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Leonardo Gambacorta *, Paolo Emilio Mistrulli

Banca d'Italia, Research Department, Via Nazionale 91, 00184 Rome, Italy

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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 owing to differences in bank capitalization. It adds to the literature by using the excess capital-to-asset ratio, which can better control the riskiness of banks' portfolios, and by disentangling the effects of the "bank lending channel" from those of the "bank capital channel." The results, based on a sample of Italian banks, indicate that bank capital matters in the propagation of different types of shocks to lending, owing to the existence of regulatory capital constraints and imperfections in the market for bank fund-raising.

JEL classification: E44; E51; E52

Keywords: Basel standards; Monetary transmission mechanisms; Bank lending; Bank capital

1. Introduction

The effects of bank capital on lending behavior have been widely debated since the 1988 Basel Capital Accord.[1] However, attention has been paid mostly to the effects of prudential regulation on banks' risk-taking profile (Dewatripont and Tirole, 1994) while the macroeconomic consequences of capital requirements have been analyzed less deeply.

* Corresponding author.
E-mail addresses: leonardo.gambacorta@bancaditalia.it (L. Gambacorta), paoloemilio.mistrulli@bancaditalia.it (P.E. Mistrulli).

[1] See Basel Committee on Banking Supervision (1999) for a reference on the subject.

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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 equity: bank capital is interpreted as an "irrelevant" balance-sheet item (Friedman, 1991; Van den Heuvel, 2003). It was only recently that bank capital has been taken into account in the context of the "bank lending channel" (Ashcraft, 2001; Jayaratne and Morgan, 2000; Kishan and Opiela, 2000). The main finding of this strand of literature is that bank capital increases the capacity to raise uninsured forms of debt and therefore banks' ability to limit the effect of a drop in deposits on lending.

Some other recent papers have analyzed a different mechanism to highlight how bank capital can affect lending behavior (Bolton and Freixas, 2001; Thakor, 1996; Van den Heuvel, 2001a). The distinguishing feature of these papers is that regulatory capital requirements are explicitly taken into account. Given that the regulatory requirement depends on the amount of loans granted, a link between bank capital and lending is established, with the additional assumption that banks face an imperfect market for their equities (Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994; Myers and Majluf, 1984; Stein, 1998). The next step is to model how monetary policy shocks affect bank capitalization and then bank lending. A possible transmission mechanism is the "bank capital channel" based on the maturity mismatch between assets and liabilities, which exposes banks to interest rate risk (Van den Heuvel, 2001a): a monetary tightening lowers banks' profits and consequently their capital accumulation; if it is too costly to issue new shares, banks could reduce lending in order to meet regulatory capital requirements.

Apart from monetary policy shocks, bank lending is also exposed to GDP shocks. One reason for this is quite obvious: demand for loans is pro-cyclical. However, banks' lending supply could behave differently according to the business cycle. One reason is that banks deeply involved in relationship lending are likely to smooth lending "through the cycle" (Boot, 2000; Thakor, 2004). In this respect, well-capitalized banks could be in a better position to absorb temporary financial difficulties on the part of their borrowers. Secondly, bank capital could be related to ex ante loan portfolio choices. This is consistent with a large body of the literature that has emphasized a link between bank capital and risk aversion (Flannery, 1989; Gennotte and Pyle, 1991; Hellman et al., 2000; Kim and Santomero, 1988; Rochet, 1992). If banks select ex ante a loan portfolio with higher return and risk, their borrowers are, on average, more financially fragile and thus more exposed to economic downturns. These considerations raise an important question: how does bank capital influence the response of bank lending to monetary policy and GDP shocks?

The main aim of this paper is to empirically address this question. Earlier empirical investigations concerning the effect of bank capital on lending mostly refer to the US banking system (Furfine, 2000; Hancock et al., 1995; Kishan and Opiela, 2000; Van den Heuvel, 2001b), and emphasize the importance of bank capital in influencing lending behavior. Findings reported in papers on European countries are far from conclusive; Altunbas et al. (2002) and Ehrmann et al. (2003) find that lending of low-capitalized banks suffers more from monetary tightening, but their results are not significant at conventional values for the main European countries. There is no conclusive evidence about the effects of bank capital on the lending behavior of Italian banks. In principle, the financial structure of the Italian economy during the 1990s makes it more likely that a "bank lending channel" was at work (Gambacorta, 2003). Most empirical papers based on VAR analysis confirm the existence of such a channel in Italy (Angeloni et al., 1995; Buttiglione and Ferri, 1994; Chiades and Gambacorta, 2004; Fanelli and Paruolo, 2003). However, there is much less evidence on cross-sectional differences in the effectiveness of the "bank lending channel" in Italy, due to capitalization.[2] So far no evidence has been provided on the existence of the so-called "bank capital channel."

