{it}(1) + \beta_{11} LOAN(1)_{it} + u_i \quad (1)$$

The short-term market interest rate is the indicator used of the monetary policy stance, in line with most studies. Deposits are included to control for the traditional deposit funding effects on loans. Bank holdings of securities are included given the role these liquid assets play in a bank lending channel in the sense of substituting between liquid securities and illiquid loans, shielding their customers and thus their loan portfolio from a change in monetary policy. Interbank lending is included because it might play a similar buffer role, as documented for Germany (*Ehrmann and Worms*, 2001, and *Worms*, 2003). GDP is included to control for demand factors, bearing in mind that tests of a bank lending and bank balance sheet channel aim to identify only loan supply effects. The model specification includes a number of one-period lagged variables to distinguish between contemporaneous and lagged responses.

The data are identical to those described in *Altunbaş et al.* (2002). Individual bank balance sheet data in eleven euro area countries for 1991-1999 are retrieved from BankScope, a database of annual bank account figures. In terms of data, there are two important caveats, which potentially apply to most euro area cross-country banking studies.

First, differences in accounting standards could distort the results of studies using cross-country data. To take this factor into consideration, we only look at the largest banks when considering a cross-border euro area sample. The key players in the euro area banking system are defined as banks with a balance sheet total above EUR 500 million. This recognizes that the implementation of the International Reporting Standards (IFRS) in the European Union is fostering harmonization of accounting standards in Europe particularly for the largest banks.[1] However, when considering larger samples, comprising banks from different sizes, we prefer to run the model for each individual country separately. By doing this, it is ensured that banks from each sample face the same accounting standards and broadly similar economic conditions. In contrast to the national results, the euro area findings may to some extent be distorted by cross-country differences in the accounting and regulatory rules. It is, however, unclear whether differences in accounting practices at the euro area level relate to the degree of bank capitalisation.

Another caveat is that in the euro area there are substantial institutional differences across the national financial systems. A particularly special case is Germany where there are around 3000 banks, of

[1] See European Commission Regulation No 1725/2003 of 29 September 2003 adopting International Accounting Standards in accordance with Regulation (EC) No 1606/2002 of the European Parliament.

which around 80% are German savings and credit co-operative banks which are not strictly profit maximizing entities (*Krahnen and Schmidt*, 2004). Moreover, German savings and credit co-operative banks have almost exclusively close relationships with the head institutions of their respective sector. These institutional factors may have substantial implications on the structure of the interbank market. In fact, German savings ("Sparkassen") and credit co-operatives ("Volksbanken" and "Raiffeisenbanken) hold around 75% and 90%, respectively, of their interbank assets vis-à-vis their head institutions, e.g. the largest savings and credit co-operative banks (*Ehrman and Worms*, 2001, and *Worms*, 2003). This structure of the German financial system is likely to have implications from a monetary policy transmission perspective. For this reason, we examine also a German sample, which covers all German commercial banks and the largest savings and credit co-operative banks.

The number of observations is divided across three capital strength categories by splitting the sample along uniform levels of the equity capital to total asset ratio, in line with the methodology used by *Kishan and Opiela* (2000). In this sample split banks scoring below an equity-assets ratio of 5% are judged as "least-capitalised," above 5% and smaller than 10% as "medium capitalised," and exceeding 10% as "best-capitalised", respectively. This division of banks according to the simple capital to total assets ratio seems to make sense from an empirical perspective. *Estrella et al.* (2000) investigate whether there is any informational content in terms of risk of failure, derived from the simple capital to total assets ratio as opposed to risk weighted capital ratios. Their results show that capital to assets ratios (simple leverage ratios) and gross revenue ratios predict failure much better than more complex risk weighted ratios over the short term (one or two years). For the euro area, *Marqués* (2001) shows similar results. Appendix B presents, as a robustness test, the estimation results based on a different sample split along three bank capital quintiles: the 20% banks with the lowest bank capital ratios, between 20% and 60% and the 20% banks with the highest bank capital ratio.

V. Results

Evidence on Germany, France, and Italy

Table 1 and B.1 provide the estimates of model equation (1) for Germany, France, and Italy. Overall the results suggest that bank capital matters for the impact of monetary policy on lending in France and Italy, whereas the German picture is less clear.

