BANK CAPITAL AND LENDING BEHAVIOR: EMPIRICAL EVIDENCE FOR ITALY

by Leonardo Gambacorta* and Paolo Emilio Mistrulli*

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Abstract

This paper investigates the existence of cross-sectional differences in the response of lending to monetary policy and GDP shocks due to a different degree of bank capitalization. The effects on lending of shocks to bank capital, that are caused by a specific (higher than 8 per cent) solvency ratio for highly risky banks, are also analyzed. The paper adds to the existing literature in three ways. First, it considers a measure of capitalization (the excess capital) that is better able to control for the riskiness of bank's portfolio than the well-known capital-to-asset ratio. Second, it disentangles the effects of the "bank lending channel" from those of the "bank capital channel" in the case of a monetary shock; it also provides an explanation for asymmetric effects of GDP shocks on lending based on the link between bank capital and risk-aversion. Third, it uses a unique dataset of quarterly data for Italian banks over the period 1992-2001; the full coverage of banks and the long sample period helps to overcome some distributional bias detected for other public available dataset. The results indicate that well-capitalized banks can better shield their lending from monetary policy shocks as they have, consistently with the "bank lending channel" hypothesis, an easier access to non-deposit fund raising. A "bank capital channel" is also detected, with higher effects for cooperative banks that suffer a higher maturity mismatching. Capitalization also influences the way banks react to GDP shocks. Again, the credit supply of well-capitalized banks is less pro-cyclical. The introduction of a specific solvency ratio for highly risky banks determines an overall reduction in lending.

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* Banca d'Italia, Research Department.

1. Introduction[1]

The role of bank capital in the monetary transmission mechanism has been largely neglected by economic theory. The traditional interpretation of the "bank lending channel" focuses on the effects of reserve requirements on demand deposits, while no attention is paid to bank's equity; bank capital is traditionally interpreted as an "irrelevant" balance sheet item (Friedman, 1991; Van den Heuvel, 2003). Moreover, in contrast with the wide literature that analyzes the link between risk aversion and wealth, there is scarce evidence on the relationship between a bank's risk attitude and her level of capitalization. This lack of attention contrasts with the importance given, both at an empirical and theoretical level, to the macroeconomic consequences of the Basle Capital Accord that designed risk-based capital requirements for banks.[2]

The main aim of this paper is to study how bank capital may influence the response of lending to monetary policy and GDP shocks. There are two ways in which bank capital may affect the impact of monetary shocks: through the traditional "bank lending channel" and through a more "direct" mechanism defined "bank capital channel". Both channels rest on the failure of the Modigliani-Miller theorem of the financial structure irrelevance but, as we will discuss, for different reasons.

Bank's capitalization influences the "bank lending channel" due to imperfections in the market for debt. In particular, bank capital influences the capacity to raise uninsured form of debt and therefore bank's ability to contain the effect on lending of a deposit drop. The mechanism is the following. After a monetary tightening, reservable deposits drop and banks raise non-reservable debt in order to protect their loan portfolios. As these non-reservable funding are typically uninsured (i.e. bonds or CDs), banks encounter an adverse selection problem (Stein, 1998); low capitalized banks, perceived more risky by the market, have

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[2] See Basle Commitee on Banking Supervision (1999) for a reference on the subject.

more difficulties to issue bonds and have therefore less capacity to shield their credit relationships (Kishan and Opiela, 2000).

The “bank capital channel” is based on three hypotheses: 1) an imperfect market for bank equity (Myers and Majluf, 1984; Stein, 1998; Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994); 2) a maturity mismatching between assets and liabilities that exposes banks to interest rate risk; 3) a “direct” influence of regulatory capital requirements on the supply of credit. The “bank capital channel” works in the following way. After an increase of market interest rates, a lower fraction of loans can be renegotiated with respect to deposits (loans are mainly long term, while deposits are typically short term): banks suffer therefore a cost due to the maturity transformation performed that reduces profits and then capital. If equity is sufficiently low (and it is too costly to issue new shares), banks reduce lending because prudential regulation establishes that capital has to be at least a minimum percentage of loans (Thakor, 1996; Bolton and Freixas, 2001; Van den Heuvel, 2001a).

Bank capitalization may also influence the reaction of credit supply to output shocks. This effect depends upon the link between bank capital and risk-aversion. A part of the literature argue that well-capitalized banks are less risk-averse. In the presence of a solvency regulation, banks maintain a higher level of capital just because their lending portfolios are riskier (e.g., Kim and Santomero, 1988; Rochet, 1992; Hellman, Murdock and Stiglitz, 2000). In this case we should observe that well-capitalized banks react more to business cycle fluctuations because they have selected *ex-ante* a lending portfolio with higher return and risk. On the contrary, other models stress that well-capitalized banks are more risk-averse because the implicit subsidy that derives from deposit insurance is a decreasing function of capital (e.g., Flannery, 1989; Gennotte and Pyle, 1991) or because they want to limit the probability not to meet capital requirements (Dewatripont and Tirole, 1994). In this case, since the quality of the loan portfolio of well-capitalized banks is comparatively higher they should reduce their lending supply by less in bad states of the nature.

The empirical investigations concerning the effect of bank capital on lending mostly refer to the US banking system (e.g., Hancock, Laing and Wilcox, 1995, Furfine, 2000, Kishan and Opiela, 2000; Van den Heuvel, 2001b). All these works underline the relative importance of bank capital in influencing lending behavior. The literature on European countries is instead far from conclusive; Altunbas et al. (2002) and Ehrmann et al. (2003)

find that lending of undercapitalized banks suffers more from a monetary tightening, but their results are not significant at conventional values for the main European countries.

This paper presents three novelties with respect to the existing literature. The first one is the definition of capitalization; we define banks' capitalization as the amount of capital that banks hold in excess of the minimum required to meet prudential regulation standards. This definition allows us to overcome some problems of the capital-to-asset ratio generally used in the existing literature. Since minimum capital requirements take into account the quality of banks' balance sheet activities, the excess capital represents a cushion that controls for the level of banks' risk and indicates a lower probability of a bank to go into default. Moreover, excess capital is a direct measure of banks capacity to expand credit because it takes into consideration prudential regulation constraints. The second novelty lies in the tentative to analyze the effects of capitalization on banks response to various economic shocks. In the case of monetary shocks we separate the effects of the "bank lending channel" from those of the "bank capital channel". We provide a tentative explanation of the effect of GDP shocks on lending based on the link between bank capital and risk-aversion. Exogenous capital shocks that refer to specific solvency ratio that supervisors set for very risky banks are also analyzed. The third novelty is the use of a unique dataset of quarterly data for Italian banks over the period 1992-2001; the full coverage of banks and the long sample period should overcome some distributional bias detected for other public available dataset. To tackle problems in the use of dynamic panels, all the models have been estimated using the GMM estimator suggested by Arellano and Bond (1991).

The results indicate that well-capitalized banks can better shield their lending from monetary policy shocks as they have, consistently with the "bank lending channel" hypothesis, an easier access to non-deposit fund raising. In this respect, banks' capitalization effect is larger for non-cooperative banks, which are more dependent on non-deposit forms of external funds. Capitalization also influences the way banks react to GDP shocks. Again, the credit supply of well-capitalized banks is less pro-cyclical. This result indicates that well-capitalized banks are more risk-averse and, as their borrowers are less risky, suffer less from economic downturns via loan losses. Moreover, well-capitalized banks can better absorb temporarily financial difficulties on the part of their borrowers and preserve long term lending relationships. Exogenous capital shocks, due to the introduction of a specific (higher than 8 per cent) solvency ratio for highly risky banks, determine an overall reduction of 20 per cent in lending after two years. This result is consistent with the hypothesis that it costs less to adjust lending than capital.

The remainder of the paper is organized as follows. The next section reviews the literature and explains the main link between capital requirements and banks' loan supply. Section 3 indicates some stylized facts concerning bank capital in Italy. In Section 4 we describe the econometric model and the data. Section 5 presents our empirical results and the robustness checks. The last section summarizes the main conclusions.

2. Bank capital and the business cycle

There are several theories that explain how bank capital could influence the propagation of economic shocks. All these theories suggest the existence of market imperfections that modify the standard results of the Modigliani and Miller theorem. Broadly speaking, if capital markets were perfect a bank would always be able to raise funds (debt or equity) in order to finance lending opportunities and her level of capital would have no role.

The aim of this Section is to discuss how bank capital may influence the reaction of bank lending to two kinds of economic disturbances: monetary policy and GDP shocks.

The first kind of shock occurs when a monetary tightening (easening) determines a reduction (increase) of reservable deposits and an increase (reduction) of market interest rates. In this case, there are two ways in which bank capital may influence the impact of monetary policy changes on lending: through the traditional "bank lending channel" and through a more "direct" mechanism defined as "bank capital channel".

Both mechanism are based on adverse selection problems that affect banks fund-raising: the "bank lending channel" relies on imperfections in the market for bank debt (Bernanke and Blinder, 1988; Stein, 1998; Kishan and Opiela, 2000), while the "bank capital channel" concentrates on an imperfect market for banks' equity (Thakor, 1996; Bolton and Freixas, 2001; Van den Heuvel, 2001a).

According to the "bank lending channel" thesis, a monetary tightening has effect on bank lending because the drop in reservable deposits cannot be completely offset by issuing other forms of funding (or liquidating some assets). Therefore a necessary condition for the "bank lending channel" to be operative is that the market for non-reservable bank liabilities is not frictionless. On the contrary, if banks had the possibility to raise, without limit, CDs or bonds, which are not subject to reserve requirements, the "bank lending channel" would be ineffective. This is indeed the point of the Romer and Romer critique (1990).

