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ORIGINAL PAPER

The effect of capital requirement regulation on the transmission of monetary policy: evidence from Austria

**Philipp Engler · Terhi Jokipii · Christian Merkl ·
Pablo Rovira Kaltwasser · Lúcio Vinhas de Souza**

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Abstract This paper analyzes the role of banks' regulatory capitalization in the transmission of monetary policy. We use a confidential dataset for Austrian banks spanning from the first quarter of 1997 to the fourth quarter of 2003. We find evidence that Austrian banks react in an asymmetric way to monetary policy depending on their regulatory excess capitalization, i.e. low capitalized banks react more restrictively to a monetary tightening than their highly capitalized peers.

Keywords Monetary Policy Transmission · Bank Lending Channel · Bank Capital Channel · Austria

JEL codes E4 · E5

P. Engler
Department of Economics, Free University of Berlin, Boltzmannstr. 20, 14195 Berlin, Germany
e-mail: philipp.engler@wiwiss.fu-berlin.de

T. Jokipii
Department of Finance, Swedish Institute for Financial Research and Stockholm School of Economics, SE-113 83 Stockholm, Sweden
e-mail: Terhi.Jokipii@hhs.se

C. Merkl (✉)
Kiel Institute for the World Economy, Christian-Albrechts University, Düsternbrooker Weg 120, 24105 Kiel, Germany
e-mail: christian.merkl@ifw-kiel.de

P. Rovira Kaltwasser
Department of Economics, Catholic University of Leuven, Naamsestraat 69, 3000 Leuven, Belgium
e-mail: pablo.rovirakaltwasser@econ.kuleuven.be

L. Vinhas de Souza
European Commission, Unit ECFIN.D.3, Avenue de Beaulieu, 1, Office -1/182, 1160 Brussels, Belgium
e-mail: Lucio-Mauro.VINHAS-DE-SOUZA@ec.europa.eu

1 Introduction

Traditionally, theory relating to the monetary policy transmission mechanism–the set of links through which monetary policy affects the economy–has largely focused on the interest rate channel, which affects firms' and households' financing costs. While the role of banks in this process has gained more attention in recent decades, the role of capital requirement regulation, as defined by the Basel Accord of 1986, has been largely ignored.[1]

This paper analyzes how excess capital (the difference between effective regulatory capital and the capital requirement) can affect lending decisions and consequently the transmission of monetary policy from the central bank to the economy in Austria. With its particular banking structure[2], Austria represents an interesting case study in the analysis of the existence of the bank lending and bank capital channel within the EU.

We are the first to test[3] whether Austrian banks' lending reaction to interest rate changes (Interbank Offered Rate[4]) depends in a significant way on their excess capitalization. Therefore, we employ a new data set including quarterly bank level statistics for Austrian banks, spanning from March 1997 to December 2003. In addition, we use an alternative measure for the monetary policy indicator, namely, the disturbance from a Vector Error Correction Model (VECM), thus inspecting the reaction to a deviation from the systematic part of monetary policy (i.e. monetary policy surprises). We specify a dynamic panel, which is estimated by means of the Arellano and Bond (1991) estimator.

We find evidence that low capitalized banks react more restrictively to a monetary tightening (for both monetary indicators) than their highly capitalized peers. The result is both statistically and economically significant.

The remainder of the paper is organized as follows: In Section 2 we describe the role that banks play in the transmission of monetary policy. In Section 3 the data set is presented. Section 4 explains the empirical model. Section 5 presents the econometric results, and Section 6 shortly concludes.

2 Theoretical background

2.1 The importance of regional transmission processes

Since 1999, monetary policy within the Euro zone has been in the hands of the European Central Bank, whose primary objective is to maintain price stability.

[1] The same as for traditional macroeconomics is true for the modern microfounded approaches. Banks do not play any role in the modern workhorse new neoclassical synthesis (New Keynesian) models (e.g., Galí 2003). Only recently some authors have started to include the banking sector (e.g., Goodfriend and McCallum 2006).

[2] For a description of the Austrian banking sector see the working paper version (Engler et al. 2005).

[3] See Gambacorta and Mistrulli (2004) and Merkl and Stolz (2006) for studies with Italian and German data respectively.

[4] Vienna Interbank Offered Rate (VIBOR) until the adoption of the Euro, Euro Interbank Offered Rate (EURIBOR) afterwards.