Two conclusions emerge. First, for France and Italy it is found that the impact of a monetary policy contraction on loan growth is most strongly negative for the least-capitalised banks, is slightly negative for medium-capitalised banks and is even significantly positive for the best-capitalised banks. In other words, poorly capitalised banks reduce comparatively strongly their loan portfolio in case of a monetary tightening as suggested by a credit channel. Prima facie, the negative GDP effect on loan growth as found for France is surprising. A negative relation between the degree of risk aversion by French banks and excess capital, e.g., capital above the required capital can, however, explain this result (see Appendix A). In addition, firms might turn to bank lending as opposed to market financing during periods of an economic slowdown. This argument particularly applies to France, because the French commercial paper and corporate bond market was much more developed compared to other euro area countries in the 1990s (*de Bondt and Lichtenberg*, 2003). In Germany the impact of a change in the short-term interest rate on loan growth is ambiguous. Even the signs are not consistent between the contemporaneous and one-period lagged short-term interest rate change. A likely explanation for this is the structure of the German interbank market. The least-capitalised German banks are able to offset a contractionary monetary policy by reducing their interbank borrowing. German savings and credit co-operative banks are accessing interbank funds through their head institutions, as discussed in the previous section and empirically examined by *Worms* (2003). The next section explores this further. Second, in Germany and Italy the least-capitalised banks reduce their securities portfolio by more than better capitalised banks. This could suggest that poorly capitalised banks use securities as a buffer stock and substitute between liquid securities and illiquid loans. In contrast, in France the strongest reduction of securities is observed for the best-capitalised banks. Although one could argue that a bank securities portfolio may be affected by a revaluation effect, there is no reason why this impact should differ along bank capital within a country with the same accounting practice. The possible effect of changes on interest rates on the value of fixed income securities is rather limited, as the overwhelming majority of European banks valued their fixed income securities using book value accounting procedures in the 1990s. This argument could, however, become a relevant factor in the future under the new International Financial Reporting Standards.

All in all, the results emphasise the role of liquid assets to shield the illiquid banks' loan portfolio from a monetary policy tightening. At the same time, the results are supportive for a bank balance sheet channel of monetary policy through bank capital, at least for France and Italy. The latter is in contrast with previous findings for euro area countries (*Ehrmann et al.* 2001 and 2003, and *Altunbaş et al.* 2002).

Table 1 Loan growth and the monetary policy impact along bank capitalisation, 1991-1999

	Germany			France			Italy		
	Capitalisation			Capitalisation			Capitalisation		
	Least	Medium	Best	Least	Medium	Best	Least	Medium	Best
ΔSTIR	-0.15§	0.03	-1.33§	-0.34§	-0.04§	0.11§	-0.36§	-0.01	0.11§
	(0.04)	(0.08)	(0.20)	(0.04)	(0.01)	(0.03)	(0.05)	(0.01)	(0.01)
ΔSTIR(1)	0.03‡	-0.06§	0.15§	-0.19§	-0.07§	0.10§	-0.12§	-0.02‡	0.06§
	(0.01)	(0.02)	(0.04)	(0.03)	(0.01)	(0.02)	(0.03)	(0.01)	(0.01)
ΔSECU	-0.32§	-0.01§	-0.17§	-0.18§	-0.08§	-0.28§	-0.55§	-0.19§	-0.01
	(0.01)	(0.00)	(0.04)	(0.03)	(0.01)	(0.02)	(0.11)	(0.03)	(0.01)
ΔSECU(1)	-0.10§	-0.02§	-0.02	-0.06§	-0.05§	-0.12§	-0.46§	-0.08§	0.01‡
	(0.01)	(0.00)	(0.02)	(0.01)	(0.01)	(0.01)	(0.10)	(0.01)	(0.01)
ΔDEPO	0.96§	0.39§	1.25§	1.02§	0.76§	0.73§	1.61§	1.06§	0.54§
	(0.01)	(0.02)	(0.06)	(0.06)	(0.02)	(0.02)	(0.39)	(0.04)	(0.01)
ΔDEPO(1)	0.24§	0.39§	0.23§	-0.04‡	0.50§	0.23§	1.59§	0.35§	0.09§
	(0.01)	(0.02)	(0.04)	(0.02)	(0.02)	(0.01)	(0.35)	(0.01)	(0.01)
ΔINTERB	-0.06§	0.09‡	0.04	0.25§	-0.04§	0.01	-0.33	0.02‡	0.06§
	(0.00)	(0.02)	(0.03)	(0.04)	(0.00)	(0.01)	(0.30)	(0.01)	(0.01)
ΔINTERB(1)	-0.02§	0.04§	0.05*	0.14§	0.01*	0.04§	-0.67‡	-0.01	0.01*
	(0.00)	(0.01)	(0.03)	(0.01)	(0.00)	(0.00)	(0.29)	(0.01)	(0.00)
ΔGDP	0.19§	0.27‡	1.64§	-1.94§	-0.06	-2.23§	-0.23	-0.08	-0.33§
	(0.07)	(0.14)	(0.49)	(0.39)	(0.29)	(0.47)	(0.32)	(0.06)	(0.02)
ΔGDP(1)	-0.84§	0.56	-8.74§	-1.73§	0.13	-1.66‡	0.68§	0.24§	-0.08§
	(0.23)	(0.48)	(1.11)	(0.25)	(0.14)	(0.70)	(0.24)	(0.04)	(0.03)
ΔLoan(1)	-0.06§	-0.51§	-0.17§	-0.07§	-0.36§	-0.23§	-0.59§	-0.36§	-0.13§
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.12)	(0.02)	(0.00)
Intercept	-0.01§	0.01§	-0.06§	0.01	0.01§	-0.02§	0.01	0.04§	0.06§
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.01)	(0.02)	(0.00)	(0.00)
Observations	1570	618	162	552	512	322	63	367	213