On the contrary, Kashyap and Stein (1995, 2000) and Stein (1998) claim that the market for bank debt is imperfect. Since non-reservable liabilities are not insured and there is an asymmetric information problem about the value of banks' assets, a "lemon's premium" is paid to investors. In this case, bank capital has an important role because it affects banks' external ratings and provides the investors with a signal about their creditworthiness. This hypothesis implies that banks are subject to "market discipline". Therefore the cost of non-reservable funding (i.e. bonds or CDs) would be higher for low-capitalized banks because they have less equity to absorb future losses and then are perceived more risky by the market.[3] Low-capitalized banks are therefore more exposed to asymmetric information problems and have less capacity to shield their credit relationships (Kishan and Opiela, 2000).[4]

It is important to note that this effect of bank capital on the "bank lending channel" cannot be captured by the capital-to-asset ratio. This measure, generally used by the existing literature to analyze the distributional effects of bank capitalization on lending, does not take into account the riskiness of a bank portfolio. A relevant measure is instead the excess capital that is the amount of capital that banks hold in excess of the minimum required to meet prudential regulation standards. Since minimum capital requirements are determined by the quality of bank's balance sheet activities (for more details see Section 3), the excess capital represents a risk-adjusted measure of bank capitalization that gives more indications on the probability of a bank default. Moreover, the excess capital is a relevant measure of the

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[3] Empirical evidence has found that lower capital levels are associated with higher prices for uninsured liabilities. See, for example, Ellis and Flannery (1992) and Flannery and Sorescu (1996).

[4] The total effect also depends on the amount of bank liquidity. Other things equal, banks with a high buffer of liquid assets should cut back their lending less in response to a monetary tightening. The intuition of this result is that banks with a large amount of very liquid assets have the option of selling them to shield loan portfolio (Kashyap and Stein, 2000; Ehrmann et al. 2003).

availability of the bank to expand credit because it directly controls for prudential regulation constraints.

The "bank capital channel" is based on three hypotheses. First, there is an imperfect market for bank equity: banks cannot easily issue new equity for the presence of agency costs and tax disadvantages (Myers and Majluf, 1984; Stein, 1998; Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994). Second, banks are subject to interest rate risk because their assets have typically a higher maturity with respect to liabilities (maturity transformation). Third, regulatory capital requirements limit the supply of credit (Thakor, 1996; Bolton and Freixas, 2001; Van den Heuvel, 2001a).

The mechanism is the following. After an increase of market interest rates, a lower fraction of loans can be renegotiated with respect to deposits (loans are mainly long term, while deposits are typically short term): banks suffer therefore a cost due to the maturity mismatching that reduces profits and then capital. If equity is sufficiently low and it is too costly to issue new shares, banks reduce lending, otherwise they fail to meet regulatory capital requirements.

The "bank capital channel" can also be at work even if capital requirement is not currently binding. Van den Heuvel (2001) shows that low-capitalized banks may optimally forgo lending opportunities now in order to lower the risk of capital inadequacy in the future. This is interesting because in reality, as shown in Section 3, most banks are not constrained at any given time. It is also worth noting that, according to the "bank capital channel", a negative effect of a monetary tightening on bank lending could be generated also if banks face a perfect market for non-reservable liabilities.

Bank capitalization may also influence the way lending supply reacts to output shocks. Bank capitalization, that is bank wealth, is linked to risk taking behavior and then to banks' portfolio choices; this means that lending of banks with different degrees of capitalization (or risk aversion) may react differently to economic downturns. While a wide stream of literature on financial intermediation has analyzed the relation between bank capitalization and risk taking behavior,[5] the nature of this link is still quite controversial. A first class of models (Kim and Santomero, 1988; Rochet, 1992; Hellman, Murdock and Stiglitz, 2000) argue that well-capitalized banks are less risk averse. In the presence of a solvency regulation, well-capitalized banks detain a higher level of capital just because their lending portfolio is riskier. In this case we should observe that well-capitalized banks react more to business cycle fluctuations because they have selected *ex-ante* a lending portfolio with higher return and risk.

In Kim and Santomero (1988), the introduction of a solvency regulation entails an inefficient asset allocation by banks. The total volume of their risky portfolio will decrease (as a direct effect of the solvency regulation), but its composition will be distorted in the direction of more risky assets (recomposition effect). In this model, the probability of failure increases after capital requirements are introduced because the direct effect is dominated by the recomposition of the risky portfolio. On the same line, Hellman, Murdock and Stiglitz (2000) argue that higher capital requirements are the cause of excessive risk-taking by banks. Since capital regulation increase banks' cost of funding (equity is more costly than debt) and lower the value of the bank, the management of the bank reacts by increasing the level of credit portfolio risk.[6]

The main implications of this class of models are three. First, well-capitalized banks are less risk averse because regulation creates an incentive in doing so. Second, risk-based capital standards would become efficient only if the weights that reflect the relative riskiness

[5] The relation between wealth and attitude towards risk is central to many fields of economics. As far as credit markets are concerned, this relation has been largely employed in analyzing the role of collateral in mitigating asymmetric information problems between banks and borrowers (see Coco, 2000 for a recent survey on this subject).

[6] A different explanation is given by Besanko and Kanatas (1996). They depart from Kim and Santomero (1988) and Hellman, Murdock and Stiglitz (2000) by allowing for *outside equity* (owned by shareholders who are not in control of the firm) and by stressing the role of managerial incentive schemes in a *moral hazard* framework. Modeling at the same time asset-substitution (among assets with different risk profiles) and effort aversion moral hazard, they show that while a higher capital requirement reduces asset-substitution problems, it lowers the incentive to exert the optimal amount of effort. This result rests on what they call a "dilution effect": if bank insiders are wealth-constrained or risk-averse, more stringent capital standards dilute insiders' ownership share, and thus their marginal benefit of effort. The main conclusion of the model is that, if the effort aversion effect is larger than the asset-substitution effect, higher capital standards induce banks to take on average more risk. Gorton and Rosen (1996) argue that excessive risk taking among well-capitalized banks could also reflect exogenous conditions such as managerial incompetence or a lack of lending opportunities.

of assets in the solvency ratio were market-based (Kim and Santomero, 1988).[7] In this case distortion in the banks' asset allocation disappears and capital requirements reflect the effective risk taking of the bank.[8] Third, these models are not able to explain why banks typically detain excess capital with respect to the minimum requirements imposed by the supervisory authority (for example, see van den Heuvel (2003) for the US). As we will see this is a crucial point in studying heterogeneity in the behavior of banks due to capitalization.

A different result is reached by other models based on a portfolio approach (Flannery, 1989; Gennotte and Pyle, 1991) for which well-capitalized banks are more risk-averse. They support this result studying the relation between deposit insurance schemes and risk-taking attitude of banks. If the insurance premium undervalues banks' risk, the implicit subsidy from deposit insurance is a decreasing function of capital. That is, highly capitalized banks are more risk-averse. This means that, since the quality of the loan portfolio of well-capitalized banks is comparatively higher, they suffer fewer losses in the case of an economic downturn; the low amount of write-offs allows well-capitalized banks to reduce their lending supply by less in bad states of the nature. In this class of models the presence of capital requirements attenuates the distortions caused by deposits guarantees: banks cannot limit the amount of equity to obtain the maximum implicit subsidy from deposit insurance. An implication of these models is that if a bank has excess capital with respect to the minimum requirements she is more risk-averse because she evaluates her risk more cautiously than the supervisory authority.

The hypothesis that that well-capitalized banks are more risk-averse can be also supported interpreting excess capital as a cushion against contingencies. When a solvency regulation is introduced, banks have to face the possibility that they could fail to meet capital requirements and that, if this really happens, they could loose part of their control in favor of

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[7] Thakor (1996) proves that a more stringent risk-based standard may reduce banks' willingness to screen risky borrowers. In this sense, market pricing of uninsured liabilities (the so-called "market discipline") could contribute to avoid excessive risk-taking by undercapitalized banks. More cautious conclusions in evaluating the potential effects of subordinated debt requirement are developed in Calem and Rob (1999). Sheldon (1996) provides weak evidence that the implementation of the Basle Accord had a risk-increasing impact on bank portfolio.

[8] Analyzing a model with limited liability (capital can not be negative as in Kim and Santomero, 1988) Rochet (1992) suggests introducing an additional regulation, namely a minimum level of capital, independent of the size of the bank assets.

supervisors (Dewatripont and Tirole, 1994; Repullo, 2000; van den Heuvel, 2001a). Therefore, banks choose a certain excess capital at time *t* taking into account the possibility that in the future they could not be able to meet regulatory standards. The amount of capital banks hold in excess to capital requirement depends on their (global) risk aversion that is independent of the initial level of wealth.[9] Differences in (global) risk aversion among banks may emerge not only for heterogeneity in corporate governance but also, and more substantially, for institutional reasons. In Italy, as we will discuss in the following section, the institutional characteristics of credit cooperative banks (CCBs) are very different with respect to that of limited companies. If we allow for heterogeneity in (global) risk-aversion among banks the excess capital becomes a crucial measure to capture differences in the risk profile of banks' portfolios. The simple capital-to-asset ratio is no longer informative because it does not capture the constraint due to regulation.

3. Some stylized facts on bank capital

The 1988 Basle Capital Accord and its subsequent amendments require capital to be above a threshold that is defined as a function of several types of risk. In other words, it is possible to distinguish between the default risk (credit risk) and the risk related to adverse fluctuations in asset market prices (market risk). [10] In Italy, the capital requirements for credit risks have been introduced in 1992, those for market risks in 1995.

As far as credit risk is concerned, capital must be at least equal to 8 per cent of the total amount of risk-weighted assets (solvency ratio).[11] A bank-specific *solvency ratio* (higher

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[9] A simple way to say that bank *i* is globally more averse than bank *j* is to assume that the objective function of bank *i* is a concave transformation of bank *j* objective function.

[10] In general the need of capital requirements arises to overcome moral hazard problems inducing banks to detain a "socially optimal" amount of capital. In the event of a crisis, the lower the leverage ratio is, the higher the probability that a bank will fail to pay back its debts. The moral hazard problem is amplified in the presence of a deposit insurance system. For a more detailed explanation of the rationale for capital requirements, see among others, Giammarino, Lewis and Sappington (1993), Dewatripont and Tirole (1994), Vlaar (2000) and Rime (2001).

[11] In Italy, regulation establishes a minimum capital requirement as a function of the amount of risk-weighted assets (and certain off-balance sheet activities). Assets are classified into five buckets with different risk weights. Risk weights are zero for cash and government bonds, 20 per cent for bank claims on other banks, 50 per cent for mortgage lending, 100 per cent for other loans on the private sector, 200 per cent for participating in highly risky non financial firms (firms that have recorded losses in the last two years). Till

than 8 per cent) can be disposed in case of a poor performance in terms of asset quality, liquidity and organization. On the contrary, the ratio decreases to 7 per cent for banks that belong to a banking group that meets an 8 per cent solvency ratio on a consolidated basis. Capital requirements on market risks are related to open trading positions in securities, foreign exchange and commodities.[12]

Banks have to hold an amount of capital that must be at least equal to the sum of credit and market risk capital requirements.[13]

One of the objectives of the 1988 Basle Accord was to increase banks' capitalization (Basle Committee on Banking Supervision, 1999). We observe that banks' capitalization increased during the period that preceded the implementation of the Basle Accord, Italian (Fig. 1) and it was slightly declining afterwards. It seems therefore that banks have constituted sufficient capital and reserves endowments before risk-based capital requirements were implemented. This seems to support the thesis that bank capital is sticky.