Furthermore, it supports a high level of employment and sustainable and non-inflationary growth. Consequently, for the implementation of these targets in an enlarging economy, it is vital to have an understanding of the transmission process of monetary policy and the real effects thereof.

Due to the relative novelty of the Euro zone as a unified entity, capital market integration across borders in Europe is far less advanced than it is in the US. Disparities in the way that monetary policy is transmitted to the real economy are consequently expected to be far greater, and thus the issue of regional monetary transmission is of more relevance in the Euro zone than in the US. Among the many structural differences that can have potentially significant effects on monetary transmission are the size, structure, and significance of the national banking sectors within the Euro area. The Austrian banking sector and its impact on transmission of monetary policy in Austria is in the focus of this paper. In what follows the rationale for the role of banks in that context will be outlined and the link of our approach to the existing literature will be established[5].

2.2 The role of banks and their regulatory capital

Information asymmetries and the costly enforcement of contracts generate agency problems within financial markets. Agency costs are, according to Bernanke and Gertler (1995), reflected in the external finance premium, which is the primary reason for the existence of a credit channel of monetary transmission. The credit channel works through three separate channels namely the balance sheet channel (not discussed here), the bank lending channel and the bank capital channel. The *bank lending channel* stresses that monetary policy affects the supply of intermediated credit, bank loans in particular, and is active through an imperfect market for bank debt (Kashyap and Stein 2000; Stein 1998). Theory predicts that bigger banks or banks with a larger share of liquid assets are able to shield their lending relationships better after a monetary tightening (i.e. are less likely to reduce lending). While they have better access to capital markets (because of their size) or they can draw on their liquidity, the smaller or less liquid peers have to cut lending. If customers of constrained banks do not have perfect substitutes for loans, they face a credit shortage, which may ultimately cause real effects in the economy.

The evidence in favor of this theory is mixed for Europe (see Angeloni et al. 2003). For Austria, Frühwirth-Schnatter and Kaufmann (2006) conclude that traditional bank characteristics, such as the size or the liquidity, cannot be used to reveal asymmetric lending reactions. They use Bayesian simulation methods and find that the bank lending channel is quite weak.[6]

Kishan and Opiela (2000) examine the relevance of capital (alternatively to size and liquidity) for the lending behavior of banks in the US. High capitalization may indicate lower risk for investors in uninsured bank debt; the external finance

[5] Note, however, that the study does not allow for a comparison between countries in the euro area because of the confidentiality of national bank supervision data sets.

[6] For Austria an interest rate puzzle seems to exist. A positive change in monetary policy, signaled to the economy via a change in the interest rate, documents an accommodative lending behavior of banks (Kaufmann 2001; Braumann 2004).

premium may therefore decrease with the degree of capitalization. Consequently, better capitalized banks might find it easier than low capitalized banks to finance their lending business. Thus, it is expected that low capitalized banks react more restrictively after a monetary tightening than their well capitalized peers. Kishan and Opiela (2000) find evidence in favor of this hypothesis for US banks. Below, we will test empirically if a similar pattern can be found for Austrian banks, using the regulatory capital in excess of the capital requirement as the distinguishing variable. While the existence of the bank lending channel has already been tested for on the basis of bank size and liquidity for Austria (Frühwirth-Schnatter and Kaufmann 2006; Kaufmann 2001, 2003), we are the first to analyze the role of excess capital (i.e. the capitalization in excess of the regulatory requirement) in banks' reaction to monetary policy.

The *bank capital channel* (Van den Heuvel 2002b, 2003) also gives a prominent role to banks in monetary transmission, using a different reasoning though: Banks are exposed to interest rate risk whenever the interest sensitivity of their assets does not match the sensitivity of their liabilities. For a bank whose liabilities re-price faster than its assets, a rise in interest rates can reduce net interest income by increasing the institution's cost of funds relative to its yield on assets and vice versa. Hence, a monetary tightening will reduce bank profits which, if retained, are part of the regulatory capital. If, as in the case discussed above, the market for bank capital is imperfect and if capitalization is low enough (i.e. close to the minimum), then the bank will have to reduce lending in order to avoid a fall of capital under the minimum regulatory level.

