

Bank heterogeneity and monetary policy transmission

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Questions asked by this study

- The special role of banking institutions in the monetary transmission mechanism has been studied extensively both at a theoretical and empirical level.
- The focus has been on the impact of monetary policy changes on bank lending.
- Evidence shows that banks alter their lending behavior in specific ways following a change in monetary policy.
- But does this reaction involve only changes in lending behavior, as studied in the bulk of the literature? What about the impact of monetary policy on bank risk and ultimately bank performance?
- Do all banks in the market respond uniformly to monetary policy changes?

Relationship with existing literature: Monetary policy and bank lending

- Bernanke and Blinder (1988) suggest that the effect of monetary policy on aggregate demand through interest rates may be enhanced by financial market imperfections and the existence of imperfect substitutability between loans and securities in bank portfolios and also between loans and other forms of external finance for borrowers.
- One of the identification schemes for the lending channel involves estimation of reduced-form lending equations, where loan supply shifts are traced using bank-level data on certain bank characteristics (see Kashyap and Stein, 2000; Ashcraft, 2006).

Relationship with existing literature:

Monetary policy and bank risk

- The impact of monetary policy changes on bank risk is much less investigated.
- Matsuyama (2007) and Dell’Ariccia and Marquez (2006) suggest that a decrease in interest rates reduces agency costs or may cause banks to relax their lending standards, thus raising credit risk.
- Empirical papers on this issue include Jimenez et al. (2007) and Ioannidou et al. (2008) who find that in a low interest-rate environment banks have incentives to take on higher risks in search for yield.

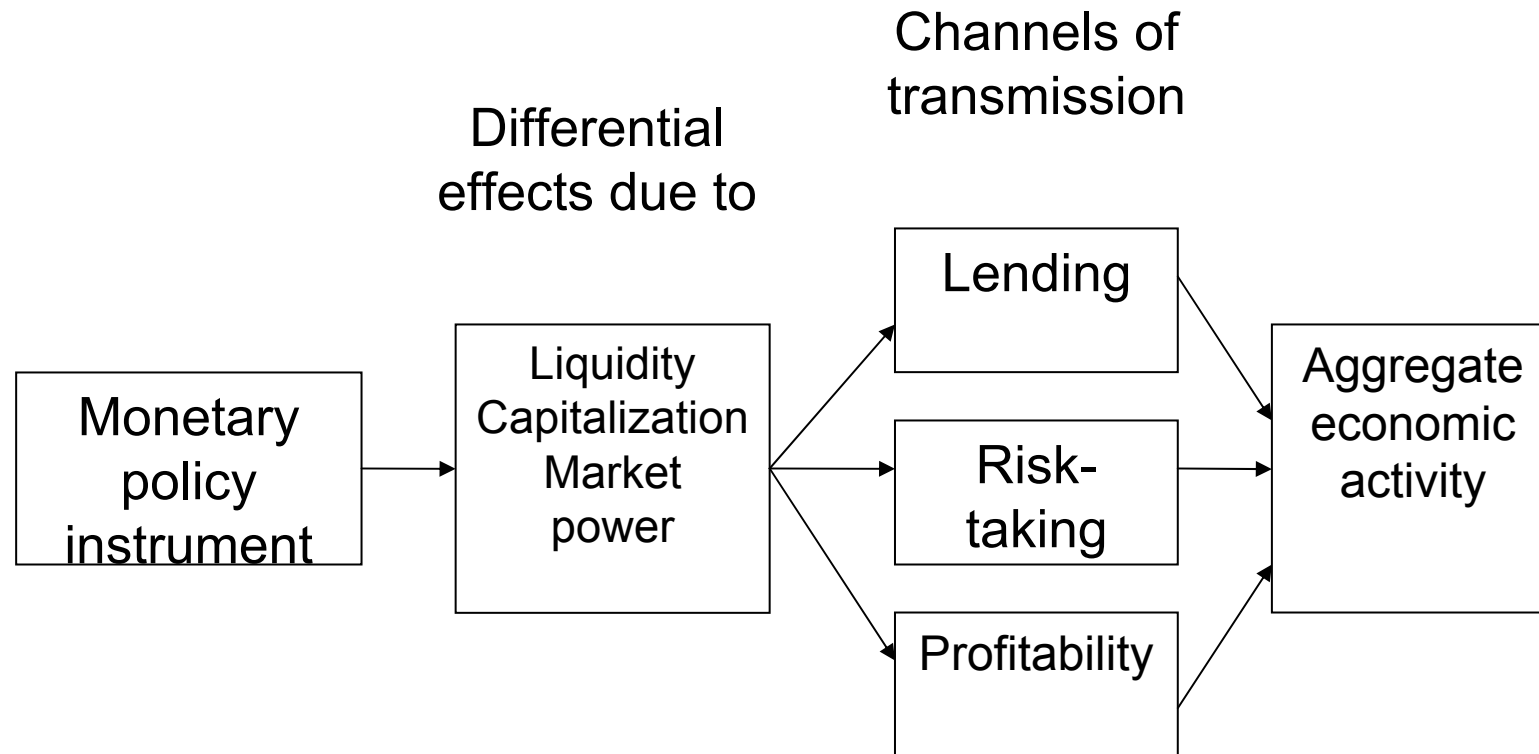
Relationship with existing literature: Monetary policy and bank performance

- The potential relationship between a change in monetary policy and the risk-taking of banks has interesting implications for the sensitivity of bank profitability to changes in monetary conditions.
- A steeper term structure of interest rates as a result of looser monetary policy has often been associated with a situation in which banks are more profitable, as they can borrow short at rates that are lower than those at which they can lend long.
- Also, policy changes can alter the risk-taking of banks and the risk perception of borrowers and thus influence banks' return on credit.
- However, interest rates have been used primarily as control variables in bank profitability equations.

Bank heterogeneity and monetary policy transmission

- What is more important in the present analysis is that not all banks respond (in terms of lending and risk-taking) following a change in policy interest rates, and this heterogeneity also has implications for the effect of monetary policy on bank performance.
- In other words, the special characteristics of each bank may cause a heterogeneous effect of monetary policy on bank lending, risk-taking and, ultimately, performance.

