Bank networks
and monetary policy transmission

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01/12/02

Abstract

This paper argues that the existence of bank networks is important for banks´ reaction to monetary policy. For the example of Germany, the VAR analysis shows that following a monetary contraction small banks access the interbank market indirectly through the head institutions of their respective network organisations. The interbank flows within these networks allow small banks to access funds that help them in keeping their loan portfolio with non-banks relatively unaffected. This implies that tests for a bank lending channel in countries with comparable bank networks should not rely on a size criterion only.

JEL classification: C32, E52, G21
Keywords: monetary policy, bank lending channel, interbank market

This paper represents the authors' personal opinions and does not necessarily reflect the views of the institutions they are affiliated to. We would like to thank Hans Bauer, Heinz Herrmann, Michael Scharnagl, Christian Upper and Raf Wouters for comments on earlier drafts, seminar participants of the Bundesbank, CFS and the ECB for further suggestions, and Anders Warne and Henrik Hansen for sharing their computer code.

1 Introduction

Of the various channels transmitting monetary policy,[1] the "credit channel" received major attention in recent research. It is built on the primary insight that financial markets are characterised by an asymmetric distribution of information among the market participants. If in such an environment monetary policy is able to alter the supply of external finance, its effects are unevenly distributed across economic agents: The more severe the informational asymmetry, the more difficult it should be for firms and households to switch between external and internal finance and the more strongly should their spending behaviour be affected.

Within this credit channel theory, the "bank lending channel" (BLC) concentrates on a specific type of external finance, namely on bank loans. Given that banks are a device to deal with the informational asymmetries between lenders and borrowers, bank loans are not perfectly substitutable by other forms of external finance, at least for some borrowers. Therefore, if banks react to restrictive monetary policy impulses by reducing their loan supply, this should affect especially those firms and households that are dependent on bank loans. This is in contrast with the traditional interest rate channel of monetary transmission, where monetary policy affects loan demand rather than loan supply.

Both microdata on firms and on banks have frequently been used to test for the existence of the BLC.[2] To identify loan demand (affected by the interest rate channel) from loan supply (the transmitter in the BLC), size was usually the discriminatory device.[3] Based on the assumption that asymmetric information problems are more severe for small firms and banks, they should experience higher financing costs and/or a stronger decrease in the availability of funds after a monetary tightening. For the case of banks, this means that small banks should show a larger decline in their lending to non-banks.

For the US, the evidence is fairly supportive for this transmission channel.[4] Therefore, this size-related idea to identify loan supply movements has been applied to other countries, too. The findings of these studies are far less conclusive, however: For example, Favero et al.

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[1] For an overview of the different transmission channels see, e.g., Cecchetti (1995) and Mishkin (1996).

[2] For studies using firm data see, e.g., Christiano et al. (1996), Gertler and Gilchrist (1994) for the US; for the euro area, Mojon (2000) provides an extensive overview of the available evidence; for Germany, see, e.g., Ehrmann (2000).

[3] Some papers also concentrated on the degree of liquidity (see, e.g., Kashyap and Stein (2000)) and on capitalisation (see, e.g., Peek and Rosengren (1995)).

[4] See, e.g., Kashyap et al. (1993), Kashyap and Stein (2000).

(1999), in a cross-sectional analysis, do not find that bank size can explain the reaction of bank lending to monetary policy for several European countries, whereas DeBondt (2000), using the same dataset for a comparable group of countries in a panel econometric analysis, does. The panel analysis of Ehrmann et al. (2001), again, does not find evidence for the BLC based on bank size as the discriminating variable.

In this paper, we will argue that tests of the BLC have to consider the peculiarities of the respective banking system to deliver insightful results. In several countries, smaller banks are organised in networks, where frequently the liquidity management of the network as a whole is performed by a large head institution. As we will see, this can change the reaction of member banks to monetary policy significantly. We will show that in response to a monetary action, funds are redistributed within bank networks: in case of a monetary tightening, the head institutions supply liquidity to their small member banks. This constitutes a powerful mechanism, which is able to counteract size-related distributional effects amongst banks.