Three conditions are necessary for the bank capital channel to be operative: an imperfect market for bank equity, a maturity mismatch between assets and liabilities exposing banks to interest rate risks, and the existence of minimum capital requirements. Van den Heuvel (2002a) presents indirect evidence for the bank capital channel for the US by regressing state level output on capital to assets ratios. He finds that states with low bank capital to assets ratios react more sensitive in their output growth to interest rate changes than states where banks are better capitalized. Gambacorta and Mistrulli (2004) and Merkl and Stolz (2006) present evidence for the bank capital channel in Italy and Germany respectively, applying a dynamic panel approach, with bank lending as endogenous variable.

If low capitalized banks react more restrictively to monetary policy than highly capitalized banks, this is both in line with the bank lending and the bank capital channel. However, we interpret our evidence for Austria in line with the traditional bank lending channel. In the working paper version of this paper[7] we experimented with a proxy for maturity transformation costs, which did not show a significant result. The descriptive statistics for the measure indicate the absence of maturity transformation costs for many banks. We observe in the dataset that especially small banks' liabilities have a longer maturity structure than their assets. As a result, these banks do not suffer from maturity transformation costs

[7] Engler et al. (2005).

in case of a monetary tightening. This phenomenon can be explained by the network structure of Austrian banks. Local savings and cooperative banks are organized in a one and two tier system respectively. Head institutes play an important role in times of a monetary contraction by providing liquidity. This result is in line with work by Ehrmann and Worms (2004) who examine banks' network structure in Germany. Second, a major share of loans is either short term or has flexible interest rates.[8] As a consequence, in times of monetary tightening Austrian banks can adjust the interest rates for a large part of the medium- and long-term loans. This means that many banks do not face significant maturity transformation costs. Therefore, we only test for the bank lending channel theory below, but not for the bank capital channel.

3 Data set

In order to estimate the model employed in our analysis, we use a sample that includes quarterly balance sheet data from the first quarter of 1997 to the fourth quarter of 2003. The data was obtained from the Oesterreichische Nationalbank (OeNB), which collects the statistics from all Austrian banks. Only banks that were in business at the end of 2003 were included in our dataset. The original sample consequently includes 894 banks. We discarded highly specialized banks from the sample.[9] In considering mergers, we assigned a dummy variable for the buying bank in the quarter when the merger took place, thus preventing biased estimations, resulting from jumps in the loan series. To keep as much information as possible, we use an unbalanced panel, additionally including all banks that were founded during the sample period and that still existed at the end. The cleaned sample contains 760 banks. They cover almost 90% of the total loans and total assets of the initial sample (see Table 1).[10]

For a description of the monetary policy indicator and the distributional pattern of the loan growth series and the excess capital variable (defined below) see the Appendix.

4 The empirical model

In order to test for banks' differential reaction to monetary policy under different degrees of excess capitalization in Austria, we employ an empirical model, similar in spirit to the model derived by Gambacorta and Mistrulli (2004). We estimate the following equation by means of the instrumental variable estimator for dynamic panels developed by Arellano and Bond (1991):

8 In the dataset we cannot discriminate between loans with flexible and fixed interest rates.

9 For further details on the outlier correction see Engler et al. (2005).

10 As of the end of the year 2003.

Table 1 Structure of the Austrian banking sector (sample after cleaning)

	Total assets as of Dec. 2003		Total loans to non-financial institutions as of Dec. 2003		
	EUR million	Share in aggregate total assets (in %)	EUR million	Share in aggregate total assets (in %)	Number of banks
Sparkassen (savings banks)	115,750	22	55,260	20	61
Erste Bank (central institution)	*61,802*	–	*20,753*	–	*1*
Volksbanken (industrial credit cooperatives)	33,624	6	17,253	6	68
Oesterreichische Volksbank AG	*12,742*	–	*4,309*	–	*1*
State mortgage banks	45,750	9	28,304	10	8
Commercial banks[a]	178,762	33	96,977	36	24
Raiffeisenkassen (agricultural credit cooperatives)	149,583	28	67,635	25	595
Raiffeisenzentralbank (head institute)	*37,836*	–	*10,512*	–	*1*
Raiffeisenlandesbanken	*45,413*	–	*18,104*	–	*8*
Other banks[b]	13,884	3	6,708	2	1
Total	537,352	–	272,136	–	760
Total assets of banking sector	605,106	–	–	–	–
Percent in sample	89	–	–	–	–

[a] Note: BA-CA, Austria's largest bank (EUR 105,659 million of assets) is included in the group of commercial banks even though it is often shown in the savings banks' sector