Transmission of monetary policy through banks



Distributional effects of monetary policy

- As shown in the diagram there are 3 channels of monetary policy and 3 bank characteristics that form distributional effects of monetary policy through banks
- The 3 bank characteristics are chosen to be liquidity, capitalization and market power on the basis of theoretical considerations and also empirical analyses, where such analysis is available.

Distributional effects of monetary policy-Liquidity

- Kashyap and Stein (2000), among others, suggest that the impact of monetary policy on lending behavior is stronger for banks with less liquid balance sheets.
- Diamond and Rajan (2006) suggest that an expansionary open market operation increases financial liquidity, which alleviates the real liquidity pressures on banks, which then allows them to fund longer-term projects and therefore enhance aggregate economic activity. Thereby one should expect lending and profitability of these banks to increase above average.
- As regards the impact on bank risk, one would expect banks with higher levels of liquid assets, which reflects higher risk aversion, to have lower incentives to take on more credit risk after an expansionary monetary policy.
- However, it may also be the case that excess liquidity of banks in a low interest rate environment provides incentives for higher risk-taking if banks feel particularly safe (a moral hazard problem).

Hypothesis 1: We expect that the impact of a monetary policy change on bank lending, risk-taking and profitability will decrease (increase) with higher (lower) levels of bank liquidity.

Distributional effects of monetary policy-Capitalization

- Peek and Rosegren (1995), among others, suggest that following a contraction in the money growth rate, poorly capitalized banks reduce their lending much more than better capitalized banks, since they usually have less access to markets for uninsured funding.
- Bolton and Freixas (2006) suggest that a monetary tightening reduces banks' incentives to increase their equity-capital base. If capital regulations are in place, banks are likely to react by decreasing the supply of loans, thus magnifying the contractionary effect of monetary policy.
- This is also related to the theory of credit rationing, which suggests that the underlying factor of a credit crunch may be a change in the risk perception of banks, which in turn could be triggered by a change in monetary policy. In these situations bank risk-taking and ultimately profitability are also likely to be heterogeneously affected on the basis of differential levels of equity capital.

Hypothesis 2: We expect that the impact of a monetary policy change on bank lending, risk-taking and profitability will decrease (increase) with higher (lower) levels of bank equity capital.

Distributional effects of monetary policy-Market power

- In the present study we depart from using size as the third bank balance sheet characteristic influencing banks' reaction to changes in policy rates and instead we use market power of banks.
- Baglioni (2007) investigated a model of the banking industry under both monopolistic competition and a Cournot oligopoly and suggested that under the former the effect of monetary policy is amplified, while under the latter it is weakened.
- If, following an expansionary monetary policy, banks on average take on higher credit risk in search for yield, then banks with high market power will probably not engage in such activities because they already extract rents from the fact that they have market power.
- However, banks with market power may also see their revenue rise from other activities besides lending (which corresponds to credit risk) and therefore their profits may rise above average following a fall in policy interest rates.

Hypothesis 3: We expect that the impact of a monetary policy change on bank lending, risk-taking and profitability will decrease (increase) with higher (lower) levels of bank market power.

Empirical methodology-Equations

- We estimate lending, risk and profitability equations

$$D(l_{it}) = a_1(z_{it})D(l_{i,t-1}) + a_2(z_{it})DM_t + u_{it}^1$$

$$D(r_{it}) = b_1(z_{it})D(r_{i,t-1}) + b_2(z_{it})DM_t + u_{it}^2$$

$$D(P_{it}) = g_1(z_{it})D(P_{i,t-1}) + g_2(z_{it})DM_t + u_{it}^3$$

where Δ denotes change, l is lending of bank i in period t (in logarithmic terms), r is a measure of bank risk, Π is a measure of bank profitability, z are the bank characteristics of liquidity, capitalization and market power (used alternatively), M is the monetary policy variable and u is the error term.

The first equation considers the response of lending to monetary policy and follows from the bank lending channel literature (see e.g. Kashyap and Stein, 2000). The second considers the impact of monetary policy on bank risk-taking and follows from the literature that explains credit risk, which however does not emphasize the effect of monetary policy (see e.g. Boyd et al., 2006). Finally, the third equation considers a simple profitability/performance equation (see e.g. Brissimis et al., 2008).

In all equations we control for the economic conditions by real GDP growth (denoted by GDP) and for financial depth by the ratio of stock market capitalization to GDP (CAP).

Empirical methodology-Estimation method

- To estimate these equations we employ a smoothing technique, and in particular the Local GMM (LGMM) method proposed by Tran and Tsionas (2008).
- The main advantage of this approach is that like all smoothing techniques it relaxes the assumption that banks share the same incentives, technology and balance sheet characteristics, and therefore that they have the same response to a shift in monetary policy.
- This is accomplished because the parameters of the estimated equations are made observation-specific through localization. LGMM allows the marginal effect of the monetary policy variable to be a function of observable covariates (in particular liquidity, capitalization, and market power) and hence it introduces heterogeneity directly into the marginal effect.
- By examining the coefficients obtained one can in fact estimate the extent of heterogeneity using simple statistical measures, like the standard deviation of the coefficients.

Empirical methodology-Dataset

- Bank-level annual data for US and EU12 banks is obtained from the Bankscope database and covers the 1994-2007 period.
- The final sample consists of 5873 observations for the United States and 6133 observations for the euro area banking sector, therefore 12006 observations in total.
- In two recent papers, Gambacorta (2005) and Ashcraft (2006) point out that results obtained from lending equations are robust to the use of annual data.

Empirical methodology-Variables

- l is measured by total customer loans in real terms and r by the ratio of problem loans to total loans. Bank performance Π is measured by the ratio of net profits to total assets (i.e. the return on assets, ROA).
- We utilize the federal funds rate as a measure of monetary policy in the US. For the euro area, we utilize the ECB policy rate from 1999 onwards (2001 for Greece) and before 1999 the official refinancing operations rate for each country separately.
- For the smoothing variables z , we use the ratio of equity to total assets to measure the capitalization of banks and the ratio of liquid assets to total assets to measure their liquidity level (see also Gambacorta, 2005; studies in Angeloni et al., 2003). Finally, we estimate market power of individual banks in terms of the Panzar and Rosse's H-statistic.