We will investigate this issue for the example of Germany, where bank networks are particularly important. However, similar structures can be found in many other countries, which makes us believe that our findings apply more generally.[5] For example, bank networks are of similar importance in Austria and Finland, as well as in Ireland and Italy. In the Finnish case, roughly 240 co-operative banks, i.e. approximately 70% of the banking population, are organised in a network with a centralised liquidity management.[6] The share of organised banks is even larger in Austria: savings banks and credit cooperative banks constitute more than 90% of all banks.[7]

Furthermore, even in countries where bank networks are not institutionalised, analogous patterns of interbank reactions to monetary policy can be imagined. For example, Furfine (1999) finds evidence that US banks entertain lending relationships in the federal funds market. It is primarily small banks for which such relationships play a role. However, we would expect that these interbank relationships in the US – which are not based on explicit institutional arrangements – counteract possible bank size related effects of monetary policy only to a lesser extent.[8]

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[5] See, e.g., Ehrmann et al (2001).
[6] See Topi and Vilmunen (2001).
[7] See Kaufmann (2001).
[8] Pill (1997) argues similarly that in a small open economy bank size in itself might not be a good proxy for tests of the bank lending channel. He finds that monetary policy tightenings in Spain are tempered by the ability of banks to borrow abroad. Also, Angeloni et al. (1995) show that the institutional features of national banking systems need to be taken into account for

Our analysis does therefore take advantage of the institutionalised bank network structure in Germany to test for effects which are likely to apply analogously also in other countries, where they may be harder to detect, however. Furthermore, this study helps to better understand another feature of the German banking system, namely the large degree of relationship lending. It has often been argued that the German system of "*Hausbanken*"[9] tends to shelter borrowers from the short-term effects of a restrictive monetary policy. Although this might be the case, it has been unclear how German banks are able to perform this task given that restrictive monetary policy leads to a drain of (or to a rise in the price for) reserves. This is especially relevant in the case of the small, local banks because they usually are assumed to entertain these close "*Hausbank*" relationships to their customers. Keeping up the lending relationships could prove difficult if they are affected disproportionately strongly from the drain of funds following a monetary contraction.

In the remainder of the paper, we will first introduce the dataset underlying our analysis and provide a description of the German interbank market, highlighting the characteristics that give rise to our presumption. Section 3 then describes how we organise the data for the empirical analysis. Section 4 analyses the reaction of bank loans to non-banks to a restrictive monetary policy shock, where we use the usual bank size criterion as the discriminatory device. We find that small banks do not decrease their lending by more than large banks do. Instead, rather the opposite seems to be the case, which contradicts the predictions of the BLC. Therefore, in section 5 we go on to investigate the interbank flows that follow a restrictive monetary policy impulse, testing our presumption that small banks can indirectly access additional interbank funds. We find that the bulk of small banks, namely those that are part of a bank network, is supplied with funds from the head institutions of their respective network. We show in section 6 that for the banks that are not organised in such a network, size matters for the reaction of their loans to non-banks to monetary policy shocks, as predicted by the BLC. Section 7 concludes.

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studies of the bank lending channel. They show that, in Italy, large banks increase the interest rates on loans by more than small banks do, a feature related to the existence of customer relationships.

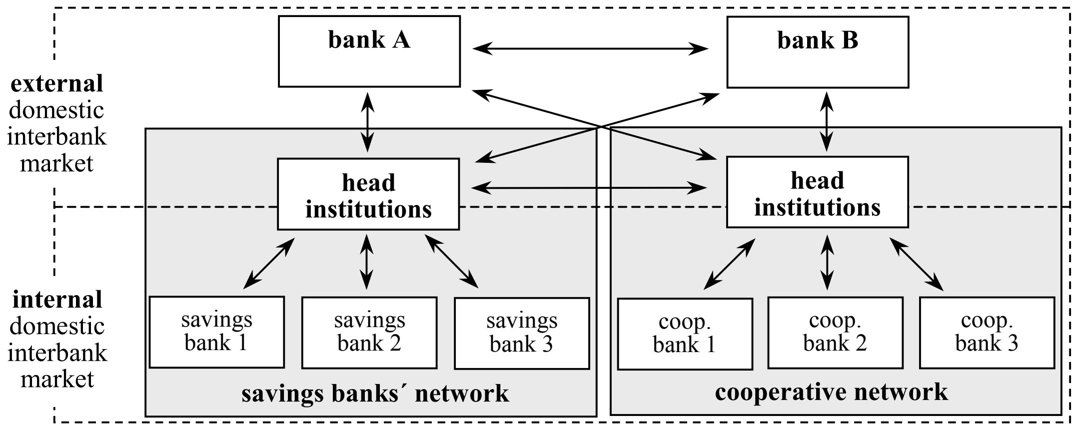
[9] See, e.g., Elsas and Krahnen (1998).

2 The database and the structure of the German interbank market

The data used in this analysis was taken from the balance sheet statistics of the Deutsche Bundesbank. It comprises individual bank balance sheet data of all German banks for the period 1992-1998 on a monthly basis.[10] The data on interbank assets and liabilities is disaggregated into several maturity categories and contains information on the respective counterparties.