[b] We only included Postsparkasse and excluded all other specialized banks from our sample

$$\begin{aligned}\Delta \ln L_{it} = {} & \sum_{j=1}^{8} \alpha_j \Delta \ln L_{it-j} + \sum_{j=0}^{3} \beta_j \Delta MP_{t-j} + \sum_{j=0}^{3} \varphi_j \Delta \ln REER_{t-j} + \sum_{j=0}^{3} \delta_j \Delta \ln y_{t-j} + \lambda X_{it-1} \\ & + \sum_{j=1}^{3} \gamma_j X_{it-1} \Delta MP_{t-j} + \sum_{j=1}^{3} \eta_j X_{it-1} \Delta \ln REER_{t-j} + \sum_{j=1}^{3} \tau_j X_{it-1} \Delta \ln y_{t-j} \\ & + \sum_{j=1}^{3} o_j SD_j + \sum_{j} \kappa_j D_j + \vartheta \ln A_{it} + \rho Liq_{it} + \varepsilon_{it} \end{aligned} \tag{1}$$

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

In order to obtain the loan growth of bank i in quarter t ($\Delta \ln L_{it}$) as an endogenous variable, we make use of a series containing the banks' claims to non-financial customers which takes the differences of the logarithms in two subsequent periods. We have applied the three-month money market rate (EURIBOR)[11] from

[11] VIBOR before 1999.

1998 to 2003 as the (nominal) monetary policy indicator MP_t.[12] The rate is a non-weighted average of daily offered rates for inter-bank deposits of the most important banks on the basis of transactions by these banks. The estimated coefficient of the change in MP_t indicates the average-capitalized bank's reaction to a change in the monetary policy indicator. The quarterly changes of the real effective exchange rate ($REER_t$) and quarterly real GDP (y_t) growth are included to control for loan demand effects.

In order to test for the importance of the level of capital for bank lending we include the normalized variable excess capital X_{it} (actual regulatory capital minus minimum regulatory capital) relative to the period's average:[13]

$$X_{it} = \frac{EC_{it}}{A_{it}} - \frac{\sum_i EC_{it}/A_{it}}{N_t} \tag{2}$$

where EC_{it} measures excess capital while A_{it} represents total assets of bank i in quarter t. By normalizing excess capital, the average-capitalized bank has a X_{it} of zero.

Note that we use a measure of excess capital instead of the capital-to-assets ratio. There are three reasons for measuring capital in this way. First, the amount of capital held in excess of the required minimum may be interpreted as a buffer that might prevent a fall below the minimum requirement in the future, e.g. after changes in the monetary policy rate, which would result in intervention by the supervisor.[14] Second, the employed measure implicitly accounts for risk as defined by the Basel I Accord. Finally, by normalizing by the average capitalization of all banks for the entire sample, the positive and negative deviations from the average allow for opposite reactions by banks that are low capitalized (below average) and highly capitalized (above average).

The interaction terms $\Sigma_{j=1}^{3}\gamma_j X_{it-1}\Delta MP_{t-j}$, $\Sigma_{j=1}^{3}\eta_j X_{it-1}\Delta \ln REER_{t-j}$ and $\Sigma_{j=1}^{3}\tau_j X_{it-1}\Delta \ln y_{t-j}$ are used to control for endogeneity. Furthermore, they serve to test for asymmetric reactions across banks to macroeconomic shocks due to their degree of capitalization. As the average-capitalized bank has a capitalization of zero, its reaction to changes in the interest rate, *REER*, and *GDP* is reflected in the estimated coefficients for these macro-variables. With the above interaction terms, we can see whether low and highly capitalized banks react in a different manner to a monetary policy shock. If the estimated total effects of the interaction terms[15] are significant, then there is an asymmetric reaction. In case of the interaction term with the monetary policy indicator this would indicate that low capitalized banks react more restrictively to a contractionary monetary policy shock than well capitalized

[12] Over the observation period, the Austrian Shilling was pegged to the German Mark and consequently, the German monetary policy, as mirrored by the German interest rate, played a relevant role in Austria.

[13] The period average was deducted to remove the time trend.

[14] For a short review of the buffer theory and literature references see e.g. Heid et al. (2003).