This paper departs in three ways from the existing literature on the monetary policy transmission mechanism. The first one is the definition of capital; we define banks' capitalization as the amount of capital that banks hold in excess of the minimum required to meet prudential regulation standards.[3] This definition allows us to overcome some problems of the capital-to-asset ratio generally used in the existing literature. The second departure lies in the attempt to analyze the effects of capital 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. The third departure is the use of a unique data set 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 biases detected in other publicly available data sets. 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 easier access to uninsured fund raising, consistent with the "bank lending channel" hypothesis. We find evidence of a "bank capital channel" that has a stronger effect on small banks whose balance sheets contain a larger maturity mismatch between assets and liabilities. Capital also influences the way banks react to GDP shocks: well-capitalized banks can better absorb temporary financial difficulties on the part of their borrowers and preserve long-term lending relationships.

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 discusses 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] See de Bondt (1999), Favero et al. (1999) and King (2002) who analyze mainly the effect of bank size and liquidity. Some evidence of the effect of capitalization on the lending of Italian banks is detected by Altunbas et al. (2002). Apart from the differences in specification, all these paper use the BankScope data set which suffers from 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. To tackle these problems our analysis is based on the Bank of Italy Supervisory Reports database, using quarterly data for the full population of Italian banks.

[3] The excess capital-to-asset ratio has been used to analyze the role of internal capital markets (Houston and James, 1998) and to assess the affects of the introduction of regulatory capital requirements on US banks' lending behavior (Brinkmann and Horvitz, 1995). See also Ayuso et al. (2004) who study the relationship between capital buffers and the business cycle.

2. Bank capital and the business cycle

There are several theories that explain how bank capital could influence the propagation of economic shocks to lending. All these theories suggest the existence of market imperfections that modify the standard results of the Modigliani and Miller's (1958) 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 its level of capital would play no role.

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

Bank capital can influence the impact of monetary policy changes on lending in two ways, both based on adverse selection problems that affect banks' fund-raising: the "bank lending channel," which relies on imperfections in the market for bank debt (Bernanke and Blinder, 1988; Kashyap and Stein, 1995; Kishan and Opiela, 2000; Stein, 1998) and the "bank capital channel," which concentrates on an imperfect market for bank equity (Bolton and Freixas, 2001; Thakor, 1996; Van den Heuvel, 2001a).

According to the "bank lending channel" thesis, a monetary tightening affects bank lending because the drop in reservable deposits cannot be completely offset by issuing non-reservable liabilities (or liquidating some assets). Since the market for bank debt is not frictionless and non-reservable liabilities are typically not insured, a "lemon's premium" has to be 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. Therefore, the cost of non-reservable funding (i.e. bonds or CDs) would be higher for low-capitalized banks if they are perceived as more risky by the market.[4] Low-capitalized banks are therefore more exposed to asymmetric information problems and have less capacity to shield their credit relationships (Jayaratne and Morgan, 2000; Kishan and Opiela, 2000).[5]

Only if banks had the possibility to issue unlimited amounts of CDs or bonds, which are not subject to reserve requirements, the "bank lending channel" would be ineffective.[6] However, even in this case, bank capital could continue to play a role in the monetary transmission if another mechanism, the so-called "bank capital channel," is at work.

The "bank capital channel" relies on three hypotheses. First, there is an imperfect market for bank equity: banks cannot easily issue new equity because of the presence of agency costs and tax disadvantages (Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994; Myers and Majluf, 1984; Stein, 1998). Second, banks are subject to interest rate risk because their assets typically have a longer maturity than liabilities (maturity transformation).

[4] 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).

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

[6] This is the point of the Romer and Romer (1990) critique.

Third, banks have to meet regulatory capital requirements linked to credit supply (Bolton and Freixas, 2001; Thakor, 1996; Van den Heuvel, 2001a).

The mechanism is the following. After an increase in market interest rates, a smaller fraction of loans can be renegotiated compared with deposits (loans are mainly long-term, while deposits are typically short-term). This means that interest rates on banks' assets are slower to adjust to changes in market interest rates than those on banks' liabilities: banks therefore bear a loss due to the maturity mismatch between assets and liabilities that reduces profits and then capital. If equity is sufficiently low and it is too costly to issue new shares, banks reduce lending, or else they fail to meet regulatory capital requirements. For the "bank capital channel" to be at work, it is not necessary that capital requirements are currently binding. Van den Heuvel (2001a) shows that even if capital is greater than regulatory capital requirements, 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.

Bank capitalization may also influence the way the loan supply reacts to output shocks if banks' profits, and thus banks' capital accumulation, depend on the business cycle. In this case, output shocks affect banks' capacity to lend if the market for equity is not frictionless and banks have to meet regulatory capital requirements. Other things being equal, well-capitalized banks are in a better position, with respect to less-capitalized banks, to absorb output shocks. Since they hold more capital in excess of the minimum required to meet prudential regulation standards, well-capitalized banks need to adjust lending less during economic downturns in order to avoid regulatory capital shortfalls. Thus, if for institutional reasons banks hold a different amount of capital in excess of regulatory requirements, this may in turn imply cross-sectional differences in lending responses to output shocks. In Italy, the institutional characteristics of credit cooperative banks[7] are very different from those of commercial banks.