A first look at the data reveals that savings banks hold almost three quarters of their interbank assets vis-à-vis their head institutions. In case of the credit cooperatives this share stands even higher, at 92%. Furthermore, savings banks and credit cooperatives hold only a relatively small share of their interbank assets vis-à-vis banks that are not part of their respective network. Contrary to this, the head institutions of the two networks hold about 54% (savings banks´ network) and about 42% (cooperative network) vis-à-vis domestic banks outside the networks. The largest share of interbank assets vis-à-vis foreign banks is held by the banks without a network affiliation. This picture does not change considerably when interbank liabilities are also considered.

Figure 1: Stylised description of the German interbank market



[10] No data are available prior to 1992; the period after 1998 was not used in this study because harmonisation procedures in the uprun to EMU led to a break in the data definitions.

Therefore, the German interbank market can be described in a stylised way as depicted in figure 1.[11] We identify two segments of the German interbank market, the *external* (see upper part of figure 1) and the *internal* interbank market (see lower part). The internal interbank market denotes the linkages within the two bank networks. The cooperative banks as well as the savings banks maintain their main lending relationships with their respective head institutions. Almost no lending takes place between the single member banks within the two networks. It is the head institutions which establish the link to the external domestic interbank market for their whole network. This external interbank market, in turn, is characterised by multiple lending relationships between all participating banks. It is only the external interbank market that has a non-negligible connection with foreign banks.

3 Definition of bank size classes and construction of grouped data

In order to test the hypothesis that the reaction of a bank´s interbank borrowing and lending to monetary policy depends on its size, the banks are classified into three size classes. Banks are denoted “small” if at a given point in time their sum of total assets is less than the 75-percentile of the distribution of total assets over all banks. A bank is denoted “large” if its total assets are equal to or larger than the 95-percentile. All other banks have “medium size” by definition. Table 1 entails information on the relative importance of these three size groups for June 1995, the middle of our sample period, but the following qualitative remarks on the structure of the German banking system hold for all other periods as well.

[11] See Upper and Worms (2001) for a more detailed description based on an estimated matrix of bilateral exposures in the German interbank market.

Table 1: Structure of the German banking system (June 1995)

bank size group		no of banks	%-share in total assets	%-share in loans to non-banks	%-share in gross domestic interbank assets	%-share in gross domestic interbank liabilities
small		**2748**	**8.4**	**9.2**	**5.2**	**5.4**
of which:	savings banks	139	0.9	1.0	0.3	0.7
	credit cooperatives	2420	6.8	7.7	4.2	3.9
	head institutions	0	0.0	0.0	0.0	0.0
	other banks	189	0.6	0.5	0.7	0.8
medium		**733**	**17.5**	**18.9**	**9.1**	**15.6**
of which:	savings banks	420	10.8	12.1	4.0	9.1
	credit cooperatives	200	3.9	4.4	2.6	1.9
	head institutions	0	0.0	0.0	0.0	0.0
	other banks	113	2.8	2.4	2.5	4.6
large		**184**	**74.1**	**71.9**	**85.6**	**79.0**
of which:	savings banks	68	8.4	9.8	3.4	6.8
	credit cooperatives	10	1.0	1.1	1.3	0.6
	head institutions	17	20.8	15.1	36.3	35.9
	other banks	89	43.9	45.9	44.6	35.7

The group of small banks contains only credit cooperatives (88%), savings banks and "other" banks. All 17 head institutions of bank networks (4 of the cooperative sector and 13 of the savings banks´ sector) belong to the group of large banks. In this group, only 0.4% of the cooperative banks could be found. The lion share of all savings banks fall into the group of medium-sized banks.

Table 1 shows furthermore that there is a glaring heterogeneity with respect to the size of the banks in terms of their share in total assets: While the small banks – by definition 75% of all banks – hold only about 8% of total assets, the 5% largest banks hold almost three quarters of total assets. This heterogeneity – although not that extreme – exists also in terms of the share in total loans to non-banks: 2420 small credit cooperatives hold about 8% of these loans, whereas 89 large "other" banks hold more than 45%.

The grouped time series are constructed as follows: In a first step, for every single period t, every bank is categorised as being small, medium or large. In a second step, the individual asset and liability positions are added up groupwise for every period (methodology (1)). Changes in the aggregated asset and liability positions of the groups can in principle be caused by two factors: Changes in the composition of the groups[12] or changes in the asset and

[12] On average, about 19 banks move from one size group into another group in every month. This is mainly due to changes in the threshold values caused by the reduction in the population and to a small extent by extraordinary increases in the size of single banks caused by mergers. On average, about 12 group switches per month could be explained by these two factors, leaving only about 7 changes that are due to a comparatively strong or weak change in total assets. This corresponds to only

liability positions of individual banks. In order to generate series that are not affected by compositional changes, an additional methodology is applied (methodology (2)). For every period *t*, we assign each bank to one of the three size groups, both for the current and the previous period *t-1* separately. All banks that are not in the same group for both these periods *t* and *t-1* are not taken into account (for the calculation referring to period *t* only). This creates size groups consisting of the same banks in *t* and in *t-1*. Then, the individual asset and liability positions of the remaining banks are added up groupwise, for *t* and *t-1*. Subsequently, period-to-period growth rates of the respective positions are calculated on the basis of this groupwise aggregated data, leading to a time series of consistent growth rates. In the last step, these growth rates are used to construct a time series of volumes by multiplying the (cumulated) growth rates with the respective starting value in January 1992.