*Notes: §, ‡ and * indicate significance at the 1%, 5% and 10% levels, respectively. The standard errors of the coefficients are in parenthesis. ΔSTIR is change in nominal short term interest rates; ΔSECU is change in total securities holdings; ΔDEPO is change in total deposits; ΔINTERB is change in interbank borrowings; ΔGDP is change in growth rate of Gross Domestic Product. ΔLOAN is the change in total loans; (1) denote one-period lag of the respective variable.*

Evidence on the key German and euro area banks

Table 2 and B.2 provide the estimates of equation (1) for German banks, excluding the non-largest savings and credit co-operative banks, hereafter denoted by "key German banks", and the largest banks in the euro area. The sample of the key German banks takes into account the importance of the interbank market for savings and credit co-operative banks. The estimates suggest that bank capital matter for the impact of monetary policy on lending of the key players in the German and euro area banking system.

Table 2 Loan growth and the monetary policy impact along bank capitalisation, 1991-1999

	Key German banks			Largest euro area banks		
Capitalisation	Least	Medium	Best	Least	Medium	Best
ΔSTIR	-0.05	-0.34§	-0.71*	-0.08§	0.02‡	-0.01
	(0.04)	(0.08)	(0.43)	(0.03)	(0.01)	(0.03)
ΔSTIR(1)	-0.07§	-0.20§	-0.12	-0.14§	0.02‡	0.01
	(0.01)	(0.02)	(0.08)	(0.02)	(0.01)	(0.02)
ΔSECU	-0.05§	-0.11§	-0.17§	-0.07	-0.01‡	0.02
	(0.01)	(0.01)	(0.05)	(0.05)	(0.00)	(0.07)
ΔSECU(1)	-0.29§	-0.04§	-0.01	-0.08§	-0.02§	-0.05
	(0.01)	(0.00)	(0.04)	(0.02)	(0.00)	(0.05)
ΔDEPO	0.68§	1.08§	1.36§	1.27§	0.32§	-0.02
	(0.02)	(0.02)	(0.05)	(0.06)	(0.01)	(0.11)
ΔDEPO(1)	0.57§	0.33§	0.26§	0.15§	0.03§	0.09
	(0.02)	(0.02)	(0.05)	(0.02)	(0.00)	(0.11)
ΔINTERB	-0.14§	-0.03‡	0.05*	-0.14§	0.12§	0.01
	(0.00)	(0.01)	(0.03)	(0.01)	(0.00)	(0.01)
ΔINTERB(1)	-0.08§	-0.01§	0.05	-0.03§	0.03§	0.01
	(0.01)	(0.00)	(0.03)	(0.01)	(0.00)	(0.01)
ΔGDP	0.01	0.83§	1.24	0.48§	-0.14§	-0.58
	(0.07)	(0.14)	(0.88)	(0.15)	(0.04)	(0.44)
ΔGDP(1)	0.95§	-0.19	-4.21*	0.47§	0.22§	0.27
	(0.27)	(0.52)	(2.50)	(0.15)	(0.04)	(0.30)
ΔLoan(1)	-0.20§	-0.22§	-0.15§	-0.06§	-0.04§	-0.30‡
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.14)
Intercept	0.01‡	0.04§	-0.03*	0.02§	0.01§	0.01
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.01)
Observations	365	257	131	853	404	48