Well-capitalized banks may react less to output shocks not only for the reason outlined above but also because their profits could be less sensitive to the business cycle, as their portfolio choices may differ from those taken by less-capitalized banks. If well-capitalized banks are also more risk-averse, they select ex ante a pool of borrowers who are on average less financially fragile, thus containing banks' exposure to default risk when an economic downturn occurs. It should be noted though that the link between bank capital and risk-taking behavior is still quite controversial.[8]

[7] Credit cooperatives are mutual banks that can act as *universal banks* offering all banking services. The main limitation on their activity is that they have to operate *prevalently* with their members and within the area in which their branches are located (see the 1993 Banking Law, Article 35).

[8] A wide stream of literature has analyzed the relation between bank capitalization and risk-taking behavior reaching different results. In some models based on a portfolio approach (Flannery, 1989; Gennotte and Pyle, 1991) well-capitalized banks are more risk-averse due to the relation between deposit insurance schemes and the risk-taking attitude of banks: if the insurance premium undervalues banks' risk, the implicit subsidy from deposit insurance is a decreasing function of capital. In this class of models the presence of capital requirements attenuates the distortions caused by deposit guarantees: banks cannot reduce equity below a certain threshold to obtain the maximum implicit subsidy from deposit insurance. The hypothesis that well-capitalized banks are more risk-averse can also be supported by interpreting capital as a cushion against contingencies (Dewatripont and Tirole, 1994; Repullo, 2000; Van den Heuvel, 2001a). On the contrary, some authors (Hellman et al., 2000;

From the preceding discussion, we can derive several implications for the subsequent empirical analysis. The "bank capital channel" and the way banks react to output shocks are closely related to the amount of capital held in excess of regulatory requirements. Thus, the traditional capital-to-asset ratio does not discriminate among banks with the same level of capital facing different regulatory constraints. By contrast, the excess capital-to-asset ratio takes regulatory requirements directly into account. Furthermore, the analysis of the "bank lending channel" has highlighted that the capacity of banks to substitute uninsured for insured liabilities depends on the amount of excess capital, as it is a proxy for banks' default risk. In this case as well, the capital-to-asset ratio seems inappropriate, as it is not sensitive to portfolio risk shifts. The excess capital-to-asset ratio does not suffer from the same limitation because regulatory capital requirements vary among different kinds of assets that are classified according to their risk. Finally, institutional characteristics may be a factor in distinguishing among banks which hold equal excess capital-to-asset ratios. The reason is that mutual banks are different from other banks in terms of corporate governance and are subject to specific prudential regulation. To tackle this problem, our analysis distinguishes between credit cooperatives and ordinary commercial banks.

3. Some simple facts on bank capital

In this section we analyze how capital behaved among different kind of banks since the implementation of the 1988 Basel Capital Accord. To this aim, we have considered four distinct samples:

(a) "banks": all institutions except credit cooperative banks;
(b) "large banks": banks with total assets above 10 billion Euros in September 2001, credit cooperative banks excluded;[9]
(c) "credit cooperatives";
(d) "all institutions": "banks" and "credit cooperatives."

The 1988 Basel Capital Accord and its subsequent amendments require capital to be above a threshold that is defined as a function of several types of risk. It is possible to distinguish between the default risk (credit risk) and the risk related to adverse fluctuations in asset market prices (market risk). In Italy, the capital requirements for credit risks were

Kim and Santomero, 1988; Rochet, 1992) argue that well-capitalized banks are less risk-averse: if capital is more costly with respect to other sources of funds, a typical moral hazard problem emerges.

[9] This definition of large banks includes a sample of intermediaries whose size is larger than the one considered by studies about the monetary policy transmission in the US (e.g., Kashyap and Stein, 1995, 2000), while it appears to be similar when compared with those considered in studies on other Eurosystem area countries (e.g., Ehrmann et al., 2003). However, banks total assets greater than 10 billion Euros are above the 95th percentile of the total asset distribution. Thus, in relative terms, our size cutoff is not different from the one typically adopted to define large banks. To control for mergers we have assumed that consolidation took place at the beginning of the period (see Appendix A for further details of merger treatment).