Since both methodologies have their specific drawbacks – (1) is sensitive to compositional changes, (2) does not necessarily contain the "true" value of the balance sheet positions of the group at hand – we perform the econometric analysis for both types of grouped data. Furthermore, the data generated by methodology (1) is used in levels (measured in 1000 DM) and alternatively in ratios, i.e. as shares of total assets. Here, we take account of the type of position we look at, when determining the denominator: if the numerator is a net position, e.g., interbank assets net of a specific interbank liability position, then the denominator is the comparable net position, e.g., total asset net of this specific interbank liability position.

Figure A1 shows the time series of the net interbank positions calculated with methodology (1). The upper panel represents the overall interbank position of small, medium-sized and large banks. The second panel reports the positions of banks on the "external" interbank market, i.e. those positions that are not held within the savings banks and the cooperative network. Those intra-network balances are shown in the third panel. Finally, the fourth panel contains the positions of German banks abroad.[13]

4 Monetary policy and bank loans to non-banks

In order to analyse the effects of monetary policy on bank loans and later on the interbank market, we employ Structural Vector Autoregressions (SVAR). In particular, we use the

0.2% of the respective population of banks, which should be negligible. We can therefore rule out the possibility that compositional changes of the groups are endogenous, i.e. caused by monetary policy.

identification scheme proposed by King, Plosser, Stock and Watson (1991), since this strategy allows us to explicitly take potential nonstationarities of our time series into account.[14]

Our initial model consists of a four-variate VAR with $X_t = [r_t \quad \pi_t \quad y_t \quad l_t]'$, where r_t stands for a nominal interest rate, π_t for inflation, y_t for real output and l_t for the real volume of bank loans to non-banks. The interest rate, which serves as the indicator for the stance of monetary policy, is the three months money market rate. For a measure of inflation, we opted for producer price inflation rather than consumer prices, since for the sample period under consideration, consumer prices are very much distorted by indirect tax increases and one-off effects of German unification. The choice of industrial production as the output variable allows us to keep the monthly frequency of the bank balance sheet database. VARs consisting of an interest rate, inflation and output became a sort of standard or basic framework for empirical monetary policy analysis within the last years. In order to test our hypothesis, which relates to the BLC, we have to enhance this basic framework with a loan variable.[15] We furthermore include seasonal dummies and a linear trend (which is restricted to lie in the cointegrating space in order to avoid a quadratic trend in the level of the variables). The lag length of our models is chosen such that autoregressive error terms are avoided, which is accomplished by the inclusion of four lags. All models are estimated as Vector Error Correction Models (VECM) in order to allow for cointegration relations between the variables.

As a matter of fact, the cointegration analysis suggests the existence of three cointegration relations (see table A1 in the appendix). A natural candidate for one of these equilibrium relationships is some kind of central bank reaction function. We expect that the Bundesbank, when setting interest rates, took into account inflation and the output gap.[16] For the sample period under study, output is not subject to a trend. Therefore, measuring the output gap as the deviation of industrial production from trend coincides with the original output variable. Another equilibrium relationship often found in empirical studies is the stationarity of the real interest rate. For the third cointegrating vector, we will test whether bank loans to non-banks l_t are cointegrating with interest rates.

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[13] A further disaggregation shows that the trending behaviour of many of those series is mainly caused by long-term positions, whereas most of the variability arises in the short maturities of up to three months.

[14] A discussion of the identification procedure is provided in the appendix.

[15] The loan aggregate we use here is fairly broad. It includes loans to government and to private non-banks, and covers mortgage loans as well as all other loan types. Repeating the analysis with a more homogeneous loan (but smaller) aggregate, i.e. loans to private firms only, does not produce qualitatively different results. Due to the fact that the broader aggregate is of higher macroeconomic importance, we decided to present the results based on this loan variable.