[15] In the calculation of the total effect of monetary policy (generally called long-term coefficient in the literature), the dynamic structure of the model has to be taken into account. The coefficient for the monetary policy indicator is calculated as follows: $\sum_{j=0}^{3}\beta_j/(1-\sum_{j=1}^{8}\alpha_j)$. Other total effects are calculated in the same way.

banks and would thus provide evidence in favor of the existence of an active bank lending channel.

We used the logarithm of total assets ($\ln A_{it}$) as a variable to control for bank size[16] and liquidity (Liq_{it}) (measured as a share of total assets).[17] Three seasonal dummies (*SD*) are introduced to capture seasonal effects. Additionally shift dummies (*D*)[18] are included to control for mergers.

The critical reader may wonder whether we run into an endogeneity bias with our panel setting. Theoretically speaking this could be the case if the European Central Bank reacted to some situation specific to Austria and thus the interest rate would not be exogenous any more. We think that this is not a practical problem for several reasons. First, we use bank level data. From an economic point of view it is extremely unlikely that the European Central Bank changes the interest rate in reaction to the situation of one specific Austrian bank. Hence, the interest rate can be considered as exogenous for each Austrian bank. Second, from an econometric point of view we were particularly careful in trying to control for endogeneity. As mentioned above we use lags of the regressors and interact them with the macro variables and instrument them with their own lags in the GMM setting. Furthermore, in an additional check of robustness, we use the residuals of a Vector Error Correction Model to see how banks react to unanticipated changes in the stance of monetary policy.

5 Econometric results

5.1 Standard specification

The standard specification indicates that the average-capitalized Austrian bank shows no reaction to changes in the interest rate in the long run (see column one of Table 2). The estimated total effect for *MP* is slightly negative but not significant. Interestingly, the short run coefficients[19] show that during the period of the interest rate increase, as well as one quarter later, lending decreases. Two periods following the shift, lending increases by almost the same amount. These countervailing signs cancel out the significant short-run effects. Thus, we neither find an "interest rate puzzle"[20] nor the typically expected negative reaction.

According to the highly significant estimated long-run coefficient of the interaction term between excess capital and changes in the monetary policy indicator, low and highly capitalized banks react in a different way to changes of the interest rate. Low

[16] When using the assets lagged by one period or alternatively, when omitting this variable entirely, the estimated coefficients are similar. In some specifications the estimation does however suffer from some higher order autocorrelation as a consequence, which may be due to jumps in the data caused by merger activity. Thus we choose the above equation that is assumed not to run into a simultaneity bias as the variable is instrumented and the alternative specifications deliver similar results.

[17] The overall liquidity is defined as the sum of cash, short-term interbank deposits and government securities.

[18] The index j for the shift dummy represents the number of mergers which is controlled for.

[19] They are not shown in the table for brevity, but are available on request.

[20] See Braumann (2004) and Kaufmann (2001, 2003).

Table 2 Standard specification, time dummy specification and credit cooperatives only (sample split)

Dependent variable: *loan growth*

	Standard regression	Time dummies	Credit cooperatives only
ΔMP	−0.02	–	0.11
	(0.88)		(0.30)
*Excess capital*ΔMP*	4.35***	4.30***	5.66**
	(0.01)	(0.01)	(0.02)
GDP growth	0.88***	–	−0.32***
	(0.01)		(0.01)
*Excess capital*GDP growth*	−1.12***	−1.24***	−1.59***
	(0.00)	(0.00)	(0.00)
Appreciation REER	−0.25	–	0.52**
	(0.34)		(0.04)
*Excess capital*appreciation REER*	2.78	2.05	2.28
	(0.45)	(0.60)	(0.62)
Excess capital	−0.15***	−0.15***	−0.11***
	(0.00)	(0.00)	(0.05)
Log (assets)	0.07***	0.15**	0.04
	(0.00)	(0.02)	(0.18)
Liquidity	−0.14***	−0.14***	−0.21***
	(0.00)	(0.00)	(0.00)
AR(1)	0.00***	0.00***	0.00***
AR(2)	0.54	0.44	0.10
Sargan test	0.82	0.76	1.00

Note: Arellano-Bond estimation, *p*-values in brackets. ***, **, * denotes significance at the 1, 5, 10% level respectively

capitalized banks behave more restrictively in cases of an interest rate increase while highly capitalized banks react more expansively. To illustrate this: using the estimated coefficient, a bank that belongs to the group of the 10% best capitalized banks reacts 0.3% points more expansively than the average bank. On the other hand, low capitalized banks' reaction is 0.1% points more restrictive than the one of average banks.[21]

The same reaction can be found in the sample split with credit cooperatives only (see column three of Table 2). The estimated sign for the interaction term is somewhat bigger in magnitude, but only significant at a 5% level.