Descriptive statistics

Table 1
Descriptive statistics

Variable	United States				Euro area			
	Mean	Standard deviation	Minimum	Maximum	Mean	Standard deviation	Minimum	Maximum
Real total assets	1.63e+07	7.67e+07	1214	1.32e+09	1.55e+08	6.58e+08	11671	9.82e+08
Real total loans	9516037	3.98e+07	816	6.88e+08	8.71e+07	6.45e+08	7312	1.13e+08
Problem loans/loans ¹	0.070	0.108	0.009	0.256	0.064	0.121	0.007	0.311
Net profits/total assets	0.021	0.038	-0.447	0.858	0.023	0.040	-0.523	0.733
Liquid assets/total assets	0.052	0.768	0.007	0.142	0.056	0.814	0.007	0.199
Equity capital/total assets	0.119	0.112	-0.013	0.256	0.126	0.104	-0.039	0.195
Market power (H-statistic)	0.673	0.175	-0.199	1.134	0.498	0.387	-0.236	1.095
Interest rate ²	4.186	1.705	1.130	6.240	3.119	1.728	1.000	6.058
Gross interest revenue/total assets	0.095	0.180	0.011	0.477	0.116	0.207	0.008	0.555
Interest expenses/total deposits and money market funding	0.039	0.220	0.008	0.126	0.046	0.398	0.012	0.241
Personnel expenses/total assets	0.019	0.062	0.003	0.210	0.015	0.079	0.003	0.199
Operating and administrative expenses/total fixed assets	0.527	2.892	0.088	1.217	0.622	3.186	0.105	1.512
Real GDP growth ³	3.174	1.136	0.759	4.548	2.236	0.851	0.794	3.854
Stock market capitalization/GDP ³	1.204	0.311	0.730	1.381	0.669	0.459	0.132	2.688
Concentration ratio ³	0.305	0.027	0.263	0.342	0.672	0.198	0.195	1

Notes: All level variables are expressed in thousand dollars.

1. This variable is multiplied by 10 for expositional brevity.

2. This variable corresponds to the federal funds rate for the United States and the European Central Bank policy rate. Before 1999 for the euro area countries (before 2001 for Greece), the euro area policy rate refers to the average of official refinancing rates for each country.

3. Values reported for these variables are euro area averages.

Empirical methodology-Estimation of bank market power

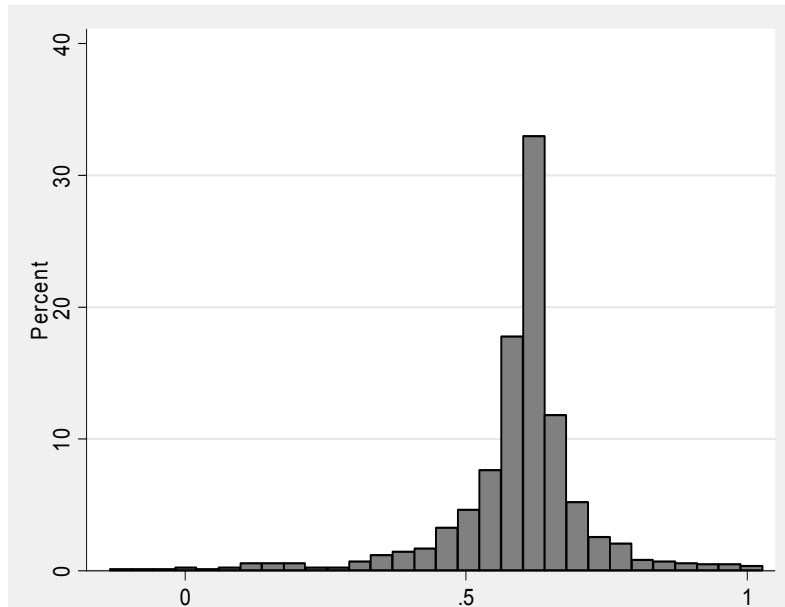
- The empirical Panzar-Rosse model involves estimation of the following revenue equation

$$\ln tr_{it} = d_0 + d_1 \ln w_{1,it} + d_2 \ln w_{2,it} + d_3 \ln w_{3,it} + d_4 \ln k_{it} + e_{it}$$

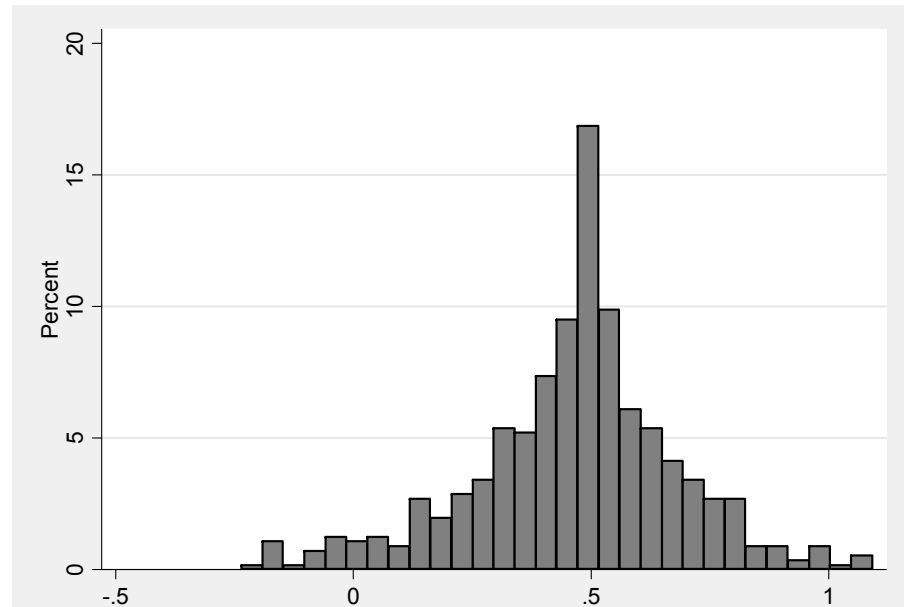
Where tr is the total revenue of banks, w_1 , w_2 , w_3 are the input prices of deposits, labor and fixed capital respectively, k is a vector of control variables and the H-statistic is $H = \delta_1 + \delta_2 + \delta_3$. In this framework, the H-statistic takes values between -1 and 1; the more negative or close to 0 the H-statistic is, the larger is market power, while the closer the H-statistic is to unity, the more competitive is the bank. Values between 0 and 1 reflect monopolistically competitive practices.