Large banks' capitalization has been constantly lower than the average.[14] At the opposite, credit cooperative banks (CCBs), typically very small, are better capitalized than

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September 1996 bad loans weight was also equal to 200 per cent. For any bank *j* its capital requirement is defined as:

$$k_j \cdot WA_j = k_j \cdot \sum_{i=1}^{5} \alpha_i A_{ij}$$

where k_j is the *solvency ratio*, WA_j the total amount of risk-weighted assets, α_i is the risk weight for asset type *i* and A_{ij} is the unweighted amount of the *i*-type asset bank *j* holds.

[12] Market risk capital requirements are computed on the basis of a quite complex algorithm. Regulation distinguishes between a "specific risk" and a "general risk". The former refers to losses that can be determined by market price fluctuations, which are specifically related to the issuer economic condition. The latter is related to asset price fluctuations correlated to market developments (*systematic risk*). The capital requirement depends on issuer characteristics and on the asset maturity. *Ceteris paribus*, the capital requirement on market risks is lower for banks belonging to a group.

[13] Prudential regulation allows banks to meet capital requirements by holding an amount of capital that is defined as the sum of the so-called *Tier 1* and *Tier 2* capital (regulatory capital). *Tier 1* or *core* capital includes stock issues, reserves and provisions for *general banking risks*; *Tier 2* or *supplementary* capital consists of general loan loss provisions, ibryd instruments and subordinated debt. *Tier 1* capital is required to be equal at least to the 50 per cent of the total. Subordinated debts must not exceed 50 per cent of *Tier 1* capital. Recently, banks have been allowed to issue subordinated debts specifically to face market risk requirements (the so-called *Tier 3* capital).

[14] We have considered large banks those with total assets greater than 10 billions euro at September 2001. To control for mergers we have assumed that consolidation happened at the beginning of the period (see Appendix 2 for further details on merger treatment).

other banks. The different capitalization degree among Italian banks could reflect a diverse capacity to issue capital. As capital is relatively costly, banks minimize their holdings, subject to different "adjustment costs" constraints. This implies that, *ceteris paribus*, capitalization is lower for those banks that incur lower costs in order to adjust their level of capital. As we have pointed in Section 2, differences in the level of capitalization depend also on banks' risk-aversion related to different corporate governance and institutional settings.

For all groups of banks the excess capital (the amount that banks hold in excess of the minimum regulatory capital requirement) has been always significantly greater than zero. This is consistent with the hypothesis that capital is difficult to adjust and banks create a cushion against contingencies. If we define as x_{it} the ratio between regulatory capital and capital requirement this should be close to one if banks choose their capital endogenously to meet the constraint imposed by the supervision authority. In reality we observe that this ratio is significantly greater than one (Fig. 2). The cushion is lower for large banks with respect to CCBs. On the basis of the literature discussed in the previous section, this stylized facts is consistent with the hypothesis that small banks are more risk-averse than large banks.

Figure 3 shows the time evolution of the deviation of excess capital from its *long run equilibrium*. For each bank *i* at time *t*, the bank deviation is defined as: $z_{it} = \frac{x_{it} - \bar{x}_i}{\sigma_{x_i}}$ where, $\bar{x}_i$ is the bank capitalization average and σ_{x_i} is the standard error of x_{it}. We can interpret $\bar{x}_i$ as a proxy of the *long-run equilibrium* capitalization, that we assume to be bank specific. We then calculate, at every time *t*, the aggregate index as a mean of each bank index.

We have split banks into three different groups: large banks, other banks (CCBs excluded), and CCBs. The indicator is more stable for large banks, more volatile for CCBs. This seems consistent with the view that large banks have easier access to capital markets and therefore can adjust more rapidly their capitalization degree to loan demand fluctuations; capitalization is less flexible for smaller banks and for CCBs, which are more dependent on self-financing.

Figure 4 shows the maturity transformation performed by banks. As we have discussed in the previous section the existence of a maturity mismatching between assets and liabilities is a necessary condition for the "bank capital channel" to be at work. Since loans have always typically a longer maturity than bank fund-raising, the average maturity of total assets is higher than that of liabilities. In this case, as predicted by the "bank capital channel", the bank suffers a cost when interest rates are raised and obtains a gain vice versa. The difference between the average maturity of assets and that of liabilities is higher for CCBs than for other banks. In fact, CCBs balance sheets are characterized by a higher percentage of long-term loans, while their bonds issues are more limited. For example, at the end of September 2002, the ratio between medium and long-term loans over total loans was 57 per cent for CCBs and 46 per cent for other banks. On the contrary, the ratio between bond and total fund raising was, respectively, 27 and 29 per cent. These differences were even higher at the beginning of our sample period. Therefore, the analysis of the maturity mismatching between assets and liabilities indicates room for the existence of a "bank capital channel" in Italy with a potential higher effect for CCBs.

There is no conclusive evidence about the effects of bank capital on lending behavior of Italian banks. In principle the financial structure of the Italian economy during the nineties makes more likely that a "bank lending channel" was at work (see Gambacorta, 2001). Most empirical papers based on VAR analysis confirm the existence of such a channel in Italy (Buttiglione and Ferri, 1994; Angeloni et al., 1995; Bagliano and Favero, 1995; Fanelli and Paruolo, 1999; Chiades and Gambacorta, 2003). However there is much less evidence on cross sectional differences in the effectiveness of the "bank lending channel" in Italy, due to capitalization (see de Bondt, 1999; Favero et al., 2001; King 2002; that analyze mainly the effect of banks dimension and liquidity; some evidence of the effect of capitalization on lending of Italian banks is detected by Altunbas, 2002). So far no evidence has been provided on the existence of the so-called "bank capital channel".

Apart from the differences in specification, all these paper use the BankScope dataset that, as pointed out by Ehrmann et al. (2003), suffers of two weaknesses. First, the data are collected annually, which might be too infrequent to capture the adjustment of bank aggregates to monetary policy. Second, the sample of Italian banks available in BankScope is biased towards large banks. For example, in 1998 only 576 up to 921 Italian banks were included in the BankScope dataset. Moreover the average size of a bank was 3.7 billion euro against 1.7 for the total population. To tackle these problems our analysis will be based on the Bank of Italy Supervisory Reports database, using quarterly data for the full population of Italian banks.

4. The econometric model and the data

The empirical specification, based on Kashyap and Stein (1995), is designed to test whether banks with a different degree of capitalization react differently to a monetary policy or a GDP shock. A simple theoretical framework that justifies the choice of the specification is reported in Appendix 1.[15]

The empirical model is given by the following equation, which includes interaction terms that are the product of the excess capital with the monetary policy indicator and the real GDP; all bank specific characteristics (excess capital, cost due to maturity mismatching, etc.) refer to *t*-1 to avoid an endogeneity bias (see Kashyap and Stein, 1995; 2000; Ehrmann et al., 2003):

$$\begin{aligned} \Delta \ln L_{it} &= \mu_i + \sum_{j=1}^{4} \alpha_j \Delta \ln L_{it-j} + \sum_{j=0}^{4} \beta_j \Delta MP_{t-j} + \sum_{j=0}^{4} \varphi_j \pi_{t-j} + \sum_{j=0}^{4} \delta_j \Delta \ln y_{t-j} + \\ &+ \lambda X_{it-1} + \phi \Delta(\rho_i \Delta MP)_{t-1} + \sum_{j=1}^{4} \gamma_j X_{it-1} \Delta MP_{t-j} + \sum_{j=1}^{4} \tau_j X_{it-1} \Delta \ln y_{t-j} + \Phi_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

with i=1,…, N (N = number of banks) and t=1, …, T (t= quarters) and where:

L_{it} = loans of bank i in quarter t

MP_t = monetary policy indicator

y_t = real GDP

π_t = inflation rate

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[15] The model presented in Appendix 1 is a slightly modified version of the analytical framework in Ehrmann et al. (2003). The main differences are two. First, it introduces bank capital regulation in a static way as in Kishan and Opiela (2000). Second, following the literature on bank capital and risk attitude (see Section 2) we model loan losses as a function of bank capitalization.

X_{it} = measure of excess capital

ρ_{it} = cost per unit of asset that the bank incurs in case of a one per cent increase in *MP*

Φ_{it} = control variables.

The model allows for fixed effects across banks, as indicated by the bank-specific intercept μ_i. Four lags have been introduced in order to obtain white noise residuals. The model is specified in growth rates in order to avoid the problem of spurious correlations among variables that are likely to be non-stationary.

The sample used goes from the third quarter of 1992 to the third quarter of 2001. The interest rate taken as monetary policy indicator is that on repurchase agreements between the Bank of Italy and credit institutions in the period 1992-1998, and the interest rates on main refinancing operation of the ECB for the period 1999-2001.[16]

CPI inflation and the growth rate of real GDP are used to control for loan demand effects. The introduction of these two variables allows us to capture cyclical movements and serves to isolate the monetary policy component of interest rate changes.[17]

To test for the existence of asymmetric effects due to bank capitalization, the following measure has been adopted:

$$X_{it} = \frac{EC_{it}}{A_{it}} - \left(\sum_t \frac{\sum_i EC_{it} / A_{it}}{N_t} \right) / T$$

where *EC* stands for excess capital (regulatory capital minus capital requirements) and *A* represents total assets. The excess capital indicator is normalized with respect to the average across all the banks in the respective sample, in order to obtain a variable that sums to zero over all observations. This has two implications. First, the sums of the interaction terms

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[16] As pointed out by Buttiglione, Del Giovane and Gaiotti (1997), in the period under investigation the repo rate mostly affected the short-term end of the yield curve and, as it represented the cost of banks' refinancing, it represented the value to which market rates and bank rates eventually tended to converge. It is worth noting that the interest rate on main refinancing operation of the ECB does not present any particular break with the repo rate.

[17] For more details on data sources, variable definitions, merger treatment, trimming of the sample and outlier elimination see Appendix 2.