The cointegrating vectors are therefore estimated as

	r_t	π_t	y_t	l_t	t
β_1'	**1** (-)	**-1.36** (0.25)	**-0.87** (0.15)	0 (-)	0 (-)
β_2'	**1** (-)	**-1** (-)	0 (-)	0 (-)	**-0.06** (0.02)
β_3'	**0.01** (0.00)	0 (-)	0 (-)	**1** (-)	**-0.01** (0.00)

It can be seen that the coefficient on inflation in the monetary policy reaction function is slightly larger than one, as would be adequate in a Taylor-rule framework. The stationarity of real interest rates can be improved by adding a linear trend for this sample period. Bank loans depend negatively on the level of interest rates, which is compatible with both, the BLC and the interest rate channel. The overidentifying restrictions cannot be rejected by a χ^2-test (see table A2 in the appendix).

The sample period under inspection is characterised by a trending behaviour of several variables, related to the uprun to EMU and the consequences of German unification, which is reflected also in the real interest rates. This is due to the fact that we have data available only for a short sample period.[17] Over a longer sample, real interest rates have been found to be stationary without the inclusion of a trend.[18] Due to the fact that including a trend into the real interest rate cointegration equation is somewhat unappealing from a theoretical point of view, we carried out a sensitivity analysis (see appendix A4). It shows that the inclusion of the linear trend improves the tests on the overidentifying restrictions substantially, but does not affect the qualitative results of the impulse response analysis.

To identify the monetary policy shock we assume that the shock is transitory, because after some time all variables should return to baseline. Additionally, we impose the standard assumption that it affects neither inflation nor output within the same month. The resulting impulse responses are depicted in the first four graphs of figure A2. All responses are presented with 90% error bounds. It can be seen that a contractionary monetary policy shock leads to a temporary decrease in inflation and output, and that it decreases bank lending significantly.

[16] This is compatible with assuming that the Bundesbank followed an intermediate monetary target when setting interest rates. See, e.g., Deutsche Bundesbank (1999), esp. p. 53.
[17] The short sample also precludes tests for the stability of the empirical results.
[18] See Ehrmann (2000).

These results are in line with conventional theory. However, the impulse responses show a brief price puzzle[19] and a surprising initial response of output. Since both of them disappear in the subsequent estimates, we do not elaborate on the model at this stage. Both effects do not affect our qualitative results that are based on extended versions of this baseline model.

To see whether the size of banks affects the response of loans to a restrictive monetary policy shock, we re-estimate this model for the group of small and large banks separately.[20] The BLC predicts that small banks' loan supply to non-banks should decline by more than that of large banks does. However, as can be seen in the last two graphs of figure A2 (see appendix), this cannot be found here: Most of the overall reduction in bank loans is borne by large banks, with small banks showing no significant response at all. To use bank size to identify loan supply from loan demand is therefore not suitable for the German case.

It remains to be seen how the small banks manage to insulate their lending from monetary policy impulses, because this requires additional funds after a restrictive monetary policy shock. The underlying assumption of the BLC, namely that small banks find it more difficult than large banks to finance their lending following an interest rate increase, does not seem to hold in the German case. There must be a mechanism at work, which enables small banks to overcome these financing problems often assumed to be relevant for other countries. Our hypothesis is that the German interbank market provides some compensation mechanism: even if small banks might see their deposits shrinking by more than large banks or might find it more difficult to access other sources of finance, they will be able to access additional funds on the interbank market. We will test this hypothesis in the subsequent section.

5 Monetary policy and interbank lending

5.1 The empirical models

In this section, the regression models are slightly adjusted versions of the ones in the preceding section. The main macroeconomic variables - interest rates, inflation and industrial production - are kept, whereas bank loans to non-banks are substituted for by various interbank lending variables. The way we measure bank lending changes somewhat, however: We are only interested in the net position of a bank on the interbank market, since for our pur-

[19] This is often found for post-unification Germany. See, e.g., Peersman and Smets (2001).
[20] For the results of the cointegration analysis, see the second and third columns of tables A1 and A2.

poses it is not relevant whether a bank adjusts its interbank position by adjusting liabilities or assets. Since the net position can be either positive or negative, it is not possible to take logarithms of the data. This is not a serious drawback in our case, as the net position should be fluctuating around a balanced position, i.e. around zero, so it cannot be subject to an exponential path in the long run.[21] The nominal values can increase over time, however.