Brissimis and Delis (2008) proposed estimating the H-statistic at the bank-level using a simple local regression. Once again, the idea is that local regression allows for observation-specific (and thus bank-specific) H-statistics through localization, and in doing so it also relaxes a number of restrictive assumptions regarding the properties of the production function of banks.

Market power estimates



H-statistic (United States)



H-statistic (Euro area)

Market power estimates

- Figures show the frequency distribution of estimated H-statistics.
- The results reveal that banks in the US behave a little more competitively on average and that the equations for euro area banks have a wider distribution of coefficients.
- This finding probably shows that certain euro area banking sectors remain quite segmented, a conclusion which is supported by the fact that M&A activity in the euro area has taken place mainly within each country and not so much across borders.
- It is interesting to note that some euro area banks are characterized by monopolistic behavior with values of coefficients close to 0 or negative, while such coefficients are very rarely found for the US banking sector.
- Bikker and Haaf (2002) and Claessens and Laeven (2004) find such differences between euro area banking sectors when estimating the Panzar-Rosse model at the country level, and this enhances confidence in our market power estimates.

Empirical results-Mean and standard deviation of the coefficients

Table 2
Mean and standard deviation of the estimated coefficients on the interest rate variable for the euro area and the United States

	Lending (capit.)	Lending (liq.)	Lending (m.p.)	Risk (capit.)	Risk (liq.)	Risk (m.p.)	Profit. (capit.)	Profit. (liq.)	Profit. (m.p.)
Euro area	-0.343	-0.295	-0.384	-0.030	-0.019	-0.051	-0.052	0.006	-0.004
	0.408	0.099	1.114	0.066	0.039	0.601	0.273	0.314	0.912
United States	-0.215	-0.307	-0.317	-0.049	-0.029	-0.048	-0.050	-0.031	-0.012
	0.367	0.076	0.882	0.053	0.019	0.510	0.264	0.287	0.797
Full sample	-0.307	-0.303	-0.353	-0.038	-0.023	-0.050	-0.051	-0.012	-0.007
	0.388	0.090	1.008	0.061	0.030	0.551	0.268	0.303	0.855
Conf. Intervals	(-0.545)- (-0.101)	(-0.462)- (-0.193)	(-0.567)- (-0.094)	(-0.089)- (0.018)	(-0.070)- (0.019)	(-0.271)- (-0.011)	(-0.200)- (0.247)	(-0.273)- (0.194)	(-0.279)- (0.233)

Notes: The table presents the mean and standard deviation (in the first and the second row for each region and the full sample) of the estimated coefficients for the lending, risk and profitability equations. It also presents the values for the constructed confidence intervals (conf. intervals) for the full sample. In each equation capitalization (capit.), liquidity (liq.) or market power (m.p.) are the smoothing variables of the policy rate.

Empirical results-Mean and standard deviation of the coefficients

- The findings reported in Table 2 confirm that a bank lending channel is less operative in the United States than in the euro area (smaller average coefficient on the monetary policy variable), a result that backs up the argument suggesting that increased market-based finance (such as exists in the Anglo-Saxon type financial system) reduces the potency of the bank lending channel.
- In both the United States and the euro area the impact of the interest rate variable on bank lending is statistically significant across all specifications.
- Differences in the impact of monetary policy on risk-taking behavior and the profitability of banks are not particularly large between the two sub-samples.

Empirical results-Standard deviation of parameter estimates by year

Table 3
Standard deviation of the estimated coefficients on the interest rate variable by year