$\sum_{j=1}^{4}\gamma_j X_{it-1}\Delta MP_{t-j}$ and $\sum_{j=1}^{4}\tau_j X_{it-1}\Delta \ln y_{t-j}$ in equation (1) are zero for the average bank ($\bar{X}_{it-1}$=0). Second, the coefficients β_j and δ_j are directly interpretable, respectively, as the average monetary policy effect and the average GDP effect.

To test for the existence of a "bank capital channel" we have introduced a variable ($\rho_i \Delta MP$) that represents the bank-specific interest rate cost due to maturity transformation. In particular ρ_i measures the loss (gain) per unit of asset the bank suffers (obtains) when the monetary policy interest rate is raised (decreased) of one percentage point. We have computed this variable according to supervisory regulation relative to interest rate risk exposure that depends on the maturity mismatching among assets and liabilities.[18] In other words, if bank's assets have a higher maturity with respect to liabilities ρ_i is positive and indicates the cost for unit of asset a bank suffers if interest rate are raised by one per cent. To work out the real cost we have therefore multiplied this measure for the realized change in interest rates. The term $\rho_i \Delta MP$ represents the real cost (gain) that a bank suffers (obtains) in each quarter. As formalized in Appendix 1, this measure influences the level of loans. Since here the dependent variable is a growth rate we have included this measure in first differences.

The set of control variables Φ_{it} include a liquidity indicator, given by the sum of cash and securities to total assets ratio, and a size indicator, given by the log of total assets. The liquidity indicator has been normalized with respect to the mean over the whole sample period, while the size indicator has been normalized with respect to the mean on each single period. This procedure removes trends in size (for more details see Gambacorta, 2001). As for the other bank specific characteristics also liquidity and size indicators refer to *t*-1 to avoid an endogeneity bias.

The fact that supervisors can set solvency ratios greater than 8 per cent for highly risky banks (see Section 3), allows us to test for the effects of exogenous capital shocks on bank lending. We analyze the impact of these supervisory actions on lending in the first two years,

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[18] See Appendix 2 for further details.

computing different dummy variables (one for each quarter following the solvency ratio raise) that equal 1 for banks whose solvency ratio is higher than 8 per cent. This allows us to capture bank lending adjustment process. A specific dummy variable controls for the effects of the introduction of market risk capital requirements in the first quarter of 1995.

The sample represents 82 per cent of total bank credit in Italy. Table 1 gives some basic information on what bank balance sheets look like. Credit Cooperative Banks (CCBs) are treated separately because they are significantly smaller, more liquid and better capitalized than other banks. This evidence is consistent with the view that smaller banks need bigger buffer stocks of securities because of their limited ability to raise external finance on the financial market. This interpretation is confirmed on the liability side, where the percentage of bonds is lower among CCBs. The high capitalization of CCBs is, at least in part, due to the Banking Law prescription that limits significantly the distribution of net profits.[19]

Within each category, banks have been split, according to their capitalization.[20] Low-capitalized banks are, independently of their form (CCBs or other banks), larger, less liquid and they issue more bonds than well-capitalized banks. While these differences are small among CCBs, they are quite significant among non-CCBs. Among non-cooperative banks, low-capitalized banks are much larger than well-capitalized ones; a higher share is listed and belongs to a banking group. Moreover, they issue more subordinated debt to meet the capital requirement. This evidence is consistent with the view that, *ceteris paribus*, capitalization is lower for those banks that bear less adjustment costs from issuing new (regulatory) capital; large and listed banks can more easily raise funds on the capital market and they can also rely on a wider set of "quasi-equity" securities that can be issued to meet capital requirements (e.g. subordinated debts); at the same time, banks belonging to a group can

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[19] According to art. 37 of the 1993 Banking Law "Banche di credito cooperativo must allocate at least seventy per cent of net profits for the year to the legal reserve."

[20] A "lowly capitalized" bank has a capital ratio equal to the average capital ratio below the 10th percentile, a "highly capitalized" bank, that of the banks above the 90th percentile. Since the characteristics of each bank could change over time, percentiles have been worked out on mean values.

better diversify the risk of regulatory capital shortage if an *internal capital market* is active at the group level.[21]

5. The results

The results of the study are summarized in Table 2, which presents the long-run elasticities of bank lending with respect to the variables.[22] The models have been estimated using the GMM estimator suggested by Arellano and Bond (1991) which ensures efficiency and consistency provided that the models are not subject to serial correlation of order two and that the instruments used are valid (which is tested for with the Sargan test).[23]

The existence of asymmetric effects due to bank capital is tested considering three samples. The first one includes all banks and is our benchmark regression; the other two consider separately credit cooperative and other banks. These sample splits are intended to capture differences in the bank capital effect due to the institutional characteristics discussed in the previous sections.

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[21] Houston and James (1998) analyze the role of internal capital markets for banks liquidity management. The same framework could be applied to soften the regulatory capital constraint among banks belonging to the same group.

[22] For example, the long-run elasticity of lending with respect to monetary policy for the average bank (reported on the second row of Table 2) is given by $\sum_{j=0}^{4}\beta_j/(1-\sum_{j=1}^{4}\alpha_j)$, while that with respect to the interaction term between excess capital and monetary policy is represented by $\sum_{j=1}^{4}\gamma_j/(1-\sum_{j=1}^{4}\alpha_j)$ (see the fifth row of Table 2). Therefore the overall long-run elasticity of the dependent variable with respect to monetary policy for a well-capitalized bank (seventh row) is worked out through $\sum_{j=0}^{4}\beta_j/(1-\sum_{j=1}^{4}\alpha_j)+\sum_{j=1}^{4}\gamma_j/(1-\sum_{j=1}^{4}\alpha_j)\ \bar{X}_{>0.90}$, where $\bar{X}_{>0.90}$ is the average excess capital for the banks above the 90th percentile. It is interesting to note that testing the null hypothesis that monetary policy effects are equal in the long-run among banks with different capitalization corresponds to testing H_0: $\sum_{j=1}^{4}\gamma_j=0$ using the t-statistic of $\sum_{j=1}^{4}\gamma_j$ in equation (1). Standard errors for the long-run effect have been approximated with the "delta method" which expands a function of a random variable with a one-step Taylor expansion (Rao, 1973). In order to increase the degree of freedom we have dropped the contemporaneous and the fourth lags that were statistically not different from zero.

[23] In the GMM estimation, instruments are the second and further lags of the quarterly growth rate of loans and of the bank-specific characteristics included in each equation. Inflation, GDP growth rate and the monetary policy indicator are considered as exogenous variables.

From the first row of the table it is possible to note that the effect of excess capital on lending is always significant and positive: well-capitalized banks are less constrained by capital requirements and have more opportunity to expand their loan portfolio. The effect is higher for CCBs than for other banks because they encounter higher capital adjustment costs: CCBs are more dependent on self-financing and cannot easily raise new regulatory capital.

The response of bank lending to a monetary policy shock has the expected negative sign. These estimates roughly imply that a 1 per cent increase in the monetary policy indicator leads to a decline in lending of around 1.2 per cent for the average bank. The effect is higher for CCBs (-1.8 per cent) than for other banks (-0.2 per cent), that have more access to markets for non-reservable liabilities. Testing the null hypothesis that monetary policy effects are equal among banks with a different degree of capitalization is identical to testing the significance of the long run coefficient of the interaction between excess capital and the monetary policy indicator (see "Excess capital*MP" in table 2). As predicted by the "bank lending channel" hypothesis the effects of a monetary tightening are lower for banks with a higher capitalization, which have easier access to non-deposit financing. Bank capitalization interaction with monetary policy is very high (in absolute value) for non-CCBs, which are more dependent on non-deposit forms of external funds. It is worth noting that well-capitalized non-CCBs are completely insulated from the effect of a monetary tightening (the effect is statistically not different from zero).

The effects of the so-called "bank capital channel" are reported on the eighth row of Table 2. The coefficients have the expected negative sign for all banks groups. These estimates roughly imply that an increase (decrease) of one basis point of the ratio between the maturity transformation cost and total assets determines a reduction (increase) of 1 per cent in the growth rate of lending. The reduction (increase) is bigger for CCBs that, as seen in Section 3, have typically a higher maturity mismatching between assets and liabilities. In fact, CCBs balance sheets are characterized by a higher percentage of long-term loans, while their bonds issues are more limited. Another possible explanation for the higher effect of the "bank capital channel" for CCBs could be their lower use of derivatives for shielding the maturity transformation gap. With these characteristic CCBs suffer a higher cost when interest rates are raised and obtains a higher gain vice versa. To sum up the results indicate the existence of a “bank capital channel” that amplifies the effects of monetary policy changes on bank lending and asymmetric effects of such a channel among banks groups.

The models show a positive correlation between credit and output. A 1 per cent increase in GDP (which produces a loan demand shift) determines a loan increase of around 0.7 per cent. The effect is lower for CCBs than for other banks. This has two main explanations. First, for CCBs local economic conditions are more important than national ones; second, they have closer customer relationships because they shall grant credit primarily to their members (see “The 1993 Banking Law”, Art. 35).

The interaction term between GDP and excess capital is negative. This means that credit supply of well-capitalized banks is less dependent on the business cycle. This result is consistent with Kwan and Eisenbeis (1997) where capital is found to have a significantly negative effect on credit risk. On theoretical ground our findings are consistent with Flannery (1989) and Gennotte and Pyle (1991) that argue that highly capitalized banks are more-risk averse and select *ex-ante* borrowers with a lower probability to go into default. Their risk-attitude therefore limits credit supply adjustments in bad states of nature, preserving credit relationships. The latter explanation needs to be discussed with respect to the institutional categories of Italian banks. From the sample split it emerges indeed that the coefficient of $\Delta(\rho_i \Delta MP)_{t-1}$ is highly significant only for CCBs, while there are no significant asymmetric effects for the other banks. This is consistent with the stylized fact discussed in Section 3 that CCBs are more risk-averse than other banks. They detain high levels of excess capital and are more able to insulate the effect of an economic downturn. As in Vander Vennet and Van Landshoot (2002) capital provides banks with a structural protection against credit risk changes. Looking at Table 2 well-capitalized CCBs are able to completely insulate the effect of GDP on their lending. On the other hand, non-CCBs seem to be risk-neutral: the effect of a 1 per cent increase in GDP on lending does not differ too much between well-capitalized (1.3 per cent) and poorly capitalized banks (1.5).