The results provide evidence for the existence of a bank lending channel in Austria. They differ somewhat from the existing literature for Austria (Kaufmann 2001, 2003; Frühwirth-Schnatter and Kaufmann 2006) which also finds some evidence for the bank lending channel when using other distinguishing features than excess capital.[22] The asymmetric reaction in the existing papers is however due to

[21] These numbers have been calculated as follows: estimated coefficient (4.35) * average capitalization of the 10% best capitalized banks (0.064) * 1% interest rate increase (0.01) = 0.003.

[22] During the sample periods of the aforementioned studies, numbers for regulatory capital were not available yet.

very small banks. Thus, the effect on the Austrian economy is considered to be irrelevant. As shown in the Appendix of the working paper version[23] the 10% lowest capitalized banks in our sample make up about 10% of the banking sector's assets and loans, whereas the most highly capitalized banks constitute a much smaller portion, i.e. low capitalized banks make up a representative share of the banking sector. As a consequence, the reaction of the low capitalized banks cannot be neglected. It is not only statistically but also economically significant.

Further, our estimation indicates that lending increases by 0.88% when GDP rises by 1%. This positive relation is in line with expectations. The highly significant estimated coefficient for the interaction term between GDP growth and excess capital shows that there is an asymmetric reaction due to capitalization. Low capitalized banks are more "procyclical" than well-capitalized banks.

The estimated coefficients for the REER and the respective interaction term are insignificant when using the entire sample, while the real effective exchange rate seems to play a certain role for credit cooperatives, as can be seen in Table 2. As the real effective exchange rate is not crucial for our argument, we will not give special emphasis to it in what follows.

The estimated coefficients for the relative liquidity, excess capital, banks' size are all significant at conventional levels for the entire sample.[24] The estimated coefficients of these variables do not have any specific interpretation in our setting, but ensure that we prevent an omitted variables bias.

5.2 Time dummies

In a first robustness check, we examine whether all time effects are captured by the macro-variables. The following model is specified:

$$\begin{aligned}\Delta \ln L_{it} = & \sum_{j=1}^{8} \alpha_j \Delta \ln L_{it-j} + \sum_{j=0}^{3} \beta_j TD_t + \lambda X_{it-1} + \sum_{j=1}^{3} \gamma_j X_{it-1} \Delta MP_{t-j} \\ & + \sum_{j=1}^{3} \eta_j X_{it-1} \Delta \ln REER_{t-j} + \sum_{j=1}^{3} \tau_j X_{it-1} \Delta \ln y_{t-j} \\ & + \sum_j \kappa_j D_j + \vartheta \ln A_{it} + \rho Liq_{it} + \varepsilon_{it}\end{aligned} \tag{3}$$

where TD_t is a time dummy for each period, which replaces changes in *MP*, *GDP*, and *REER* in the standard specification. If the estimated coefficients of the remaining variables are similar to those already obtained, this indicates that the previous equation has been well specified with regard to the time effect of the panel.

This robustness check (see column two of Table 2) confirms the choice of the macro-variables. The estimated coefficients for the interaction terms as well as the micro-variables and their significances are comparable to those in the specification above.

[23] Engler et al. (2005).

[24] The banks' size does not seem to play a role for credit cooperatives, which may be due to the network structure of this sector (see, e.g., Ehrmann and Worms 2004).

Table 3 VECM residuals

Dependent variable: *loan growth*	
Δ MP (ResVECM)	0.35
	(0.21)
*Excess capital*Δ MP (ResVECM)*	4.05**
	(0.02)
GDP growth	−0.01
	(0.93)
*Excess capital*GDP growth*	−1.13***
	(0.00)
Appreciation REER	−0.57***
	(0.00)
*Excess capital*appreciation REER*	1.77
	(0.60)
Excess Capital	−0.12***
	(0.01)
Log(Assets)	0.06***
	0.00
Liquidity	−0.14***
	(0.00)
AR(1)	0.00***
AR(2)	0.58
Sargan test	0.69