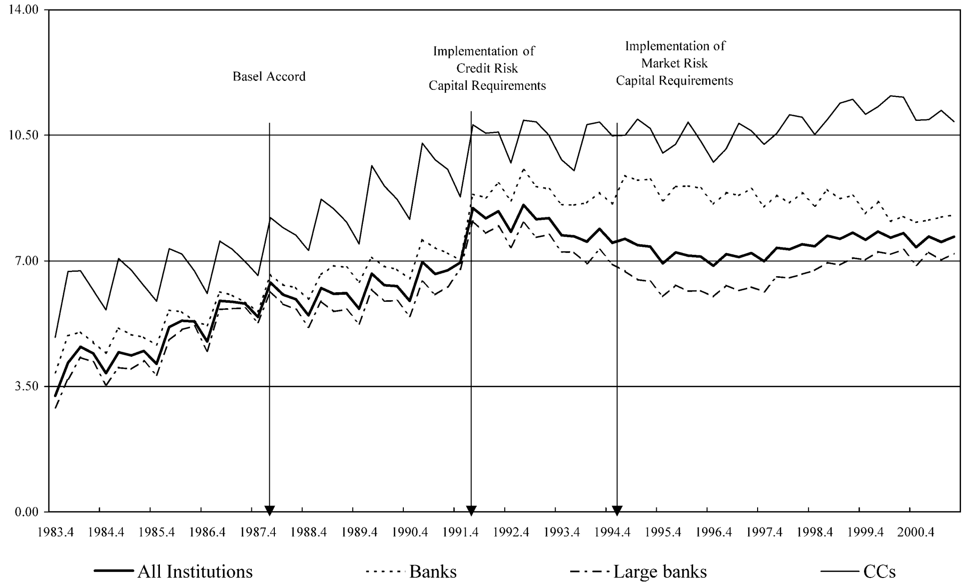

Fig. 1. Capital and reserves as a percentage of total assets.

introduced in 1992, those for market risks in 1995. Banks have to hold an amount of capital that must be at least equal to the sum of credit and market risk capital requirements.[10]

One of the objectives of the 1988 Basel Accord was to increase banks' capital levels (Basel Committee on Banking Supervision, 1999). We observe that, for the banking system as a whole ("all institutions"), banks' capital increased during the period that preceded the implementation of the Basel Accord in Italy and it declined slightly afterwards (Fig. 1). It seems, therefore, that banks accumulated sufficient capital before risk-based capital requirements were implemented. This apparently supports the thesis that bank capital is sticky. Large banks' capital levels have been constantly below the average. By contrast, credit cooperatives (from now on, simply CCs), who are typically very small, are better capitalized than other banks. The different capital ratios among Italian banks could reflect heterogeneity in their capacity to issue capital. As capital is relatively costly, banks minimize their holdings, subject to different "adjustment cost" constraints. This implies that, ceteris paribus, capital ratios are lower for those banks that incur lower costs in order to adjust their level of capital. The different levels of capital could also be due to the fact that as bank size increases, banks can better diversify the risk of capital shocks.

[10] As far as credit risk is concerned, capital must be at least equal to 8 percent of the total amount of risk-weighted assets (solvency ratio). A bank-specific solvency ratio (higher than 8 percent) can be set in the case of a poor performance in terms of asset quality, liquidity and organization. On the contrary, the ratio decreases to 7 percent for banks belonging to a banking group that meets an 8 percent solvency ratio on a consolidated basis. Capital requirements against market risks are related to open trading positions in securities, foreign exchange and commodities.

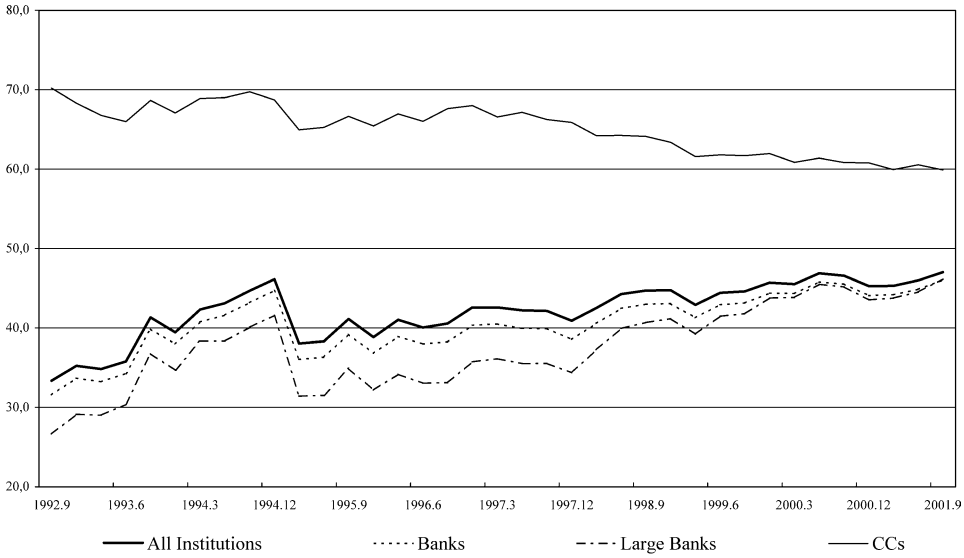

Fig. 2. Excess capital (regulatory capital minus minimum capital requirement) as a percentage of regulatory capital.

For all kinds of banks the excess capital (the amount that banks hold in excess of the minimum regulatory capital requirement) has always been much 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 excess capital (regulatory capital[11] minus capital requirement) and regulatory capital this should be close to zero 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 zero (Fig. 2). The cushion is smaller for large banks than for CCs.