As explained in Section 4, the effects of exogenous capital shocks on bank lending are captured by dummy variables related to the introduction of a specific (higher than 8 per cent) solvency ratio. In this case there are not many differences among the three samples. The introduction of specific solvency ratio determines an overall reduction of around 20 per cent in bank lending after two years. The magnitude of the effect is similar among banks groups. This result seems consistent with the hypothesis that issuing new equity can be costly for a bank in the presence of agency cost and tax disadvantages (Myers and Majluf, 1984; Stein, 1998; Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994).

5.1 Robustness checks

We have tested the robustness of these results in several ways. The first test was to introduce additional interaction terms combining excess capital with inflation, making the basic equation (1):

$$\begin{aligned}(2)\quad \Delta \ln L_{it} &= \mu_i + \sum_{j=1}^{4}\alpha_j \Delta \ln L_{it-j} + \sum_{j=0}^{4}\beta_j \Delta MP_{t-j} + \sum_{j=0}^{4}\varphi_j \pi_{t-j} + \sum_{j=0}^{4}\delta_j \Delta \ln y_{t-j} + \lambda X_{it-1} + \\ &+ \phi\Delta(\rho_i \Delta MP)_{t-1} + \sum_{j=1}^{4}\gamma_j X_{it-1}\Delta MP_{t-j} + \sum_{j=1}^{4}\tau_j X_{it-1}\Delta \ln y_{t-j} + \sum_{j=1}^{4}\psi_j X_{it-1}\pi_{t-j} + \Phi_{it} + \varepsilon_{it}\end{aligned}$$

The reason for this test is the possible presence of endogeneity between inflation and capitalization; excess capital may be higher when inflation is high or vice versa. Performing the test, however, nothing changed, and the double interaction was always not significant ($\sum_{j=1}^{4}\psi_j$ turned out to be statistically not different from zero).

The second robustness check was to compare equation (1) with the following model:

$$\begin{aligned}(3)\quad \Delta \ln L_{it} &= \mu_i + \sum_{j=1}^{4}\alpha_j \Delta \ln L_{it-j} + \theta_t + \lambda X_{it-1} + \phi\Delta(\rho_i \Delta MP)_{t-1} + \\ &+ \sum_{j=1}^{4}\gamma_j X_{it-1}\Delta MP_{t-j} + \sum_{j=1}^{4}\tau_j X_{it-1}\Delta \ln y_{t-j} + \Phi_{it} + \varepsilon_{it}\end{aligned}$$

where all variables are defined as before, and ϑ_τ describes a complete set of time dummies.

This model completely eliminates time variation and test whether the three pure time variables used in the baseline equation (prices, income and the monetary policy indicator) capture all the relevant time effect. The results are presented in the fourth column of Table 2. Again, the estimated coefficients on the interaction terms do not vary much between the two kinds of models, which testifies to the reliability of the cross-sectional evidence obtained.

A geographical control dummy was introduced in each model, taking the value of 1 if the main seat of the bank is in the North of Italy and 0 if elsewhere. In all cases the maturity transformation variable and the interactions between monetary policy and output shocks with respect to excess capital remained unchanged.

The last robustness check was to include the interaction between monetary policy and the liquidity indicator in the baseline regression. The reason for this test was to verify if the asymmetric effects of monetary policy due to excess capital remained relevant; the interactions between monetary policy and liquidity, indeed represent a significant factor. We obtain:

$$\begin{aligned}(4)\quad &\Delta \ln L_{it} = \mu_i + \sum_{j=1}^{4} \alpha_j \Delta \ln L_{it-j} + \sum_{j=0}^{4} \beta_j \Delta MP_{t-j} + \sum_{j=0}^{4} \varphi_j \pi_{t-j} + \sum_{j=0}^{4} \delta_j \Delta \ln y_{t-j} + \lambda X_{it-1} + \\ &+ \phi \Delta(\rho_i \Delta MP)_{t-1} + \sum_{j=1}^{4} \gamma_j X_{it-1} \Delta MP_{t-j} + \sum_{j=1}^{4} \tau_j X_{it-1} \Delta \ln y_{t-j} + \sum_{j=1}^{4} \psi_j Liq_{it-1} \Delta MP_{t-j} + \Phi_{it} + \varepsilon_{it}\end{aligned}$$

The results, presented in the fifth column of Table 2, confirm that liquidity is an important factor enabling banks to attenuate the effect of decrease in deposits on lending but, at the same time, leave unaltered the distributional effects of excess capital. The result on liquidity is in line with Gambacorta (2001) and Ehrmann et al. (2003); banks with a higher liquidity ratio are better able to buffer their lending activity against shocks to the availability of external finance, by drawing on their stock of liquid assets. In these works, however, bank capital (defined as the capital-to-asset ratio) does not significantly affect the banks' reaction to a monetary policy impulse. This additional test therefore allow us to cast some doubt on the use of the capital-to-asset ratio to capture distributional effects in a lending regression because this measure poorly approximate the relevant capital constraint under the Basle standards.

6. Conclusions

This paper investigates the existence of cross-sectional differences in the response of lending to monetary policy change and output shocks due to a different degree of capitalization. It adds to the existing literature in three ways. First, it considers a measure of capitalization that is better able to capture the relevant capital constraint under the Basle standards than the well-known capital to asset ratio. Defining banks' capitalization as the amount of capital that banks hold in excess of the minimum required to meet prudential regulation standards we are able to measure the effect of capital requirements and to reflect information on the structure of the loan portfolio or its risk characteristics. Second, it disentangles the effects of the "bank lending channel" (triggered by deposits reduction) from those of the "bank capital channel" (due to the maturity transformation); different kinds of shocks on lending for the Italian banking system are analyzed; not only monetary policy shocks, but also GDP and capital shocks. In the last case, shocks are genuinely exogenous because they refer to an increase in minimum capital requirements that supervisors set for very risky banks. Third, it use a unique dataset of quarterly data for Italian banks over the period 1992-2001; the full coverage of banks and the long sample period should overcome some distributional bias detected for other public available dataset.

The main results of the study are the following. Well-capitalized banks can better shield their lending from monetary policy shocks as they have, consistently with the "bank lending channel" hypothesis, an easier access to non-deposit fund raising. In this respect, banks' capitalization effect is larger for non-cooperative banks, which are more dependent on non-deposit forms of external funds. A "bank capital channel" is also detected, with higher effects for cooperative banks whose balance sheets are characterized by a higher maturity mismatching between assets and liabilities. Capitalization also influences the way banks react to GDP shocks. Again, the credit supply of well-capitalized banks is less pro-cyclical. This result has at least two explanations. First, well-capitalized banks are more risk-averse (as argued by Flannery, 1989 and Gennotte and Pyle, 1991) and, as their borrowers are less risky, suffer less from economic downturns via loan losses. Second, well-capitalized banks can better absorb temporarily financial difficulties on the part of their borrowers and preserve long term lending relationships. Exogenous capital shocks, due to the imposition of a specific (higher than 8 per cent) solvency ratio for highly risky banks, determine an overall reduction of 20 per cent in lending after two years. This result is consistent with the hypothesis that it costs less to adjust lending than capital.

This study shows that capital matters for the response of bank lending to economic shocks. Notwithstanding, it is difficult to draw what are the implications of this result with respect to the new directions of the Basle Accord that should be implemented in 2005. The main goal of the amendments is to make the risk weights used to calculate the solvency ratio more risk-sensitive. In fact, as shown in Section 3 the actual buckets are somewhat too crude and could lead to regulatory arbitrage. The new weights will be dependent on the ratings of the borrowers given by rating agencies or internal models developed by banks. This has two consequences. First, the new Basle Accord will affect banks differently, depending on their riskness: for riskier (safer) banks the level of capital requirement will be higher (lower), compared with the present regulation that establish a solvency ratio that is almost constant among different classes of risk for private customers. As a direct consequence, heterogeneity in the response of lending to GDP shock due to capitalization could be attenuated. On the other hand, the new capital regulation, by imposing a higher degree of information disclosure could make "market discipline" more effective thereby reducing the information problems on which the "bank lending channel" and the "bank capital channel" rely.

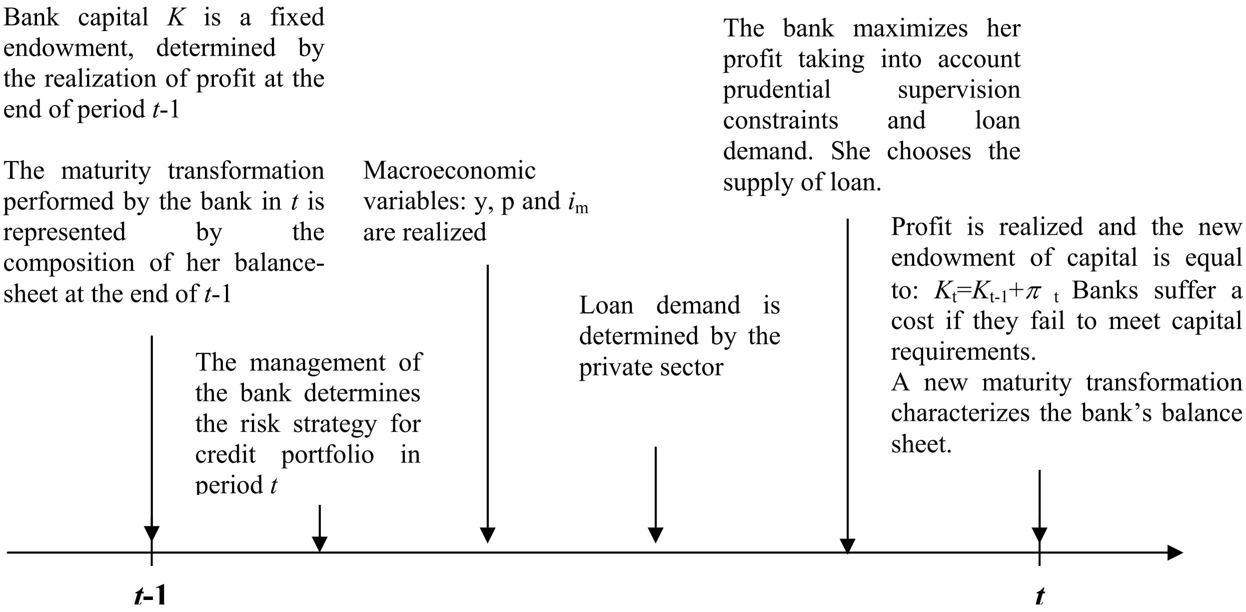
Second, the pro/counter-cyclicality of capital regulation will strongly depend upon the capacity of external rating agencies and internal models to anticipate economic downturns. If borrowers are downgraded during recession this should lead to higher capital requirements that could exacerbate the effect on lending. On the contrary, if ratings are able to anticipate slowdowns or responds smoothly to economic conditions (they are set "through the cycle") the effects of monetary policy and GDP shock on lending should be less pronounced.