Note: Arellano-Bond estimation, *p*-values in brackets. ***, **, * denotes significance at the 1, 5, 10 percent level respectively

5.3 VECM residuals

In order to test for robustness (see Table 3), we identify an alternative measure for monetary policy shocks given by the disturbance term of a Vector Error Correction Model (VECM). This procedure is supposed to capture the information contained by the deviations (the residuals) from the assumed rule followed by the monetary policy authority, to influence main macroeconomic variables. In other words, the residuals of the VECM are likely to contain additional information which is not observable in the simple interest rate series, namely, the deviations from the systematic part of the monetary policy. In this context, the VECM specification is given by[25]

$$\Delta Z_t = HCZ_{t-1} + F\Delta Z_{t-p} + u_t$$

with

$$u_t \sim iid\ N(0, \Sigma_u) \tag{4}$$

[25] The VECM was identified by means of the Cholesky decomposition.

The variables included in the vector Z_t are ordered as follows: logarithm of gross domestic product, logarithm of consumer price index, monetary policy indicator (interbank offered rate) and the logarithm of the real effective exchange rate. The model is estimated by 2SLS, the chosen order of cointegration is 2 and the number of lags of the endogenous variables is four.[26] We then replace the monetary policy indicator (interbank offered rate) in our panel regression by a vector that contains the residuals of the interest rate equation in the VECM model. Under this new specification the econometric model is given by:

$$\begin{aligned}\Delta \ln L_{it} = & \sum_{j=1}^{8} \alpha_j \Delta \ln L_{it-j} + \sum_{j=0}^{3} \beta_j \Delta MPRvecm_{t-j} + \sum_{j=0}^{3} \varphi_j \Delta \ln REER_{t-j} \\ & + \sum_{j=0}^{3} \delta_j \Delta \ln y_{t-j} + \lambda X_{it-1} + \sum_{j=1}^{3} \gamma_j X_{it-1} \Delta MPRvecm_{t-j} \\ & + \sum_{j=1}^{3} \eta_j X_{it-1} \Delta \ln REER_{t-j} + \sum_{j=1}^{3} \tau_j X_{it-1} \Delta \ln y_{t-j} \\ & + \sum_{j=1}^{3} o_j SD_j \sum_{j} \kappa_j D_j + \vartheta \ln A_{it} + \rho Liq_{it} + \varepsilon_{it}\end{aligned} \tag{5}$$

where MP_{t-j} in equation (1) is replaced by $MPRvecm_{t-j}$. The results are shown in Table 3.

The estimated coefficient of the interaction term between excess capital and $\Delta MPRvecm_{t-j}$ is similar in magnitude to the coefficient for ΔMP_{t-j} in the standard specification. All in all, the results are very similar to the standard specification, supporting the previous results, with one exception: The estimated coefficient for GDP growth is not significant any more.

Thus, the result that banks react in an asymmetric way to monetary policy depending on their degree of excess capitalization does not only hold for the conventionally used Interbank Offered Rate. The same is true for the second monetary policy measure, which extracts the unsystematic parts of monetary policy by means of a VECM.

6 Conclusion

Using quarterly balance sheet data from the OeNB covering all Austrian banks, we employ an unbalanced panel to test for the reaction of banks under different degrees of excess capitalization. We are successful in finding evidence that low capitalized banks react more restrictively after a monetary tightening than highly capitalized banks. We interpret this result to be in line with the bank lending channel theory. The existence of the bank capital channel is excluded due to the lack of maturity transformation in the Austrian banking system. Descriptive statistics show that savings banks and credit cooperatives reduce their maturity transformation costs by making use of their respective head institutes.

[26] Ehrmann (2000) also uses a cointegration rank of order 2 to estimate the monetary rule for Austria, however, he uses only two lags for the endogenous variable.

A better understanding of the interbank market structure and flows in Austria is surely a very promising question for future banking research.[27] Furthermore, it will be a major challenge for macroeconomic theorists and empiricists to quantify the potential business cycle effects which are generated by the banking system due to changes in monetary policy. This study made only a first step into this direction, by showing that there is indeed an asymmetric reaction to monetary policy among Austrian banks. As these asymmetries are not restricted to the smallest banks only, they may have meaningful macroeconomic effects.