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 $z_{it} = (x_{it} - \bar{x}_i)/\sigma_{x_i}$, where $\bar{x}_i$ is the average bank capitalization and σ_{x_i} is the standard deviation 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. The indicator is more stable for large banks, more volatile for CCs. This seems consistent with the view that large banks have easier access to capital markets and therefore can adjust their capital ratios more rapidly to loan demand fluctuations; capital is less flexible for smaller banks and for CCs, which are more dependent on self-financing.

Figure 4 shows the maturity transformation performed by banks. As we discussed in the previous section, the existence of a maturity mismatch between assets and liabilities

[11] Regulatory capital is defined as the sum of the so-called "Tier 1" and "Tier 2" 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, hybrid instruments and subordinated debt.

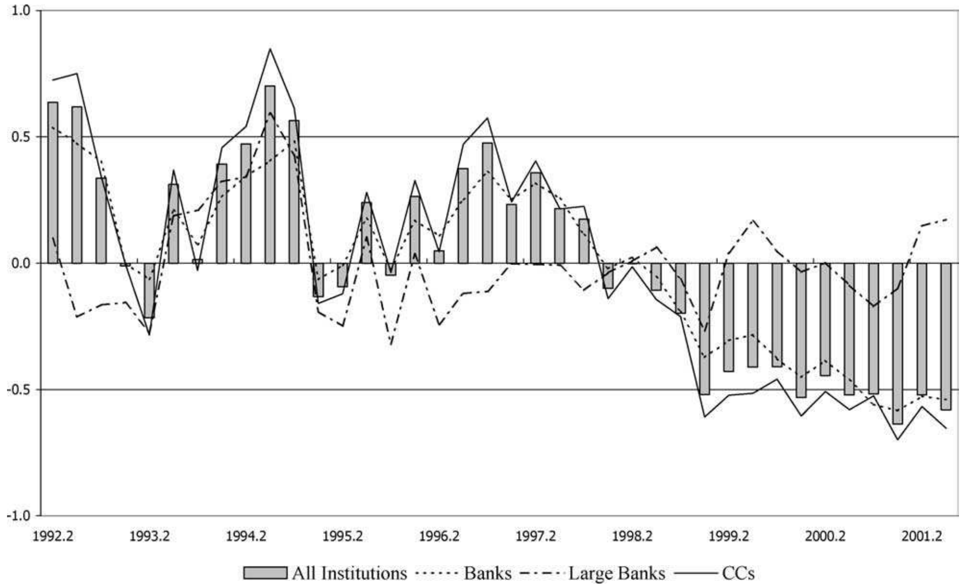

Fig. 3. The evolution of banks' capitalization. Normalized distance from long-run average.

is a necessary condition for the "bank capital channel" to be at work. Since loans typically have a longer maturity than bank fund-raising, the average maturity of total assets is longer than that of liabilities. In this case, as predicted by the "bank capital channel," the bank bears a cost when interest rates are raised and benefits when they are lowered. The difference between the average maturity of assets and that of liabilities is greater for CCs than for banks. In fact, CCs' balance sheets contain a larger percentage of long-term loans, while their bond issues are more modest. For example, at the end of September 2001, the ratio between medium and long-term loans over total loans was 57 percent for CCs and 46 percent for banks. On the contrary, the ratio between bonds and total fund-raising was, respectively, 27 and 29 percent. These differences were even greater at the beginning of our sample period. Therefore, the analysis of the maturity mismatch between assets and liabilities indicates that there is room for a "bank capital channel" in Italy with a potentially greater effect for CCs.

4. The econometric model and the data

The empirical specification, based on Kashyap and Stein (1995), is designed to test whether banks with different capital ratios react differently to a monetary policy or a GDP shock.

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 or the real GDP; all bank-specific characteristics (excess capital, cost due to maturity mismatch,