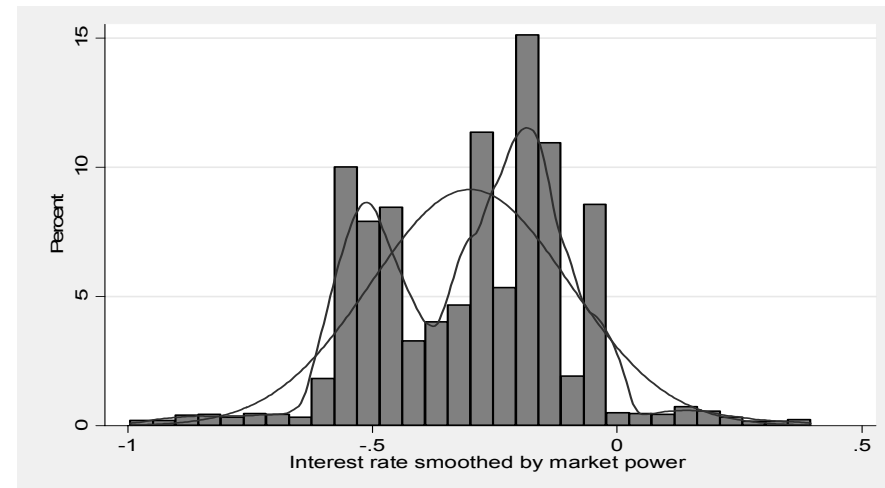
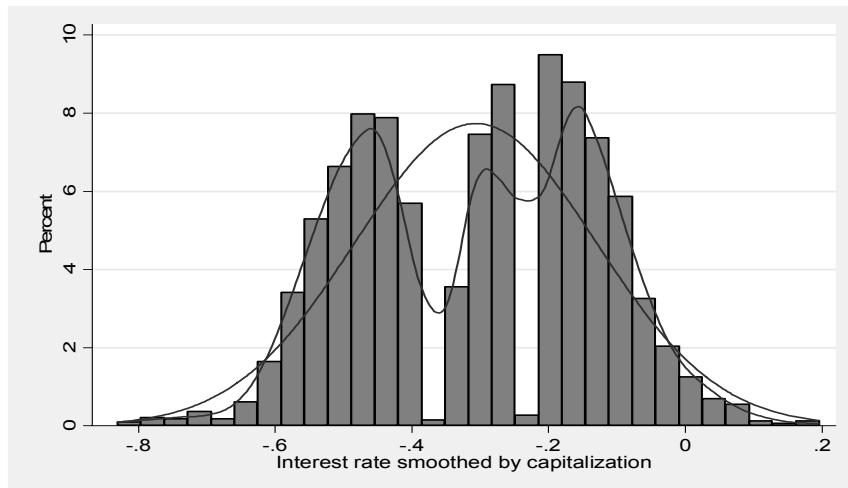
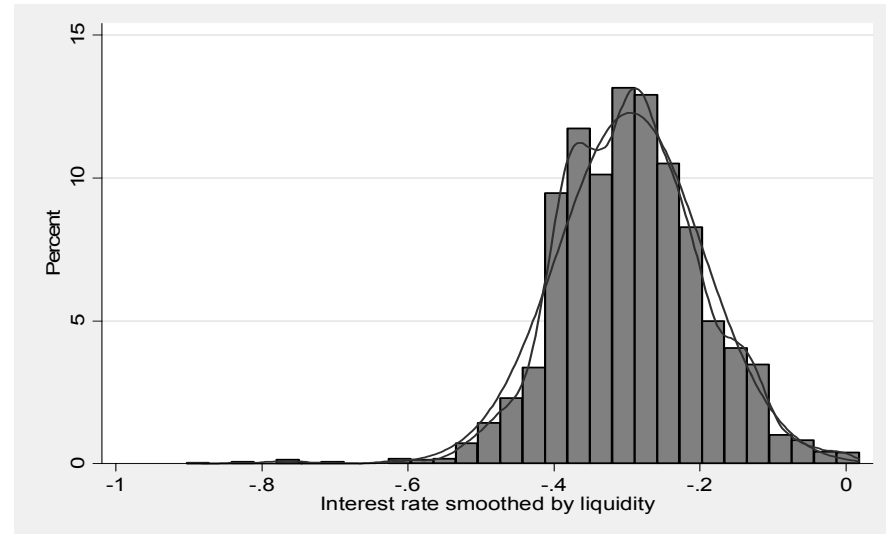
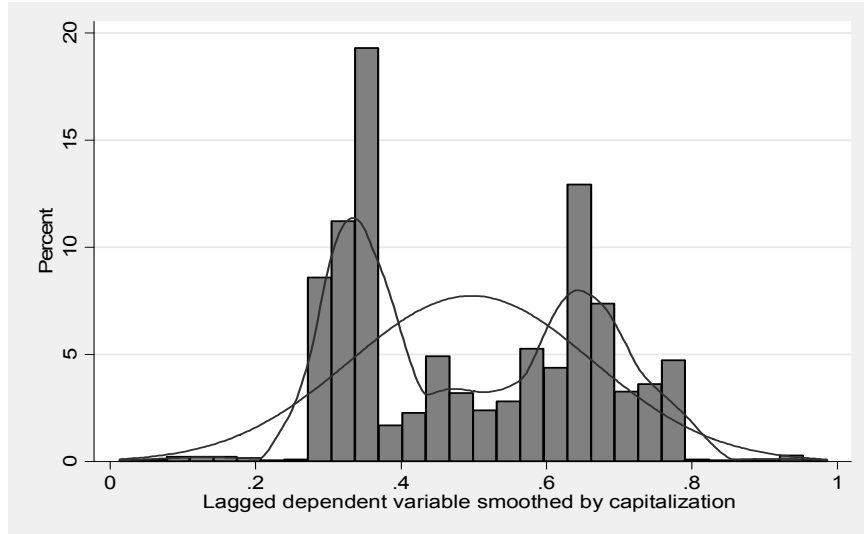
year	Lending (capit.)	Lending (liq.)	Lending (m.p.)	Risk (capit.)	Risk (liq.)	Risk (m.p.)	Profit. (capit.)	Profit. (liq.)	Profit. (m.p.)
1994	0.342	0.083	0.637	0.073	0.036	0.621	0.222	0.342	0.805
1995	0.421	0.085	0.604	0.062	0.035	0.618	0.235	0.364	0.878
1996	0.412	0.091	0.682	0.061	0.032	0.616	0.223	0.301	0.840
1997	0.373	0.089	0.741	0.053	0.032	0.601	0.218	0.270	0.746
1998	0.351	0.084	0.807	0.054	0.034	0.568	0.211	0.285	0.713
1999	0.320	0.086	1.003	0.060	0.034	0.507	0.235	0.290	0.801
2000	0.297	0.094	1.556	0.063	0.037	0.582	0.257	0.350	0.893
2001	0.585	0.099	1.971	0.078	0.047	0.577	0.341	0.387	1.121
2002	0.353	0.090	1.215	0.067	0.044	0.593	0.355	0.344	1.003
2003	0.299	0.079	0.787	0.053	0.041	0.505	0.317	0.305	0.865
2004	0.363	0.080	0.783	0.056	0.031	0.518	0.327	0.207	0.788
2005	0.347	0.103	0.958	0.054	0.038	0.498	0.211	0.240	0.810
2006	0.453	0.100	0.868	0.059	0.034	0.409	0.274	0.257	0.851
2007	0.512	0.107	0.622	0.069	0.044	0.501	0.320	0.305	0.857
Average	0.388	0.093	0.945	0.062	0.037	0.551	0.268	0.303	0.855

Notes: The table presents year-by-year the standard deviation of the estimated coefficients for the lending, risk and profitability equations. In each equation capitalization (capit.), liquidity (liq.) or market power (m.p.) are the smoothing variables of the policy rate.

Empirical results-Standard deviation of parameter estimates by year

- Table 3 presents the course over time of the standard deviation of the coefficients obtained from the nine estimated equations.
- The information that can be extracted from these figures is that there is an apparent increase in the standard deviation of the coefficients during episodes of distress (see figures for 2001 or figures for 2007), while low values occur during episodes of relative stability.
- This is quite expected as, in general, distress causes different behaviors and stability enhances uniformity.