*Notes: §, ‡ and * indicate significance at the 1%, 5% and 10% levels, respectively. The standard errors of the coefficients are in parenthesis. ΔSTIR is change in nominal shortterm interest rates; ΔSECU is change in total securities holdings; ΔDEPO is change in total deposits; ΔINTERB is change in interbank borrowings; ΔGDP is change in growth rate of Gross Domestic Product. ΔLOAN is the change in total loans; (1) denote one-period lag of the respective variable.*

Three conclusions emerge. First, the impact of a monetary policy contraction on loan growth is significantly negative for the least and medium-capitalised key German banks and for the least-capitalised largest banks in the euro area. The result that the bank lending response on monetary policy depends on the degree of bank capitalisation suggests that a bank lending and bank balance sheet channel might be operative. This conclusion is also consistent with the results obtained for all German banks using different sample splits (see Appendix B). The second finding is that the decline in the securities holdings by banks is most strongly for the least-capitalised banks, suggesting that bank lending channel effects could be partly offset by an active asset and liability management by banks. The third and final empirical finding is that banks probably also use their interbank borrowing to shield their loan portfolio from a monetary contraction. The least-capitalised key German banks and largest euro area banks reduce their interbank lending the most strongly, whereas the best-capitalised banks increase their interbank borrowing.

Overall, the results are supportive for the existence of a bank balance sheet channel of monetary policy through bank capital of the key German and euro area banks. However, a bank lending channel seems to be rather weak due to the fact that an active asset and liability management by banks via securities and interbank borrowing mainly offset changes in monetary policy.

VI. Conclusion

This paper contributes to previous bank-level panel data studies by examining loan supply effects in relation to the degree of bank capitalisation in the euro area. Poorly capitalised banks are found to be relatively responsive to a monetary tightening and to reduce their securities holdings and interbank lending relatively strongly. These results suggest that a bank balance sheet channel is operative in the euro area and that a bank lending channel is probably offset by an active asset and liability management by banks. This has important implications for the conduct and effects of monetary policy and it revisits the connection between monetary policy and stability in the banking sector. Although banking stability is not a primary objective for central banks, central banks benefit of awareness of risks posed to banking stability. Consequently, there is a need for monitoring banking stability in general and the degree of bank capitalisation in particular from a monetary policy perspective in order to assess the transmission of monetary impulses.

Given our finding that bank capital matters for the extent of the impact of monetary policy on bank lending, there are several avenues of future research. An immediate topic of interest is to analyse the impact of the proposed Basle II capital requirements on the relation between bank lending and monetary policy transmission, including its potential pro-cyclical impact. Another issue for further research is a better understanding of how the (institutional) differences between banks and other financial intermediaries can affect the relation between bank capital and the transmission of monetary policy.

Appendix A Theoretical model on bank capital, bank lending, and monetary policy

This Appendix introduces a theoretical model, which illustrates why bank capital might matter for the impact of monetary policy on bank lending. It provides a basis for the theoretical foundation of our empirical model equation (1) in the main text. The one-period model of a representative bank originates from *Gambacorta and Mistrulli* (2003 and 2004). *Froot and Stein* (1998), *Bolton and Freixas* (2000), *Chami and Cosimano* (2001), and *Van den Heuvel* (2002a and 2002b) provide more elaborated models from a theoretical perspective.