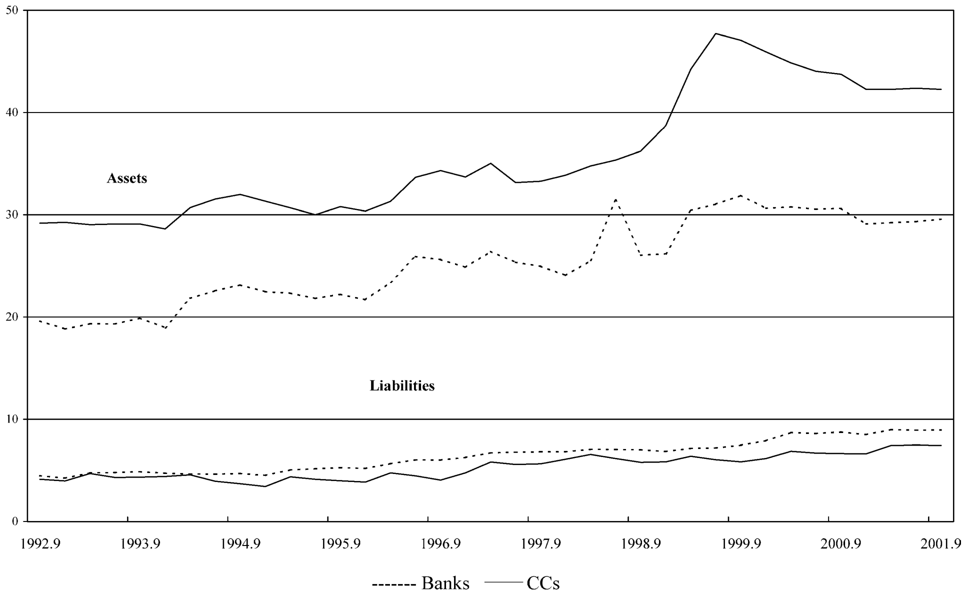

Fig. 4. Maturity transformation. Asset and liability months-to-maturity. The asset (M_t^A) and liability (M_t^L) months-to-maturity statistics have been computed, for each quarter t, as follows: $M_t^A = \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{K}\bar{d}_j\frac{a_{ij}}{A_i}$, $M_t^L = \frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{K}\bar{d}_j\frac{l_{ij}}{L_i}$, where N is the number of banks, K the number of months-to-maturity brackets, $\bar{d}_j$ is the median value of the maturity interval for the jth bracket ($j = 1, 2, \ldots, K$). a_{ij} (l_{ij}) is the amount of assets (liabilities) belonging to the jth bracket and held by the ith bank ($i = 1, 2, \ldots, N$). $A_i = \sum_{j=1}^{K} a_{ij}$ and $L_i = \sum_{j=1}^{K} l_{ij}$.

etc.) refer to $t-1$ to avoid an endogeneity bias (see Ehrmann et al., 2003; Kashyap and Stein, 1995, 2000):[12]

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

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

L_{it} loans of bank i in quarter t,
MP_t monetary policy indicator,

[12] A simple theoretical framework that justifies the choice of the specification is reported in the working paper version of this study (Gambacorta and Mistrulli, 2003).

y_t real GDP,
π_t inflation rate,
X_{it} measure of excess capital,
ρ_{it} maturity transformation cost per unit of asset computed for a one percent 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 are introduced in order to obtain white noise residuals. The model is specified in growth rates 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.[13]

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.[14]

To test for the existence of asymmetric effects due to bank capital, the following measure is adopted:

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

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 $\sum_{j=1}^{4} \gamma_j X_{it-1} \Delta MP_{t-j}$ and $\sum_{j=1}^{4} \tau_j X_{it-1} \Delta \ln y_{t-j}$ in Eq. (1), are zero for the average bank ($\overline{X}_{it-1} = 0$). 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 introduce a variable ($\rho_i \Delta MP$) that represents the bank-specific interest rate cost due to maturity transformation. In other words, this cost depends on the fact that banks' assets have a longer maturity than their liabilities. In particular, ρ_i measures the loss per unit of asset the bank suffers when the monetary policy interest rate is raised by one percentage point. We compute this variable according to supervisory regulations relating to interest rate risk exposure that depends on the maturity mismatch between assets and liabilities.[15] To work out the real cost, we

[13] As pointed out by Buttiglione et al. (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 was the value to which market rates and bank rates eventually tended to converge. It is worth noting that the interest rate on main refinancing operations of the ECB does not present any particular break with the repo rate.

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

[15] See Appendix A for further details.

therefore multiply this measure by the actual change in interest rates. The term $\rho_i \Delta MP$ represents the real cost that a bank bears in each quarter.[16]

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 is 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. As for the other bank specific characteristics, liquidity and size indicators refer to $t-1$ to avoid an endogeneity bias.

The fact that supervisors can set solvency ratios greater than 8 percent for highly risky banks (see Section 3), allows us to test for the effects of capital shocks on bank lending. We analyze the impact of these supervisory actions on lending in the first two years, 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 percent. This allows us to capture the 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 percent of total bank credit in Italy. Table 1 gives some basic information on what bank balance sheets look like. Credit cooperatives are treated separately because they are considerably smaller, more liquid and better capitalized than 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 smaller among credit cooperatives. The high capitalization of CCs is due, at least in part, to the Banking Law prescription that significantly limits the distribution of net profits.[17]

Within each category, banks are split according to their capital.[18] Low-capitalized banks are larger and less liquid irrespective of their form (CCs or banks), and they issue more bonds than well-capitalized banks. While these differences are small among CCs, they are quite significant among banks. In this group, low-capitalized banks are much larger than well-capitalized ones; a greater share is listed and belongs to a banking group. Moreover, they issue more subordinated debt to meet regulatory capital requirements. This evidence is consistent with the view that, "ceteris paribus," capital 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 better diversify the risk of regulatory capital shortage if an internal capital market is active at the group level.[19]

16 As formalized in Gambacorta and Mistrulli (2003), this measure influences the level of loans. Since the dependent variable is a growth rate, we include this measure in first differences.

17 According to Article 37 of the 1993 Banking Law, "Banche di credito cooperativo must allocate at least 70 percent of net profits for the year to the legal reserve."

18 A "low-capitalized" bank has a capital ratio equal to the average capital ratio below the 10th percentile, a "well-capitalized" bank, that of the banks above the 90th percentile. Since the characteristics of each bank could change over time, percentiles are worked out on mean values.