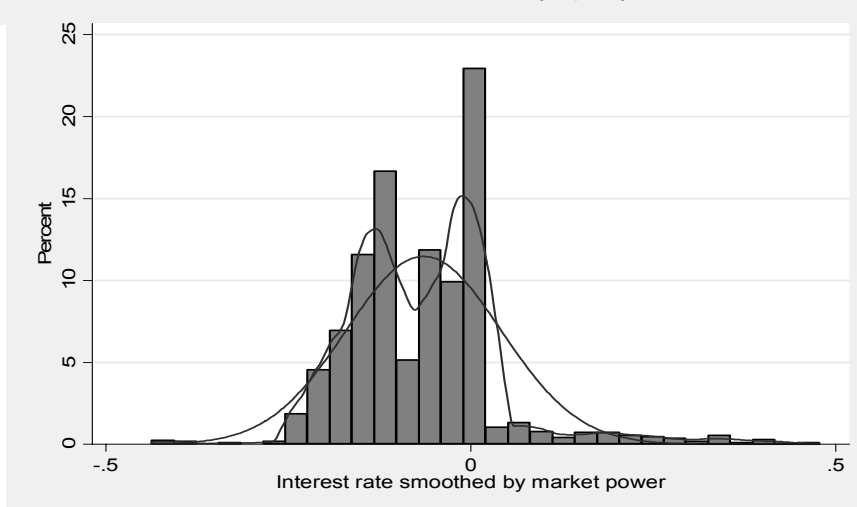
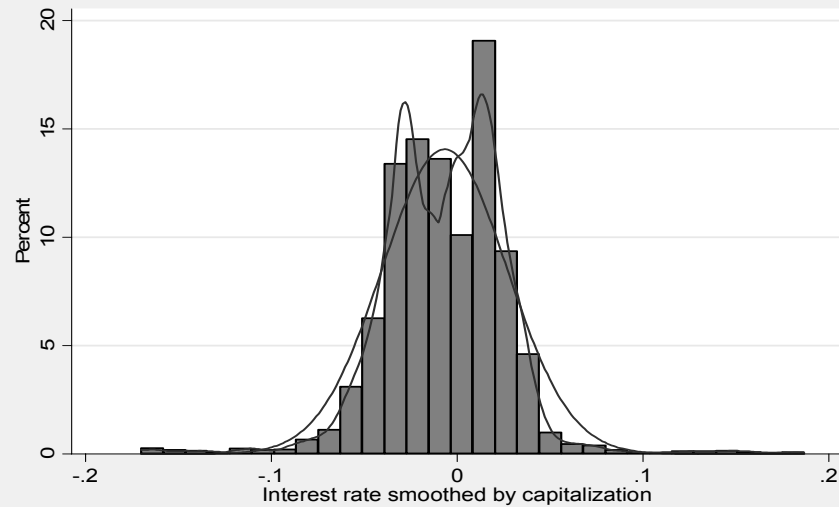
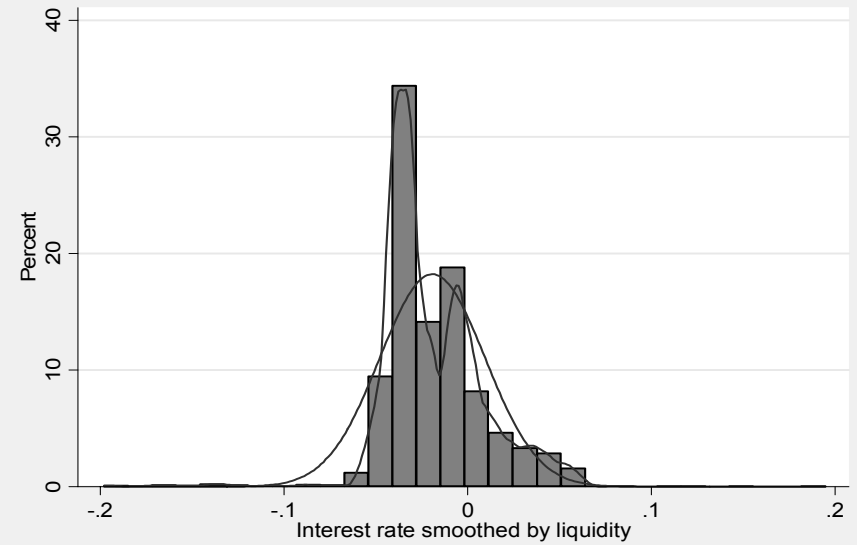
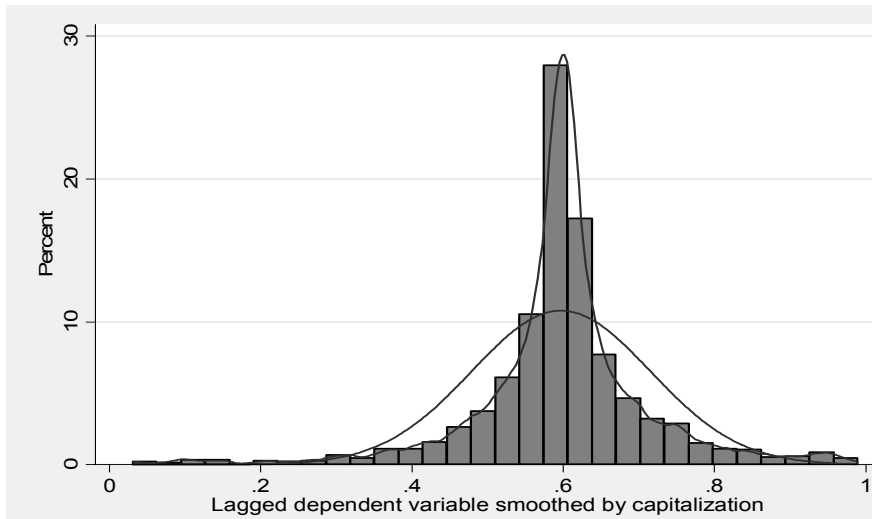
Empirical results-Distribution of coefficients on the monetary policy variable obtained from the lending equation



Empirical results-Distribution of coefficients on the monetary policy variable obtained from the lending equation

- Persistence in lending varies considerably among banks.
- The average values reported for the coefficients of the interest rate variable in the lending equations are negative and statistically significant, regardless of which smoothing variable is used.
- However, the above Figures reflect the wide heterogeneity in the bank-level coefficients.
- For example, the third Figure shows that when M is smoothed by the capitalization of banks, the impact of monetary policy on loan growth ranges substantially and that the distribution of this coefficient is trimodal (with modes at about -0.5, -0.3 and -0.15).
- This implies that monetary policy changes cause a very different response of banks on the basis of their capital structures, with more capitalized banks (i.e. those on the right end of the distribution) responding less to monetary policy changes.
- Also, market power of banks and competitive conditions in general prove to be a significant element through which monetary policy affects lending.
- The same holds when liquidity is used as the smoothing variable.
- Overall, these findings suggest that hypothesis 2 above is confirmed as regards the effect of monetary policy on bank lending.