A simplified version of a bank balance sheet is:

$$L + S = D + B + K \qquad \text{(A.1)}$$

with L the amount of loans outstanding, S the amount of other, mostly liquid, assets, D deposits, B bank bonds, and K bank capital. Bank bonds comprises both bank bonds issued to the market, such as subordinated debt, and interbank debt.

Under monopolistic competition, the interest rate on loans, i_l, for a given loan demand and macroeconomic conditions is:

$$i_l = c_0.L^d + c_1.i_m + c_2.y + c_3.p + \eta \text{, } c_0 < 0, c_1 > 0, c_2 > 0, c_3 > 0 \qquad \text{(A.2)}$$

where i_l is determined by loan demand, L^d, the risk-free interest rate, approximated by the monetary policy rate, i_m, real GDP, y, the price level, p, and a risk premium, η.

Bank capital is divided into capital required for regulatory or internal reasons, K^r, and a buffer or excess capital, K^b. Negative values of the buffer capital are extremely costly for banks. Assuming no equity issuance by the bank, realised profits or losses, π, determine capital in the next period:

$$K_t = K_t^{\,r} + K_t^{\,b} = K_{t-1} + \pi_t \qquad \text{(A.3)}$$

The amount of required capital depends, in spirit of the Basle I capital requirements, on a fixed amount of risky assets, L:

$$K^r = k.L \text{, } 0 < k < 1 \qquad \text{(A.4)}$$

At the beginning of period t before the actual supply of credit is decided, the strategic credit profile is determined by bank management, depending on the bank risk aversion, θ, where $\theta=0$, when the bank is risk neutral. Hence, the risk premium equals:

$$\eta = \eta_0 + \eta_1.\theta \text{, } \eta_0 > 0, \eta_1 < 0 \qquad \text{(A.5)}$$

The bank risk aversion, in turn, relates, negatively or positively, to the buffer capital at the end of the previous period, in line with studies linking capital and risk:

$$\theta = \mu.K_{t-1}^b \text{, } \mu <, > 0 \qquad \text{(A.6)}$$

The proportion of defaulting or non-performing loans, j, depends negatively on economic activity (y) and on the chosen risk position of the bank:

$$j = j_0.y + j_1.\theta.y + j_2.\theta \text{, } j_0 < 0, j_1 < 0, j_2 < 0 \qquad \text{(A.7)}$$

For liquidity management reasons the amount of liquid assets is a fixed share of deposits:

$$S = s.D \text{, } 0 < s < 1 \qquad \text{(A.8)}$$

The demand for deposits is negatively related to the monetary policy rate:

$D = d.i_m$, 0 < d < 1 (A.9)

The interest rate paid on bank bonds, i_b, includes a premium over the monetary policy rate negatively linked to the previous period buffer capital, since the buffer capital determines to a large extent the credit rating of the bank and thus the funding cost of bank loans.

$$i_b = i_m + b_o K_{t-1}^b + b_1 i_m K_{t-1}^b, \; b_0 < 0, \; b_1 < 0 \quad \text{(A.10)}$$

The effect of changes on monetary policy interest rates on bank costs, C^{MT}, due to the maturity transformation role of banks is:

$$C^{MT} = \rho_{t-1}.\Delta i_m (L + S), \; \rho > 0 \quad \text{(A.11)}$$

where ρ depends on the interest rate sensitivity and (unhedged) maturity mismatch of each bank. Since loans typically tend to have a longer duration than deposits ρ is positive.

Banks' operating costs, such as screening and monitoring costs, largely depend on the amount of loans:

$$C^{oc} = g_o + g_1.L, \; g_0 > 0, \; g_1 > 0 \quad \text{(A.12)}$$

Simply speaking, equation (A.2) captures the traditional interest rate channel. Equations (A.3)-(A.7) and (A.11) relate to the idea of a bank balance sheet channel through bank profits and capital, whereas equations (A.8)-(A.10) reflect a bank lending channel.