The estimations are therefore performed in three ways. Firstly, the series of the asset and liability volumes that were achieved with methodology (1) are used. Alternatively, those volumes are used to construct ratios, i.e., the levels are scaled by total assets of the respective group, the latter corrected for interbank liabilities. In a third variant, the series derived with methodology (2) are used to ensure that the results are not driven by changes in the composition of the size classes. This sensitivity analysis is necessary and useful because in the sample period studied, the German banking industry underwent significant changes due to merger and acquisition activities.[22] We can, however, safely conclude that all three ways of measuring interbank lending yield qualitatively equivalent results. We do therefore only report the results based on the series derived with methodology (1).[23]

In order to enhance comparability across models, the monetary policy shock should be identical in all models. Preliminary estimations showed that this can be achieved by keeping one interbank variable in each of the different variants of the model. This provides an "anchor" that limits the deviations between the models to a minimum and creates basically identical responses of interest rates, inflation and industrial production across all different models. The anchor that performs best in this respect is the net interbank position of the group of largest banks in the internal interbank market. In the following, the VARs hence consist of $X_t = [r_t \quad \pi_t \quad y_t \quad l_{1,t} \quad l_{2,t}]'$, where $l_{1,t}$ denotes this anchor variable, and $l_{2,t}$ stands for various alternative interbank variables that change from specification to specification and that make it possible to test our hypothesis of a differential behaviour across size groups.[24]

For most of the models, a cointegrating rank of four results (see table A3 in the appendix). In order to harmonise the various regressions, this rank is maintained for all of the models. The cointegrating vectors regarding the Bundesbank reaction function and real interest

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[21] Although it should be fluctuating around zero, the variables can deviate from zero for long periods of time. Therefore, they need not be stationary – and indeed, they turn out to be I(1).
[22] For a description, see, e.g., Worms (2001).
[23] Results obtained with the other methodologies can be found in Ehrmann and Worms (2001).

rates are restricted to be numerically identical to the ones estimated in the preceding section in each of the models, again to enhance comparability of the results. The other relations are allowed to vary, but relate the interbank lending to interest rates, allowing for a time trend. The overidentifying restrictions can never be rejected, as is shown in table A4 (see appendix). The estimated cointegration relations of the interbank variables are provided in table A5 (also in the appendix).

5.2 Segments of the interbank market

Figure A3 in the appendix shows the impulse responses for the various interbank lending models. The first row depicts the responses of interest rates, inflation and output to a monetary policy shock. The price puzzle and the surprising initial output response have disappeared. This indicates that the VARs are well specified.

The second row looks at lending of banks in the overall interbank market, separately for all three size classes. Since the variables are defined as net asset positions, i.e. assets minus liabilities, a negative reaction signals an increase in the net borrowing of a specific bank group. The impulse responses show that banks of all size categories increase their net borrowing following a monetary contraction. This might seem puzzling at first sight, since the database comprises the full population of German banks. However, the German interbank market is not a closed system, since banks have access to the international interbank market. So it seems as if all bank groups had a chance to cushion the restrictive effect of monetary policy by financing their loans following a monetary policy tightening via the interbank market. In the following, we will therefore look at different segments of interbank lending.

The third row of figure A3 contains the responses of the lending positions in the external interbank market, i.e. excluding network balances. The responses of banks‘ positions are quite revealing. Small banks do not increase their borrowing in this market segment, whereas medium-sized and large banks attract additional finance through this channel. These impulse responses are in line with the BLC. If this were the only source of interbank credit, small banks would face a deterioration of their financing situation, and as such would be forced to restrict their bank lending by more than large banks.

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[24] The anchor is highly collinear with the internal bank lending variables of the other size classes. Nonetheless, the regressions yield practically identical results when estimating a model with both the anchor and another internal bank lending variable or with one internal variable only.

The channel that counteracts these distributional effects of monetary policy is analysed in row 4 of figure A3. Here, we look at positions on the internal interbank market. It turns out that small banks raise additional funds following a monetary tightening in this market segment. Actually, virtually all of their borrowing in the overall interbank market is supplied through the network links, as can be seen by comparing the magnitude of responses in rows 2 and 4. Similarly, medium-sized banks borrow on the intra-network segment, and get the bulk of their financing needs from this source. On the other hand, the group of large banks, which includes all head institutions of both the savings banks´ and credit cooperative networks, turns out to be a net lender after the monetary contraction.

The last market segment that can be distinguished is bank lending from abroad. This aggregate consists of all interbank positions of German banks with banks abroad, including foreign branches of German banks.[25] Here, again, the responses are in line with the assumptions of bank lending theories – small banks suffer from informational disadvantages that prevent them from increasing their exposure to the international interbank market. The largest banks, on the other hand, receive the main parts of their additional funding from abroad. The results are therefore consistent with the notion that after a restrictive monetary policy measure the group of large banks borrows funds from abroad that are then channelled to the small and medium-sized banks by the head institutions of the two bank networks. This inflow of funds can of course take different forms, either an increased borrowing or a withdrawal of deposits, either at foreign banks or at the foreign branches of the German banks.