19 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. See also Ashcraft (2001).

Table 1
Data description (September 2001)

	Credit cooperatives[a]			Banks[b]					All institutions		
	well capitalized	low capitalized	total	well capitalized	low capitalized	large banks[c]	total	large banks[c]	well capitalized	low capitalized	total
Number of banks	40	40	401	15	16	5	155	31	55	55	556
Banks belonging to a group[d]	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	1,341	12,468	35,766	9,160	38,581	159	12,486	2,692
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
Excess capital/ 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 supervisory reports.

Notes. Excess capital is given by regulatory capital minus capital requirements. A "low-capitalized" bank has a capital ratio (excess capital/total assets) equal to the average capital ratio below the 10th percentile, a "well-capitalized" bank has the average capitalization above the 90th percentile.

[a] Credit cooperatives are mutual banks that can act as universal banks offering all banking services. The main limitation on their activity is that they have to operate prevalently with their members and within the area in which their branches are located (see the 1993 Banking Law, Art. 35).

[b] All institutions except credit cooperatives. This group typically includes limited companies banks.

[c] Large banks are non cooperative banks with total assets greater than 10 billions of Euro at September 2001.

[d] Only groups with more than a bank member are considered.

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.[20] The models are 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).

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

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 opportunities to expand their loan portfolio. The effect is higher for CCs than for banks because they encounter higher capital adjustment costs: CCs are more dependent on self-financing and cannot easily raise new regulatory capital (the null hypothesis that the coefficients of CCs and banks are equal in a nested model is rejected; p-value: 0.00).

The response of bank lending to a monetary policy shock has the expected negative sign. These estimates roughly imply that a one percent increase in the monetary policy indicator leads to a decline in lending of around 1.2 percent for the average bank. The effect is higher for CCs (−1.8 percent) than for banks (−0.2 percent), which have more access to markets for non-reservable liabilities (the two institutional categories are statistically different; p-value: 0.00). Testing the null hypothesis that monetary policy effects are equal among banks with different capital ratios 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 smaller for banks with higher capital ratios, which have easier access to uninsured financing. Bank capital interaction with monetary policy is very high (in absolute value) for banks that are more dependent on non-deposit forms of external funds. It is worth noting that well-capitalized banks are

[20] 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 $\sum_{j=0}^{4}\beta_j/(1-\sum_{j=1}^{4}\alpha_j)+\sum_{j=1}^{4}\gamma_j/(1-\sum_{j=1}^{4}\alpha_j)\overline{X}_{>0.90}$, where $\overline{X}_{>0.90}$ 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 Eq. (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 drop the contemporaneous and the fourth lags that are statistically not different from zero.

Table 2
The effect of bank capital on lending

Dependent variable: quarterly growth rate of lending	Model 1 baseline regression						Model 2 T-dummies		Model 3 liquidity $*$ *MP*	
	All institutions		Credit cooperatives		Banks		All institutions		All institutions	
	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; p-value)		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

(*continued on next page*)

Table 2 (*Continued*)

Notes. Model 1 is given by Eq. (1), which includes interaction terms that are the product of the excess capital with the monetary policy indicator and the real GDP. Seasonal dummies are also included. Four lags have been introduced in order to obtain white noise residuals (three lags in the liquidity regression). 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). In the GMM estimation, instruments are the second and further lags of the 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 exogenous variables. The sample goes from the third quarter of 1992 to the third quarter of 2001. Model 2 excludes "direct" macro controls ($\beta_j = \varphi_j = \delta_j = 0$) and includes a set of time dummies. Model 3 includes the interaction between monetary policy and the liquidity indicator.

* Significant at the 10% level.

** Idem., 5%.

*** Idem., 1%.

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 of one basis point in the ratio between the maturity transformation cost and total assets determines a reduction of 1 percent in the growth rate of lending. The reduction is bigger for CCs, which as we saw in Section 3, typically have a greater maturity mismatch between assets and liabilities (the null hypothesis of equal coefficients between CCs and banks can be rejected at a 5 percent level of confidence; p-value: 0.01). In fact, CCs balance sheets contain a larger percentage of long-term loans, while their bonds issues are lower. Another possible explanation for the greater effect of the "bank capital channel" for CCs could be they make less use of derivatives to shield the maturity transformation gap. With these characteristics CCs bear a higher cost when interest rates are raised and obtain a higher gain in the opposite case. 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 different institutional categories of banks.

The models show a positive correlation between credit and output. A one percent increase in GDP (which produces a loan demand shift) causes a loan increase of around 0.7 percent. The effect is smaller for CCs than for banks because they operate prevalently within the area in which their branches are located and national conditions are less relevant (Padoa-Schioppa, 1996). The two categories are statistically different (p-value: 0.00).

The interaction term between GDP and excess capital is negative. This means that the 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 grounds our findings are consistent with Flannery (1989) and Gennotte and Pyle (1991), who argue that well-capitalized banks are more risk-averse and select ex ante borrowers with less probability of defaulting. This means that when an economic downturn occurs well-capitalized banks suffer less loan losses and their capital changes less with respect to other banks.