The representative bank maximises profit subject to the balance sheet (A.1), loan demand (A.2) required bank capital restrictions (A.4).

$$\underset{L}{Max}\, \pi = i_L.L + i_m.S - j.L - i_B.B - C^{MT} - C^{OC} \quad \text{(A.13)}$$

The solution to the loan supply is:

$$\begin{aligned} L^S = {} & \frac{g_1 - \eta_o}{2c_0} + \frac{c_3}{-2c_0} p + \frac{b_0(k-1) + c_1}{-2c_0} i_m + \frac{b_1(1-k)}{2c_0} i_m K_{t-1}^b + \frac{c_2 - j_0}{-2c_0} y + \frac{j_1.\mu}{2c_0} y.K_{t-1}^b + \\ & \frac{1}{2c_0} \rho_{t-1}\Delta i_m + \frac{(\eta_1 - j_2).\mu + (k-1).b_2}{-2c_0} K_{t-1}^b \end{aligned} \quad \text{(A.14)}$$

$$L^S = \mathrm{E}_0 + \mathrm{E}_1 p + \mathrm{E}_2 i_m + \mathrm{E}_3 i_m K_{t-1}^b + \mathrm{E}_4 y + \mathrm{E}_5 y.K_{t-1}^b + \mathrm{E}_6 \rho_{t-1}\Delta i_m + \mathrm{E}_7 K_{t-1}^b \quad \text{(A.15)}$$

The crucial terms for the estimated loan supply equation in the main text are the ones with the monetary policy rate, e.g., E_2, E_3, and E_6. Starting with E_2, if the value of $b_0(k-1) < 0$ (credit channel) is smaller than the cost of funds effect $c_1 > 0$ (interest rate channel) then an increase in the monetary policy interest rate causes a decline in loan supply. For the E_3 term, parameter b_1 is crucial. The supply of loans of well-capitalised banks is expected to be less affected by a monetary policy tightening as they can counteracts this effect by issuing bonds at a low price. The term E_6 is negative and indicates that due to the longer duration of banks' assets than liabilities (*$\rho>0$*) a monetary policy tightening results in a reduction in bank profits, and thus in capital and ultimately in the supply of loans.

Finally, note that the effect of a change in the capital requirements on loan supply works through the solvency ratio, k, and the resulting change in the buffer or excess capital. In other words, such a change affects the terms E_2, E_3, E_5, E_6, and E_7.

Appendix B Estimation results with a sample split along banks with the 20% lowest equity capital to total asset ratio, between 20% and 80%, and above 80%

Table B.1 Loan growth and the monetary policy impact along bank capitalisation, 1991-1999

	Germany			France			Italy		
Capitalisation	≤ 20%	20%< <80%	≥ 80%	≤ 20%	20%< <80%	≥ 80%	≤ 20%	20%< <80%	≥ 80%
ΔSTIR	-0.12‡	0.12‡	-0.19	-0.13§	-0.10§	0.13§	-0.27§	0.05§	0.07§
	(0.06)	(0.05)	(0.11)	(0.02)	(0.02)	(0.04)	(0.02)	(0.01)	(0.02)
ΔSTIR(1)	-0.02*	0.07§	0.05	0.10§	-0.07§	0.13§	-0.11§	-0.06*	0.08§
	(0.01)	(0.01)	(0.03)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
ΔSECU	-0.07§	-0.11§	-0.01	-0.49§	-0.09§	-0.26§	-0.66§	-0.07§	-0.18§
	(0.01)	(0.02)	(0.01)	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.04)
ΔSECU(1)	-0.15§	-0.04§	0.03‡	-0.02§	-0.07§	-0.12§	-0.63§	0.00	0.02
	(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)
ΔDEPO	0.79§	0.33§	0.84§	0.92§	1.02§	0.72§	1.32§	0.85§	0.65§
	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.06)	(0.04)	(0.05)
ΔDEPO(1)	0.16§	0.13§	0.01	-0.10§	0.60§	0.24§	0.84§	-0.02	0.12§
	(0.01)	(0.02)	(0.01)	(0.02)	(0.03)	(0.01)	(0.02)	(0.03)	(0.02)
ΔINTERB	-0.07§	0.08§	0.21§	0.21§	-0.03	0.02§	0.03*	-0.02‡	0.07§
	(0.00)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
ΔINTERB(1)	0.03§	-0.01§	0.06§	0.17§	-0.01‡	0.04§	0.05§	-0.01§	0.02§
	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)
ΔGDP	0.62§	-0.28§	0.47§	-6.12§	-1.04§	-3.11§	-0.22§	-0.13§	-0.22§
	(0.08)	(0.09)	(0.18)	(0.41)	(0.26)	(0.42)	(0.06)	(0.05)	(0.06)
ΔGDP(1)	0.31	0.28	-1.63‡	-5.23§	-0.41‡	-1.95‡	0.66§	0.07*	-0.10
	(0.32)	(0.27)	(0.70)	(0.27)	(0.18)	(0.88)	(0.08)	(0.04)	(0.07)
ΔLoan(1)	-0.14§	-0.02§	-0.20§	-0.06§	-0.63§	-0.25§	-0.46§	-0.19§	-0.13§
	(0.00)	(0.01)	(0.01)	(0.00)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)
Intercept	0.00	-0.02§	-0.02§	-0.04§	0.01§	-0.02§	0.01§	0.04§	0.05
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Observations	437	1417	496	263	831	292	131	376	136