The results from this analysis are clear and robust to all three ways of defining the interbank lending variables: the German system of network linkages across banks tends to alleviate possible disadvantages of small banks on the interbank market. By accessing the external interbank market through their head institutions, which themselves belong to the group of large banks, small banks may overcome size-related market frictions. This mechanism enables them to more or less completely overcome possible disadvantages.[26] Therefore, coop-

[25] On average over the sample period 1992-1998, around 55% of these interbank positions were denominated in DM. The remaining positions are converted into DM at the current exchange rate. This leads to some ambiguity in the impulse responses: if an interest rate increase leads to an exchange rate appreciation, then this c.p. lowers the reported DM-value of the interbank positions. In our estimations, we would therefore report a fall in the net position of German banks. However, we consider the size of this bias likely to be smaller than the overall effect we observe. Firstly, because it concerns less than 50% of the positions, and secondly because the magnitudes of the actual responses would be unreasonably large if they were induced by exchange rate changes only: In figure A3, e.g., a 5 basis point interest rate increase lowers the net foreign interbank positions by 0.8%. We would expect the exchange rate effect to be much smaller. Under the assumption that small banks do not actively change their positions abroad, a rough guess of this magnitude could be found by the response of this position, which is around 0.004%.

[26] Further evidence on this is presented in a panel analysis in Worms (2001).

erative and savings banks should be more able to shelter their lending to non-banks from interest rate shocks than are banks of similar size that do not belong to a network.

5.3 The reaction of internal interbank market positions

As has been seen in section 5.2, it is the internal interbank market that performs a redistributive task following a monetary policy shock. Further investigation shows that the interbank flows that can be observed in response to a restrictive monetary policy shock refer to short-term maturities. Since the analysis had only considered net positions so far, we are not able to tell whether the groups of smaller banks withdraw funds they had deposited with their head institutions, or whether they take up new loans. Figure A4 in the appendix provides the impulse response analysis of the gross positions on the internal interbank market. The groups of small and medium-sized banks reduce their asset holdings on the internal interbank market, which is reflected in a reduction of the liabilities on the side of the group of large banks. Medium-sized banks furthermore take up new loans; this reaction is quantitatively much less important than the reduction of assets, and as such not reflected in a significant response of the asset side of the group of large banks.

It can therefore be concluded that the savings banks and credit cooperatives deposit short-term funds with their head institutions, when they have an ample supply of such funds (like for example following a monetary easing) and that in times of shortages, these funds are withdrawn and flow back to the smaller banks.

Interestingly, the head institutions of the two networks react to these outflows of funds by adjusting their lending to non-banks accordingly. Following a monetary tightening, they face an outflow of funds to the affiliated institutions, and consequently reduce their loans to non-banks significantly. It turns out that the decrease of bank lending to non-banks for the group of large banks (as shown in figure A2) is mostly borne by the head institutions: separating the response of the large banks into the head institutions and the other large banks, we find a significant negative response of the head institutions, whereas that of the other large banks is only insignificantly negative.

6 Loans from banks without network links

The preceding section has shown that the system of bank networks can in principle serve as a powerful tool for overcoming distributional effects of monetary policy across banks of different size. Logically, the question arises, whether the results obtained for the reaction of loans to non-banks in section 4 will change if only banks without network links are considered. To investigate this, we have removed all banks from our sample that report non-zero network positions. None of the remaining banks can access the internal interbank market of the savings banks or credit cooperative networks. We are left with only very few banks in the group of small and medium-sized banks (in June 1995 only 91 out of 3665 banks), which are quantitatively negligible (in June 1995 their market share in bank lending amounts to only 0.7%). The response of their loans to non-banks to a monetary contraction is shown in figure A5 (see appendix), and compared to the response of loans by the largest banks (again, excluding all banks which are part of a network system). Loans to non-banks from smaller banks show no significant reaction instantaneously, but strongly decrease in the subsequent months. This reaction is much more pronounced than that of the large banks, and additionally takes much longer to return to baseline.[27] This is the size-related result usually obtained in empirical studies for other countries that have a banking system without some sort of internal interbank market.

Due to the fact that both lending variables were included in the same model, it is possible to apply simple t-tests on which reaction coefficient is stronger.[28] The following table presents the results:

Period	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
t-stat	-1.34	0.71	**1.99****	**1.54***	**1.37***	**2.00****	**1.68****	**1.32****	1.23	1.08

** 5% significance level, * 10% significance level

We test a one-sided null hypothesis, namely that large banks react at least as strongly with their lending to a monetary policy shock than does the group of small and medium-sized

[27] Using the narrow loan aggregate (loans to private firms and to self-employed only), we find a similar decrease in the loans of small and medium-sized banks, and no significant response of the loans of large banks. The t-tests show that the reaction of bank lending is much stronger for the smaller bank groups, also for this loan aggregate.