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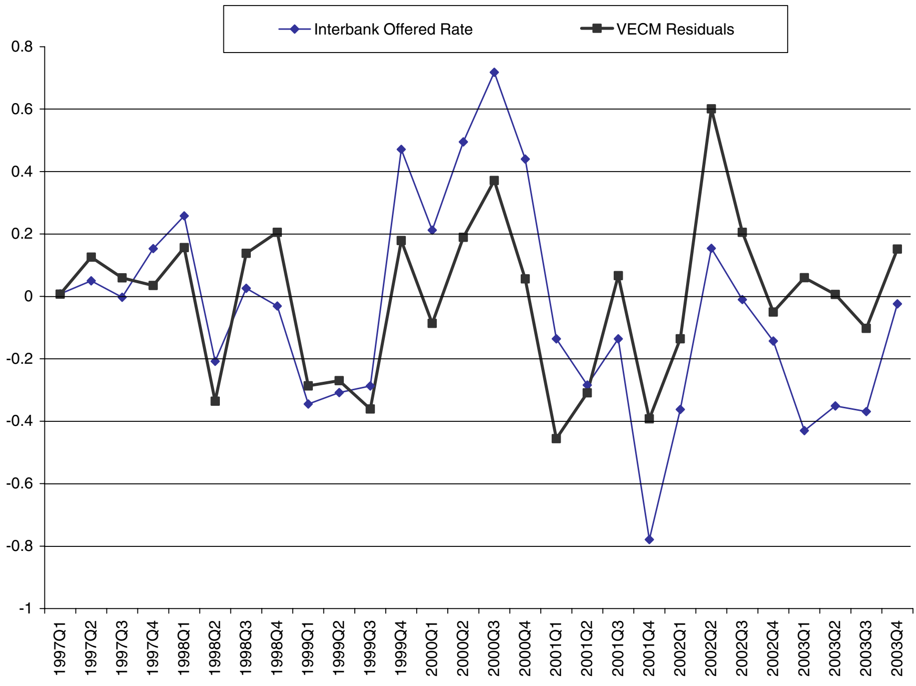
Appendix

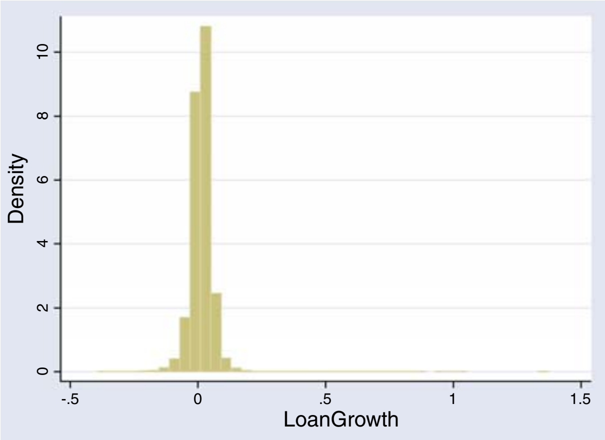
Descriptive statistics

a) Changes in the monetary policy indicators (in %)



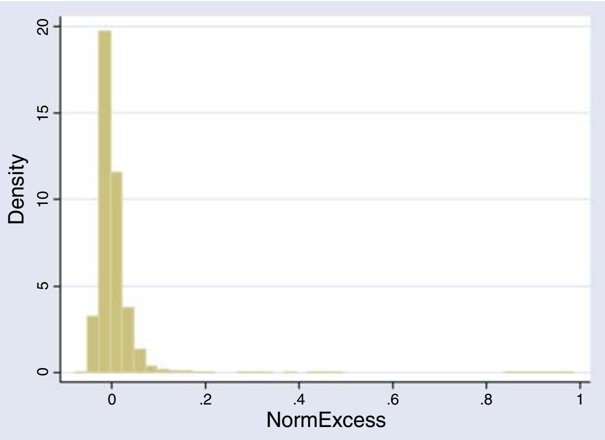
[27] See Ehrmann and Worms (2004) for Germany.

b) Distribution of loan growth



Note: Most of the loan growth density in around zero. The upward outliers are controlled for by the merger shift dummies.

c) Distribution of excess capital



Note: The excess capital is normalized around zero. The distribution is limited by the capital requirement regulation on the left hand side and by the overall balance sheet size on the right hand side.

d) Low and highly capitalized banks

	Number of observations	Relative capitalization compared to average	Standard deviation
Below average capital	10565	−0.016	0.009
Above average capital	7422	+0.022	0.045

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