Empirical results-Distribution of coefficients on the monetary policy variable obtained from the risk equation



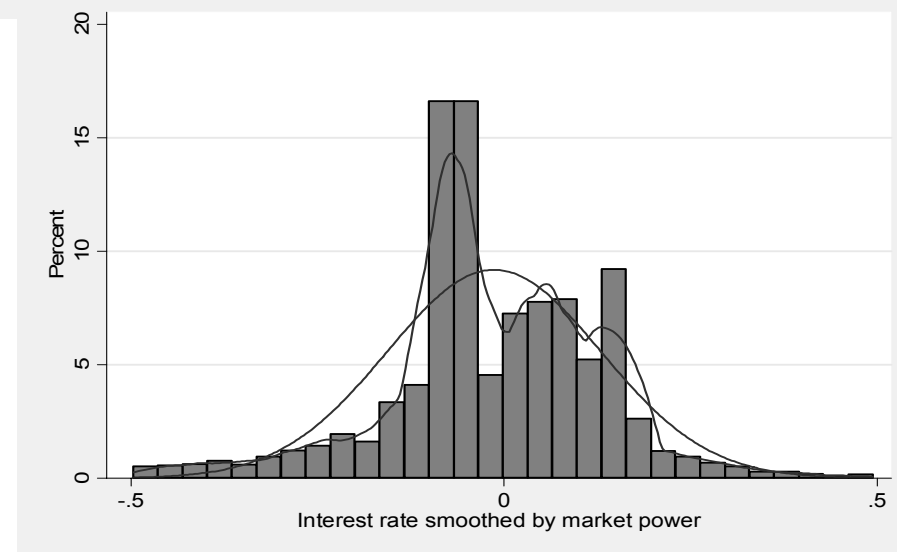
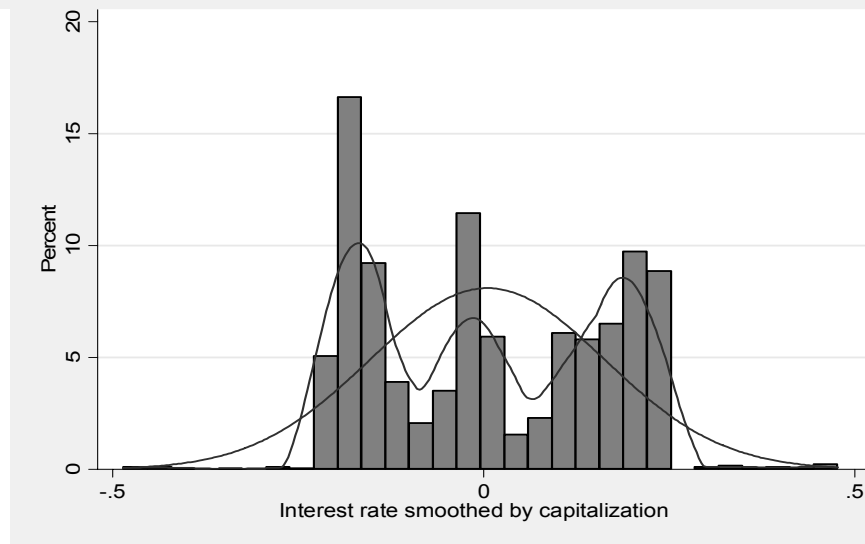
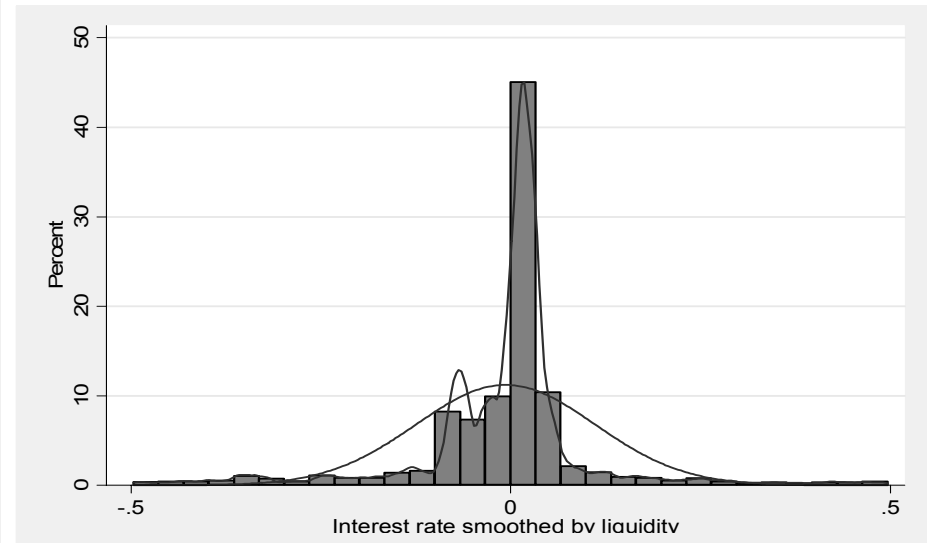
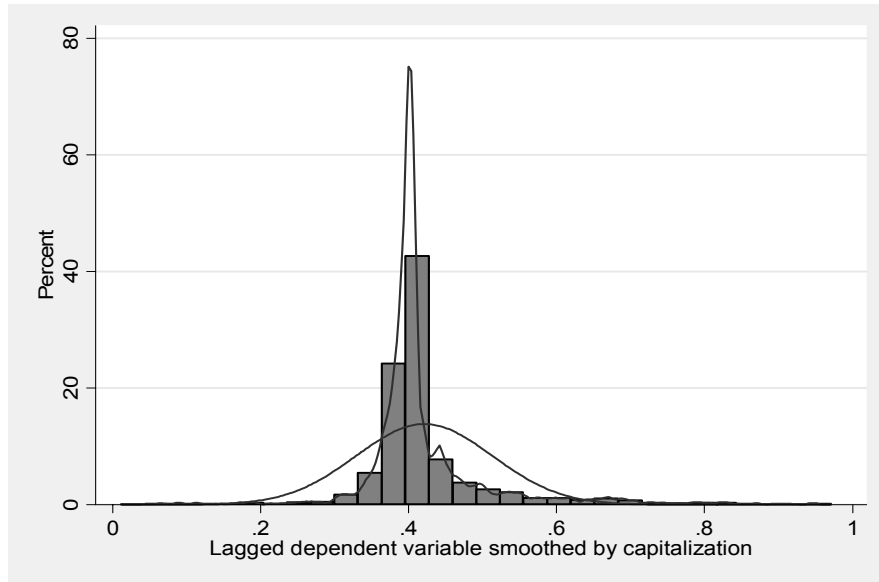
Empirical results-Distribution of coefficients on the monetary policy variable obtained from the risk equation