Appendix 1 – A simple theoretical model

In order to justify the empirical framework adopted for the econometric analysis, in this Appendix we develop a simple one-period model highlighting the main channels through which bank capital can affect loan supply (see Kishan and Opiela, 2000; Ehrmann, 2003). A causal interpretation of the step of the model is given in Figure A1.[24]

Figure A1

The sequential steps of the model



The balance sheet constraint of the representative bank is given by the following identity:

(A1.1) $$L + S = D + B + R + X$$

where L stands for loans, S for securities, D for deposits, B for bonds, R for capital requirements and X for excess capital. At the end of t-1 bank capital, defined as $K = X + R$,

[24] It is worth stressing that this causal interpretation has the only aim to stress that bank-specific characteristics are given in t-1 and are predetermined with respect to the maximization in t. On the contrary, the steps in t, whose subscript is for simplicity omitted in the model, are simultaneously determined.

is a given endowment. This hypothesis indicates that the management of the bank (that for simplicity is also the her owner to rule out informational asymmetries problems) does not alter the capitalization of the firm buying or selling shares between *t*-1 and *t*; capital remains therefore fixed until period *t* when it will be modified by the realization of the profit or the loss ($K_t=K_{t-1}+\pi_t$).[25]

At the beginning of period *t* the management of the bank determines the risk strategy for credit allocation. The allocation of credit portfolio among industries, sectors of activity, geographical areas, depends upon the risk-aversion of the management that we indicate with $\theta\in[-\infty,+\infty]$. This measure could be interpreted as an Arrow-Pratt measure of absolute risk aversion that is equal to zero if the bank is risk neutral. It is worth noting that the decision upon the risk strategy profile is taken before the actual supply of credit. The latter will be chosen to meet loan demand after the realization of economic conditions. Therefore, in choosing the risk profile the management of the bank takes into account the ex-ante information about the possible distribution of the macro variables (income, price, interest rates) and selects a strategy for each possible state of the world.

The choice of the risk profile for lending portfolio (that, as we have shown, depends on the risk-aversion of the management of the bank) has two important implications. First, it influences the percentage of non-performing loans (*j*) that are written-off at time *t*. Second, it affects the average rate of return of lending since risky loans are associated with a higher level of return. This means that the risk premium is negatively related to the bank risk aversion.

In the spirit of the actual BIS capital adequacy rules, *R* is given by a fixed amount (*k*) of loans.[26] We assume that capital requirements are linked only to credit risk (loans) and not

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[25] This is an extreme case of capital costly adjustment that we assume here to simplify the model. This hypothesis is widely used in the literature (see, amongst others, Koehn and Santomero, 1980; Kim and Santomero, 1988; Rochet, 1992). Issuing new equity can be costly for a bank. The main reasons are agency cost and tax disadvantages (Myers and Majluf, 1984; Stein, 1998; Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994). A discussion on the exogeneity/endogeneity of the capital goes behind the scope of this study. Here exogeneity has been assumed in order to simplify the algebra given that it does not modify the main findings of the model. In the empirical part of the paper this hypothesis is relaxed using the Arellano and Bond (1991) procedure that allows us to control for endogeneity through instruments variables (see Section 4).

[26] More complicated version of the capital constraint would have not changed the main result of the analysis. A possible extension of the simple capital requirement rule could be to consider a different weight on

to interest rate risk (investment in securities that for simplicity are considered completely safe).

(A1.2) $$R = kL$$

We assume that banks hold capital in excess of capital requirements. This hypothesis is consistent with the fact that capital requirement constraints are slack for most banks at any given time. Banks may hold a buffer as a cushion against contingencies (Wall and Peterson, 1987; Barrios and Blanco, 2001) as they face capital adjustment costs or to convey positive information on their economic value (Leland and Pile, 1977; Myers and Majluf, 1984). Another explanation is that banks face a private cost of bankruptcy, which reduces their expected future income. Van den Heuvel (2001a) argues that even if capital requirement is not currently binding, a low capitalized bank may optimally forego profitable lending opportunities now, in order to lower the risk of future capital inadequacy. To capture this aspects in a simple way we assume that banks pay a lump-sum tax if they can not meet capital requirements in *t*.

After the realization of macroeconomic variables, the private sector sets its lending demand. The bank acts on a loan market characterized by monopolistic competition, which enables her to set the interest rate along the loan demand schedule.[27] The interest rate on loan (i_l) is therefore given by:[28]

(A1.3) $$i_l = c_0 L^d + c_1 i_m + c_2 y + c_3 p + \eta \quad (c_0>0,\ c_1>0,\ c_2>0,\ c_3>0)$$

non-performing loans ($j\,L$): $R=k_1\,(1\text{-}j)\,L+\,k_2\,j\,L$, with $1 \geq k_2 \geq k_1 \geq 0$. This should reflect that till 1996 the weight applied to non-performing loans were double with respect to performing loans ($k_2=0.16>k_1=0.08$). Another possible extension could be to consider a different weight for loans backed by real guarantee. Indeed, loans to the private sector bear a weight of 0.04 if backed by real guarantees, 0.08 in all other cases (non-performing loans backed by real guarantees included).

27 This hypothesis is generally adopted by the existing literature on bank interest rate behavior. For a survey on modeling the banking firm see Santomero (1984). See also Green (1998) and Lim (2000).

28 For simplicity we assume that all banks face the same loan demand schedule, i. e., the coefficients c_i for i=0, 1, 2, 3, are equal among banks. The model could be easily extended to a more general case where each coefficient depends upon some bank-specific characteristics but this goes behind the scope of this study. This simplifying hypothesis allows us to concentrate on the effects of bank specific characteristics on loan supply.

that is positively related to loan demand (L^d), the opportunity cost of self-financing, proxied by the money market interest rate (i_m), the real GDP (y), the price level (p) and to the risk-premium (η).[29]

The risk premium in equation (A1.3) is negatively related to the bank's risk-aversion that, as discussed before, influences the risk profile of loan portfolio. Therefore, we have:

(A1.4) $$\eta = \eta_0 + \eta_1\theta \qquad (\eta_0>0,\ \eta_1<0)$$

Loans are risky and, in each period, a percentage j of them is written off from the balance sheet, therefore reducing bank's profitability. The percentage of loans which goes into default (j) depends inversely on the state of the economy, proxied by real GDP, and on the risk-taking behavior of the bank (θ).Therefore, per-unit loan losses of the bank are given by:

(A1.5) $$j(y,\theta) = j_0 y + j_1\theta y + j_2\theta \qquad (j_0<0, j_1<0, j_2<0)$$

Equation (A1.5) states that the quality of bank portfolios reacts differently to changes in the state of the economy and this in turn depends on the bank's *ex-ante* risk attitude. The cross product indicates that write-offs of more risk-averse banks react less to GDP shocks. If the bank is risk-neutral (θ=0), j depends only on real GDP.

Following the literature that links risk-aversion and bank capital (see Section 2), we hypothesize that the parameter θ is linked to the excess capital X at the end of period t-1:[30]

(A1.6) $$\theta = \mu X_{t-1}$$

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[29] As far as the GDP is concerned, there is no clear consensus about how economic activity affects credit demand. Some empirical works underline a positive relation because better economic conditions would improve the number of project becoming profitable in terms of expected net present value and, therefore, increase credit demand (Kashyap, Stein and Wilcox, 1993). This is also the hypothesis used in Bernanke and Blinder (1988). On the contrary, other works stress the fact that if expected income and profits increase, the private sector has more internal source of financing and this could reduce the proportion of bank debt (Friedman and Kuttner, 1993). On the basis of the evidence provided by Ehrmann et al. (2001) for the four main countries of the euro area and by Calza et al. (2001) for the euro area as a whole, we expect that the first effect dominates and that a higher income determines an increase in credit demand (c_2>0).

[30] An analysis of the causal direction of influence between capital (wealth) and risk-aversion goes behind the scope of this paper. In the model we suppose that this link is bi-directional. For a discussion on the link between bank capital and risk-aversion see Section 2.

It is worth noting that we analyze the link between risk-aversion and excess capital instead of the level of capital. As discussed in the introduction and in Section 2, the excess capital is a risk-adjusted measure of bank's wealth that is independent of prudential supervision constraints and therefore can be correctly studied with respect to risk-aversion. On the contrary, the level of capital, largely used in the existing literature, does not give information on the structure of the loan portfolio or its risk characteristics.

As discussed in Section 2, the effect of the excess capital on banks' risk attitude is controversial in the existing literature; therefore the sign of μ is not certain a priori. A positive value of μ would imply that well-capitalized banks are more risk-averse: they *ex-ante* select less risky borrowers whose ability to repay their debt is less influenced by output shocks. In this case, the low burden of write-offs on their profit and loss account allows well-capitalized banks to smooth the effects of an economic downturn on credit supply. In other words, well-capitalized banks can better perform the "intertemporal smoothing function" described by Allen and Gale (1997), as they are more able to preserve credit relationships in bad states of nature. On the contrary, if μ is negative well-capitalized banks are more risk-lover and the quality of their credit portfolio should suffer more the effects of a drop in income.

The bank holds securities in order to face unexpected deposit outflows. We assume that security holdings are a fixed share of the outstanding deposits:

(A1.7) $$S = sD \qquad (0<s<1)$$

Deposits are fully insured and are not remunerated. Their demand schedule is negatively related to the deposit opportunity cost that is equal to the monetary policy rate i_m:

(A1.8) $$D = d\, i_m \qquad (0<d<1)$$

The latter equation implies that the overall amount of deposits is completely controlled by the monetary authority.