The link between bank-capital and risk attitude needs to be discussed in relation to the institutional categories of Italian banks. From the sample split it emerges that the heterogeneity coefficient is highly significant only for CCs, while there are no significant asymmetric effects for the banks. CCs retain 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 CCs are able to completely insulate the effect of GDP on their lending. On the other hand, the effect of a 1 percent increase in GDP on lending does not differ too much between well-capitalized (1.3 percent) and low-capitalized banks (1.5).

As explained in Section 4, the effects of the introduction of a specific (higher than 8 percent) solvency ratio on bank lending are captured by dummy variables. In this case there are not many differences among the three samples. The introduction of a specific solvency ratio determines an overall reduction of around 20 percent in bank lending after two years. The magnitude of the effect is similar among bank institutional categories (p-value: 0.79 percent) because higher solvency ratios have been mostly imposed on small risky banks. In other words, these banks, independently of the institutional category they belong, have very similar management weakness. This result seems consistent with the hypothesis that issuing new equity can be very costly for highly risky banks owing to high agency costs in the market for equity (Calomiris and Hubbard, 1995; Cornett and Tehranian, 1994; Myers and Majluf, 1984; Stein, 1998).

5.1. Robustness checks

We test the robustness of these results in several ways. The first test introduces additional interaction terms by combining excess capital with inflation, making the basic Eq. (1):

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

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

The second robustness check compares Eq. (1) with the following model:

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

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

This model completely eliminates time variation and tests whether the three pure time variables used in the baseline equation (prices, income and the monetary policy indicator) capture all the relevant time effects. 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 is introduced in each model and given the value of one if the head office of the bank is in the north of Italy and zero if elsewhere. In all cases the maturity transformation variable and the interactions between monetary policy and output shocks with respect to excess capital remain unchanged.

The last robustness check includes the interaction between monetary policy and the liquidity indicator in the baseline regression. The reason for this test is to verify if the asymmetric effects of monetary policy due to excess capital remain relevant; the interactions between monetary policy and liquidity do in fact represent a significant factor. We obtain:

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

The results, which are presented in the fifth column of Table 2, confirm that liquidity is an important factor in enabling banks to attenuate the effect of a decrease in deposits on lending but, at the same time, they leave the distributional effects of excess capital unaltered. The result on liquidity is in line with Ehrmann et al. (2003) and Gambacorta (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 studies, however, bank capital (defined as the capital-to-asset ratio) does not significantly affect 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 approximates the relevant capital constraint under the Basel 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 differences in capital ratios. We find that well-capitalized banks can better shield their lending from monetary policy shocks as they have easier access to non-deposit fund-raising, in accordance with the "bank lending channel" hypothesis. In this respect, the bank capital effect is greater for banks that are more dependent on uninsured forms of external funds, than for credit cooperatives. We also find evidence of a "bank capital channel" that has stronger effects on credit cooperatives whose balance sheets contain a larger maturity mismatch between assets and liabilities. Bank capital also influences the way banks react to GDP shocks. Again, the credit supply of well-capitalized banks is less pro-cyclical. Capital shocks due to the imposition of a specific solvency ratio (higher than 8 percent) for highly risky banks determine an overall reduction of 20 percent in lending after two years.

All in all, these results indicate that bank capital is a relevant balance-sheet item for the propagation of different kinds of shocks to lending, owing to the existence of regulatory capital constraints and imperfections in the market for bank fund-raising. This implies that when evaluating different schemes of regulation on bank capital, one has to consider, not only microeconomic effects on banks' soundness, but also the macroeconomic consequences of those same schemes. This is an important issue to be analyzed in the future amendments of the Basel Accord.

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Appendix A. 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, 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. Capital is given by the ratio of regulatory capital in excess of capital requirements to total asset.

The cost a bank bears owing to its maturity transformation function stems from the different sensitivity of its assets and liabilities to interest rates. Using a maturity ladder, we have:

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

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 percent increase in the monetary policy interest rate ($\Delta i_m = 0.01$). Broadly speaking if $\sum_j (\chi_j \cdot A_j - \zeta_j P_j) > 0$, ρ_i represents the cost per unit of asset bank i bears if the monetary policy interest rate is raised by one percentage point. We obtain χ_i and ζ_i directly from supervisory regulations on interest rates risk exposure. In particular, the regulations assume, for any given class j of months-to-maturity: 1) the same sensitivity parameter $(\chi_j = \zeta_j)$ and 2) a non-parallel shift in the yield curve ($\Delta i_m = 0.01$ for the first maturity class and then decreasing for longer maturity classes). Then, for each bank, after classifying assets and liabilities according to their months-to-maturity class, we computed the bank-specific variable ρ_i. This variable was multiplied then by the change in 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 belong. 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 data set was composed of 556 banks (20,572 observations).

A "low-capitalized" bank has a capital ratio equal to the average capital ratio below the 10th percentile, a "well-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.

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