*Notes: §, ‡ and * indicate significance at the 1%, 5% and 10% levels, respectively. The standard errors of the coefficients are in parenthesis. ΔSTIR is change in nominal short term interest rates; ΔSECU is change in total securities holdings; ΔDEPO is change in total deposits; ΔINTERB is change in interbank borrowings; ΔGDP is change in growth rate of Gross Domestic Product. ΔLOAN is the change in total loans; (1) denote one-period lag of the respective variable*

Table B.2 Loan growth and the monetary policy impact along bank capitalisation, 1991-1999

	Key German bank			Largest euro area banks		
Capitalisation	≤ 20%	≤ 20%	20%< <80%	≤ 20%	20%< <80%	≥ 80%
ΔSTIR	-0.79§	-0.02	0.11	-0.03‡	0.01	-0.04§
	(0.10)	(0.10)	(0.35)	(0.02)	(0.01)	(0.00)
ΔSTIR(1)	0.00	-0.20§	-0.19‡	-0.23§	-0.01	-0.01*
	(0.01)	(0.02)	(0.08)	(0.01)	(0.01)	(0.00)
ΔSECU	-0.46§	-0.04§	-0.18§	0.27§	-0.05§	-0.02§
	(0.04)	(0.00)	(0.03)	(0.01)	(0.01)	(0.00)
ΔSECU(1)	-0.20§	0.00	0.01	-0.07§	-0.03§	-0.02§
	(0.03)	(0.00)	(0.01)	(0.01)	(0.00)	(0.00)
ΔDEPO	1.27§	0.93§	1.31§	0.59§	0.56§	0.08§
	(0.05)	(0.02)	(0.05)	(0.02)	(0.04)	(0.00)
ΔDEPO(1)	0.23§	0.01	0.25§	0.18§	0.03§	-0.02§
	(0.04)	(0.02)	(0.02)	(0.01)	(0.01)	(0.00)
ΔINTERB	-0.10§	-0.07§	0.07‡	-0.07§	-0.03*	0.01§
	(0.01)	(0.01)	(0.03)	(0.00)	(0.02)	(0.00)
ΔINTERB(1)	0.07§	-0.02§	0.03*	-0.01§	-0.01§	0.02§
	(0.01)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)
ΔGDP	1.52§	0.51§	0.20	0.66§	-0.06	-0.32§
	(0.20)	(0.14)	(0.48)	(0.11)	(0.08)	(0.02)
ΔGDP(1)	-1.24§	0.70	0.17	0.69§	0.20§	0.14§
	(0.46)	(0.63)	(2.17)	(0.14)	(0.07)	(0.01)
ΔLoan(1)	-0.18§	-0.04§	-0.14§	-0.24§	0.01‡	-0.18§
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Intercept	0.03§	0.02§	-0.01	0.03§	0.01§	0.01§
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)
Observations	159	420	149	216	708	223

*Notes: §, ‡ and * indicate significance at the 1%, 5% and 10% levels, respectively. The standard errors of the coefficients are in parenthesis. ΔSTIR is change in nominal short term interest rates; ΔSECU is change in total securities holdings; ΔDEPO is change in total deposits; ΔINTERB is change in interbank borrowings; ΔGDP is change in growth rate of Gross Domestic Product. ΔLOAN is the change in total loans; (1) denote one-period lag of the respective variable.*

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