Because banks are risky and bonds are not insured, bond interest rate incorporates a risk premium that we assume depends on banks' excess capital at the end of period t-1. Subscribers of the bonds have a complete knowledge of the last balance sheet of the bank and demand a lower interest rate if the bank, taking into account the riskiness of her credit, is well capitalized. We include both a direct influence of capitalization on the spread between the interest rate on bond and the money market rate and an interaction term between the two rates.

(A1.9) $$i_b\left(i_m, X\right) = i_m + b_0 X_{t-1} + b_1 i_m X_{t-1} \qquad (b_0<0,\ b_1<0)$$

This assumption implies that the relevance of the *bank lending channel* depends on banks' capital adequacy, which determines the degree of substitutability between insured, typically deposits, and uninsured banks' debt, typically bonds or CDs (Romer and Romer, 1990). Equation (A1.9) also implies that, because of *market discipline,* it could be optimal for banks to hold a capital endowment greater than the lowest level necessary to meet regulatory capital requirement.

The effects of the so-called "bank capital channel" are captured by the following equation:

(A1.10) $$C^{MT} = \rho_{t-1} \Delta i_m (L+S) \qquad (\rho>0)$$

where C^{MT} represents the total cost (or gain) suffered (obtained) by the bank in case of a change in monetary policy due to the maturity transformation performed by the bank in t-1, before the monetary shock occurs. In particular, ρ_{t-1} reflects how assets and liabilities differ in terms of interest rate sensitivity at the end of t-1 and it depends on the maturity transformation performed by the bank. In particular, this parameter represents the cost (gain) per unit of asset that the bank incurs in case of a one per cent variation in the monetary policy interest rate. Therefore, since loans have typically a longer maturity than bank fund-raising we expect that $\rho_{t-1}>0$. In this case the bank suffers a cost when interest rates are raised and obtains a gain vice versa.

Operating costs (C^{OC}), which can be interpreted as screening and monitoring costs, depend on the amount of loans:

(A1.11) $$C^{OC} = g_0 + g_1 L$$ (g_0>0, g_1>0)

The representative bank maximizes her profits subject to the balance-sheet constraint (A1.1), the regulatory capital requirement (A1.2) and loan demand (A1.3):[32]

$$\underset{L}{Max}\ \pi = i_L L + i_m S - jL - i_B B - C^{MT} - C^{OC}$$

s.t. (A1.1), (A1.2) and (A1.3)

Solving the maximization problem it is possible to find the optimal level of loan supply:

(A.12) $$L^s = \Psi_0 + \Psi_1 p + \Psi_2 i_m + \Psi_3 i_m X_{t-1} + \Psi_4 y + \Psi_5 y X_{t-1} + \Psi_6 \rho_{t-1} \Delta i_m + \Psi_7 X_{t-1}$$

where:

$$\Psi_0 = \frac{g_1 - \eta_0}{2c_0};\ \Psi_1 = \frac{c_3}{-2c_0} > 0;\ \Psi_2 = \frac{b_0(k-1) + c_1}{-2c_0};\ \Psi_3 = \frac{b_1(1-k)}{2c_0} > 0;$$

$$\Psi_4 = \frac{c_2 - j_0}{-2c_0} > 0;\ \Psi_5 = \frac{j_1 \mu}{2c_0};\ \Psi_6 = \frac{1}{2c_0} < 0;\ \Psi_7 = \frac{(\eta_1 - j_2)\mu + (k-1)b_2}{-2c_0}.$$

Equation (A.12) states that a monetary tightening determines a decrease in lending (Ψ_2<0) only if the "bank lending channel" (b_0(1-k)<0) is greater than the "opportunity cost" effect (c_1>0). The effect of a monetary squeeze is smaller for well-capitalized banks (Ψ_3>0) that have a greater capacity to compensate the deposit drop by issuing bonds at a lower price. Credit supply reacts positively to an output expansion (Ψ_4>0), but the effect depends on the bank's excess capital, affecting its risk attitude and its sensitivity to the business cycle. The effect of capital regulation on credit supply could be checked through the solvency ratio (k) and the excess capital (X). A higher capital requirement (k high) reduces the effect of the "bank lending channel" (it lowers b_0(1-k)) and the effects via "market discipline" (it lowers Ψ_3). On the other hand, excess capital alters the asymmetric effects on output, but its sign is

[32] In this model, banks optimally choose loan supply. Since K is given, the optimal choice of L determines the level of excess capital X>0. We assume that banks never expand loan supply till the point where X=0, because they want to avoid capital inadequacy costs (seeDewatripont and Tirole, 1994 and Van den Heuvel, 2001a).

not clear *a priori* because, as we have seen, this depends also on the banks' risk-aversion effect. The effect of the so-called "bank capital channel" are captured by $\Psi_6 < 0$; due to the longer maturity of bank assets with respect to liabilities (ρ>0), in case of a monetary tightening (Δi_m>0) the bank suffers a the maturity transformation cost; the reduction in profit, given the capital constraint, determines a decrease in lending.

The last coefficient reflects the direct influence of excess capital on loan supply. A sufficient condition for Ψ_7 to be positive is that the saving obtained by the bank on bond's funding due to market discipline (represented by the absolute value of b_2) overcomes the risk-aversion effect (whose sign is uncertain a priori).

The empirical model (1) in Section 4 is given by a slightly modified version of equation (A.12). In particular, the main differences are three. The first one is due to non-stationary of some variables that could cause problems of spurious correlation. Since these variables have a unit root (this has been checked by means of an Augmented Dickey Fuller test) we have expressed the model in growth rates. The ratios X_{t-1} and ρ_{t-1} turn out to be stationary and are included in levels. The second one regards the number of lags to use in the specification. In fact, the contemporaneous variables were not sufficient to capture the dynamic of the interaction terms and the macro variables. We have therefore included a more complete dynamic setting, allowing to the adjustment to be completed in four periods (one year). We rule out the interactions of X_{it-1} with contemporaneous values of the monetary policy indicator and real GDP to avoid endogeneity problems. The third difference regards the inclusion of quarterly dummies (to tackle seasonality problems) and other control variables (to control for specific effects in the loan supply equation due to regulation, see Section 4). These modifications are standard in the literature. For similar approaches see Kashyap and Stein (1995, 2000) for the US and Ehrmann et al. (2003) for the euro area countries.

Appendix 2 - Description of the database

The data are taken from the Bank of Italy Supervisory Reports database. Loans do not include bad debts and repurchase agreements. Liquidity is equal to the sum of cash, interbank deposits, securities and repurchase agreements at book value (repos have been considered for statistical reasons). The size of a bank is measured by the logarithm of the total balance sheet. Capitalization is given by the ratio of regulatory capital in excess of capital requirements to total asset (see Section 3). The growth rates are computed by first difference of variables in logs.

The cost a bank suffers from her maturity transformation function is due to the different sensitivity of her assets and liabilities to interest rates. Using a maturity ladder, we have:

$$\rho_i = \frac{\sum_j \left(\chi_j \cdot A_j - \zeta_j P_j \right)}{\sum_j A_j} * 100$$

where A_j (P_j) is the amount of assets (liabilities) of j months-to-maturity and χ_j (ζ_j) measures the increase in interest on assets (liabilities) of class j due to a one-per-cent increase in the monetary policy interest rate (Δi_m=0.01). Broadly speaking if $\sum_j \left(\chi_j \cdot A_j - \zeta_j P_j \right)>0$, ρ_i represents the cost per unit of asset bank i suffers in case the monetary policy interest rate is raised of one percentage point. We obtain χ_i and ζ_i directly from supervisory regulation on interest rates risk exposure. In particular, the regulation assumes, for any given class j of months-to-maturity: 1) the same sensitivity parameter ($\chi_j = \zeta_j$) and 2) a non-parallel shift of the yield curve (Δi_m=0.01 for the first maturity class and then decreasing for longer maturity classes). Then, for each bank, after having classified assets and liabilities according to their months-to-maturity class, we have computed the bank specific variable ρ_i. This variable has been then multiplied by the change of the monetary policy indicator (Δi_m) to obtain the realized loss (or gain) per unit of asset in each quarter.

In assembling our sample, the so-called special credit institutions (long-term credit banks) have been excluded since they were subject to different supervisory regulations regarding the maturity range of their assets and liabilities. Nevertheless, special long-term credit sections of commercial banks have been considered part of the banks to which they belonged. Foreign banks are also excluded as they are subject to their *home country control.*

Particular attention has been paid to mergers. In practice, it is assumed that these took place at the beginning of the sample period, summing the balance-sheet items of the merging parties. For example, if bank A is incorporated by bank B at time *t*, bank B is reconstructed backward as the sum of the merging banks before the merger.

Data are quarterly and are not seasonally adjusted. Three seasonal dummies and a constant are also included. For cleaning, all observations for which lending, liquidity and total assets are equal to or less than zero were excluded. After this treatment, the sample includes 691 banks and 26,108 observations.

An observation has been defined as an outlier if it lies within the top or bottom percentile of the distribution of the quarterly growth rate of lending. If a bank has an outlier in the quarterly growth rate of lending it is completely removed from the sample. The final dataset was composed of 558 banks (20,727 observations).

A "lowly capitalized" bank has a capital ratio equal to the average capital ratio below the 10^{th} percentile, a "highly capitalized" bank, that of the banks above the 90^{th} percentile. Since the characteristics of each bank could change over time, percentiles have been worked out on mean values.