- Credit risk is highly persistent and the monetary policy variable has on average a negative but marginally significant coefficient.
- Theory suggests that on the one hand low interest rates indeed tend to create excessive risk-taking, but on the other they also reduce the risk of outstanding bank credit.
- The average results are in line with the limited previous literature in that the average effect of interest rates on bank risk is negative.
- Note, however, that the distributions of the estimated coefficients are bimodal for all three specifications, and represent wide differences of bank behavior.
- For banks with higher liquidity and capitalization the impact of a monetary policy change on credit risk is close to 0, which implies that the relevant parts of hypotheses 1 and 2 are confirmed.
- However, there also exist some banks in the sample that seem to take on extra risk following an increase in policy rates (i.e. many coefficients are positive). This implies that higher liquidity and, primarily, capitalization induce some banks (those on the right end of the distributions in the second and third Figures) in light of e.g. a contractionary monetary policy to continue promoting risk-taking activities despite the fact that funding becomes more expensive.

Empirical results-Distribution of coefficients on the monetary policy variable obtained from the risk equation

- Even when market power is used as the smoothing variable (fourth Figure), more than 20 percent of banks that are identified with comparatively high market power do not change their attitude toward credit risk (see the highest peak of the distribution where coefficients are very close to 0) and only 17 percent of banks with less market power clearly follow risk-averse strategies (see the second peak on the left of the distribution).
- Finally, the fact that in all three graphs the distributions are bimodal with a peak in the neighborhood of zero (indicating no or small response) and a peak in the region of negative values, definitely implies that the patterns studied are complicated, the effects are highly heterogeneous and inference cannot be made adequately on the basis of normal, symmetric or unimodal distributions that are associated with parametric models.

Empirical results-Distribution of coefficients on the monetary policy variable obtained from the profitability equation



Empirical results-Distribution of coefficients on the monetary policy variable obtained from the profitability equation

- Like in the case with lending and risk bank profits persist, yet heterogeneity in this persistence is much less pronounced.
- The average coefficient on the monetary policy variable is not statistically significant and takes a value very close to 0 in all three specifications.
- Yet, heterogeneity of the coefficients in the profitability equations is quite large, especially when the monetary policy variable is smoothed by capitalization and market power.
- This indicates that for many banks monetary policy has a significant, negative or positive impact based on the level of capitalization and market power.
- In particular, note that, when M is smoothed by capitalization, the relative coefficients have a mean value of -0.051. The distribution of the coefficients (see third Figure) is trimodal and the highest peak is on the left side (at around -0.21).
- While the presence of a second highest peak implies that a considerable portion of banks do not respond to a monetary policy change (because coefficients around this peak take values close to zero), there is also a third mode on the right end of the distribution showing that for approximately 10 percent of the banks in the sample that are well-capitalized, profitability and monetary policy changes are positively related.

Empirical results-Distribution of coefficients on the monetary policy variable obtained from the profitability equation

- Therefore, the part of hypothesis 2 (and the associated literature) that relates to bank profitability does not fully describe the relationship in hand, as it does not predict the positive relationship identified for many banks in our sample.
- Similar implications can be made for the profitability equation, when the smoothing variable is capitalization.
- In the profitability equations, a considerable difference is found between US and euro area banks in that most of the latter are the ones identified with a non-existent (or even a positive) relationship between a policy change and profitability.
- Two explanations can be considered for this pattern. First, in the euro area the negative relationship may be masked by the considerable changes that occurred in the member countries during the sample period and the comparatively small volatility in interest rates relative to these changes.
- Second, the maturity structure of bank balance sheets in the euro area is quite different from that in the United States and more detailed data may be needed to generate a negative relationship.

In conclusion

- The present study seeks to identify whether data from the last 14 years assign a special role to monetary policy in shaping bank profitability, lending and risk-taking.
- We find that bank-level responses to policy rate changes are often far from the average, normal response.
- The validity of this argument is uncovered with the help of a local generalized method of moments technique, which provides observation-specific estimates of the impact of monetary policy on bank balance sheets. Therefore, heterogeneous bank behavior is identified at the bank level and is actually measured by the standard deviation of the distribution of estimated coefficients.
- The present analysis showed that banks with healthier balance sheets and market power follow different strategies from the ones with weaker balance sheets, and in some cases they seem to take advantage of the market.
- Novel results are that for banks with relatively high liquidity and capitalization the relationship between risk and interest rates can be positive. The same holds for the relationship between bank profitability and interest rates and, in addition, this relationship turns positive for banks that hold high market power.
- An obvious immediate extension is to use measures of heterogeneity to assess the effect of monetary policy on real output in empirical models similar to the ones proposed by Driscoll (2004) or Ashcraft (2006).
- Other issues concerning differential responses of banks to regulation, with respect to their market power levels and their risk-taking behavior are also important extensions.

Thank you!

Relationship between coefficient on the monetary policy variable (obtained from the lending equation) and liquidity