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Table 1

DATA DESCRIPTION
(September 2001)

	Credit Cooperative Banks			Other Banks					Total		
	highly capitalized	*lowly capitalized*	Total	*highly capitalized*	*lowly capitalized*	*large banks* (2)	Total	*large banks* (2)	*higly capitalized*	*lowly capitalized*	Total
Number of banks	40	40	401	15	16	5	155	31	55	55	556
Banks belonging to a group (1)	0.0	0.0	0.0	33.3	81.3	100.0	71.6	100.0	0.0	67.9	19.9
Listed banks	0.0	0.0	0.0	0.0	37.5	80.0	16.8	51.6	0.0	26.8	4.7
Mean total assets	160	246	205	1341	12468	35766	9160	38581	159	12486	2692
- fraction of total assets	7.8	12.0	100.0	1.4	14.1	12.6	100.0	84.2	0.6	45.9	100.0
Liquidity/total assets	33.5	21.2	25.3	23.1	18.7	15.3	18.2	13.9	34.3	17.8	23.3
Loans/total assets	39.7	50.0	47.8	40.8	51.3	50.1	49.4	50.0	39.3	51.1	48.3
Bad loans/total loans	7.5	6.4	5.6	11.2	8.3	10.0	6.2	4.3	6.6	5.7	5.8
Bonds issues/deposits and bonds	18.5	30.6	27.3	23.5	30.7	31.7	29.3	33.5	19.5	29.4	27.9
Subordinated debt/capital requirement	0.0	2.9	2.3	1.1	19.3	16.9	14.4	34.1	1.4	16.7	5.7
(Regulatory capital - capital requirement) / total assets	16.0	2.5	7.9	10.4	1.6	1.3	4.3	3.3	15.4	2.0	6.9
Share of branches located in the South of Italy	32.5	26.7	22.6	26.3	28.6	44.7	22.6	19.9	34.5	27.4	22.6

Source: Bank of Italy supervisiory returns.
Note: A "lowly capitalized" bank has a capital ratio (regulatory capital - capital requirement/total assets) equal to the average capital ratio below the 10th percentile, a "highly capitalized" bank has the average capitalization of the banks above the 90

(1) Only groups with more than a bank member are considered. - (2) Large banks are non cooperative banks with total assets greater than 10 billions of euro at September 2001

Table 2

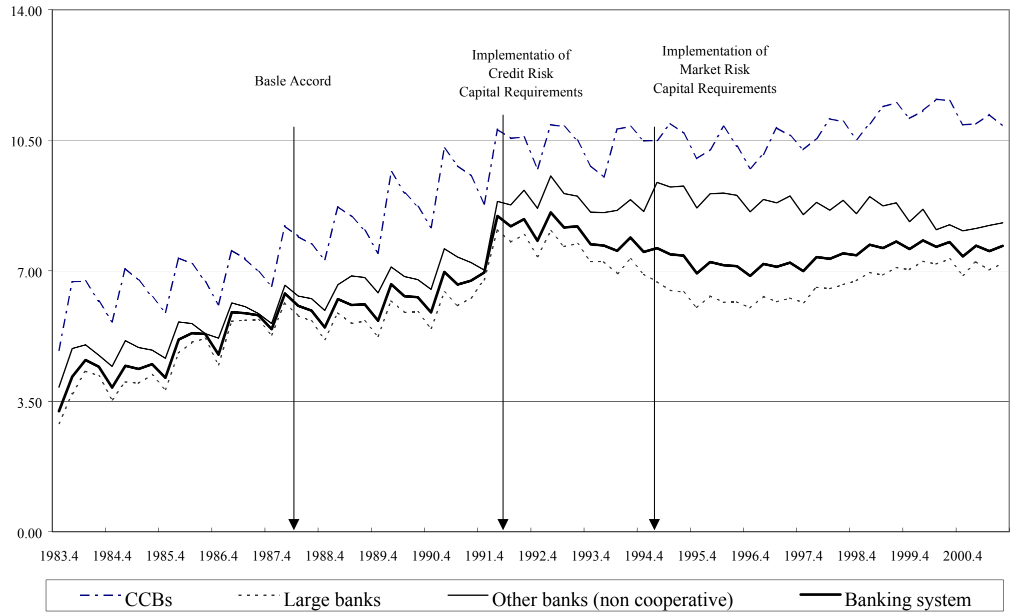
THE EFFECT OF BANK CAPITAL ON LOAN SUPPLY

Dependent variable: quarterly growth rate of lending	Model 1 Baseline regression						Model 2 T-dummies		Model 3 Liquidity*MP interactions	
	Total		Credit Cooperative Banks		Other Banks		Total		Total	
	Coeff.	S.Error	Coeff.	S.Error	Coeff.	S.Error	Coeff.	S.Error	Coeff.	S.Error
Excess Capital (t-1)	0.744 ***	0.021	1.058 ***	0.032	0.516 ***	0.057	0.763 ***	0.019	0.713 ***	0.022
Long-run coefficients										
Monetary policy (MP)	-1.187 ***	0.055	-1.778 ***	0.091	-0.201	0.175			-1.282 ***	0.056
Real GDP growth	0.668 ***	0.087	0.751 ***	0.125	1.350 ***	0.295			0.708 ***	0.087
Inflation (CPI)	1.127 ***	0.116	2.558 ***	0.175	0.654 **	0.300			1.312 ***	0.117
Excess capital*MP ("bank lending channel")	8.010 ***	0.906	8.921 ***	1.119	11.790 ***	2.139	7.363 ***	0.714	6.445 ***	0.984
MP effect for:										
well capitalized banks	-0.622 ***	0.092	-1.106 ***	0.110	0.176	0.196			-0.799 ***	0.100
poorly capitalized banks	-1.615 ***	0.066	-2.159 ***	0.122	-0.968 ***	0.208			-1.628 ***	0.068
Maturity transformation ("bank capital channel")	-1.173 ***	0.053	-1.287 ***	0.091	-0.597 ***	0.154	-0.933 ***	0.011	-1.116 ***	0.054
Excess capital*GDP ("risk-aversion effect")	-4.894 ***	1.621	-11.620 ***	2.517	-2.304	4.092	-4.336 ***	1.274	-4.375 ***	1.650
GDP shock effect for:										
well capitalized banks	0.323 **	0.145	-0.126	0.217	1.278 ***	0.329			0.380 **	0.153
poorly capitalized banks	0.930 ***	0.122	1.246 ***	0.180	1.491 ***	0.388			0.943 ***	0.122
Liquidity *MP ("bank lending channel")									0.992 ***	0.248
MP effect for:										
liquid banks									-1.124 ***	0.058
low liquid banks									-1.416 ***	0.071
Specific capital requirements (total effect after two years)	-0.199 ***	0.023	-0.188 ***	0.016	-0.186 *	0.107	-0.215 ***	0.021	-0.243 ***	0.023
Sargan test (2nd step; pvalue)		0.115		0.146		0.092		0.112		0.106
MA(1), MA(2) (p-value)	0.000	0.129	0.000	0.077	0.000	0.479	0.000	0.103	0.000	0.131
No of banks, no of observations	556	17792	401	12795	155	4960	556	17792	556	17792

*=significance at the 10 per cent; **=significance at the 5 per cent; ***=significance at the 1 per cent.

Fig. 1

Capital and Reserves (1)
(as a percentage of total assets)



(1) Large Banks are those with more than 10 billions euro at 2001.3.

Fig. 2

Capital Requirement and Regulatory Capital
(percentage values)

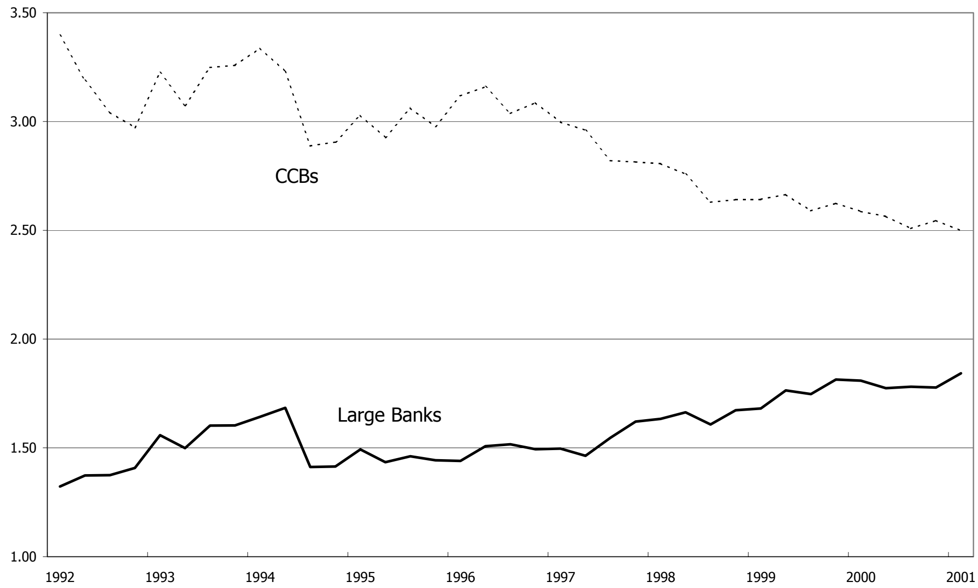


Fig. 3

The evolution of banks' capitalization
(normalized distance from long run average capitalization, quarterly data)

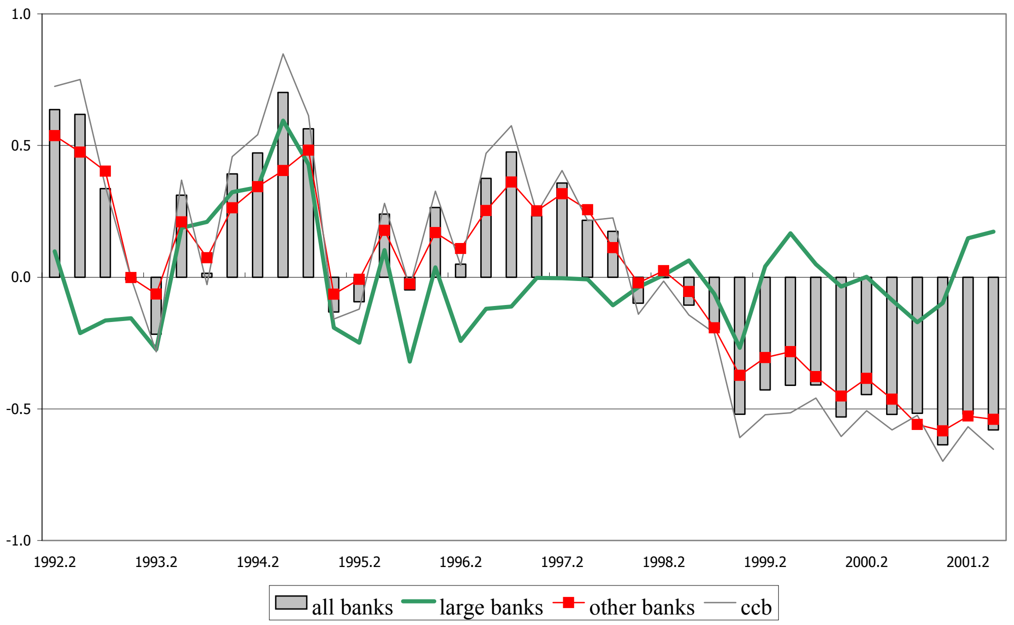


Fig. 4

Maturity transformation
(months-to-maturity, average)