[28] We are reporting the tests for single time periods rather than the whole impulse responses, since the calculation of the latter necessitates cumbersome calculations of the covariances for all periods and all variables.

banks ($H_0 : \theta_{large} \geq \theta_{small+medium\ sized}$, or, alternatively $H_0 : \theta_{large} - \theta_{small+medium\ sized} \geq 0$). Therefore, we can reject the null whenever the t-statistic exceeds the critical value of 1.65 (5% significance level), or 1.28 (10% significance level). The test results are rather clear: For periods 2 to 7, we can reject the null. Only for the period in which the monetary policy shock occurs can the opposite hypothesis be rejected. There is a clear support for a stronger reaction of loans from small banks following a monetary policy contraction once all banks that belong to a bank network are removed from our sample. However, it has to be kept in mind that this is only a very small fraction of all German banks and as such should not be of major concern to policy makers.

7 Conclusions

This paper has provided an empirical analysis of how interbank lending reacts to a monetary policy contraction. Using the bank balance sheet database of the Deutsche Bundesbank, which covers all German banks, we have constructed size-sorted time series to test hypotheses related to the bank lending channel (BLC). Several recent contributions have argued that a meaningful test for the existence the BLC can be performed by analysing the reaction of bank loans following a monetary policy shock: the loans of small banks, it is claimed, should fall by more than those of relatively larger banks.

We have argued that, contrary to this reasoning, size in itself might not be a good proxy to test for the BLC in the German case. The majority of small German banks is organised within either the savings banks' network or the credit cooperative network. These networks seem to access the interbank market as a whole, with the large head institutions establishing the link between the external and the intra-network interbank market. The reaction of banks that are part of such a network is therefore not only dependent on the characteristics of the single bank, but also on the position of the network on the external interbank market.

It has been shown that, following a monetary contraction, funds are channelled from the head institutions of the two networks to their affiliated small banks. Large banks on average access the international interbank market to dampen the liquidity drain following a monetary contraction, and then funds are redistributed through the internal interbank market of the two networks to smaller banks via the head institutions.

Small banks do not seem to play a major role on the external interbank market. Their only source of additional funds is the internal interbank market. Neither the domestic external market nor the international interbank market are accessed by the group of small banks.

We have furthermore shown that applying a size measure to test for the existence of the BLC is much more appropriate in the German case once all the banks that are organised in one of the two networks are removed from the sample. In this case, the size of a bank significantly affects the reaction of its loan volume to monetary policy impulses: loans to non-banks from small banks decrease by more than those from large banks do. However, it has to be noted that only very few small banks are outside the bank networks and as such subject to these distributional effects of monetary policy.

Although we have explicitly tested for the German case only, the existence and importance of bank networks in many other countries makes us confident that the mechanisms identified in this paper shed light on the banking sector's reaction to monetary policy in a much broader range of countries. Ehrmann et al. (2001) gives an overview of several recent studies of the BLC in European countries. As a matter of fact, in countries with important networks like Austria, Finland or Italy, a bank's size does not determine its reaction to monetary policy. Against this background, the fact that for the US such a bank size effect is typically found (see, e.g., Kasyhap and Stein (2000)), leads us to the conclusion that the bank relationships on the federal funds market in the US as described in Furfine (1999) do not affect banks' reactions to monetary policy as strongly as the institutionalised networks in the European countries listed above. We do therefore generally conclude that, when testing for the BLC, it is crucial to explicitly take the characteristics of a country's banking structure into account.

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APPENDICES

APPENIDX 1: ESTIMATION AND IDENTIFICATION STRATEGY

To estimate the structural responses of each economy to a monetary policy shock, we used structural vector autoregressions (SVARs). A detailed discussion of our methodology can be found in Ehrmann (2000), so we provide here only a quick overview of the estimation strategy. We apply a procedure set forth in King et al. (1991).[29] Their identification strategy is based on the implications of cointegrating relations in a multivariate system. In a system with r cointegrating relations there will be k common trends, where $k = n - r$, and thus k shocks that are assumed to have long-term effects on the variables in the system, whereas r shocks affect the variables only temporarily. In such a system, it is possible to identify only the subsystems of permanent or transitory shocks. Assuming that monetary policy shocks exert only temporary effects on the variables in our VARs, we need $r(r-1)/2$ additional restrictions. The methodology of King et al. employs a triangular specification, and we identify the monetary policy shock by assuming that it afects affects neither inflation nor output within the same month.

[29] For a detailed derivation of their approach, see also Warne (1993).

APPENDIX 2: TEST STATISTICS

Table A1: L-max statistics for the test of cointegration rank

	Total bank loans	*Bank loans small banks*	*Bank loans large banks*
$r = 0^a$	36.24	35.93	31.36
$r = 1^b$	17.90	29.60	18.33
$r = 2^c$	12.53	17.99	13.72
$r = 3^d$	**5.49**	10.77	**6.65**

90% critical values: [a] 19.88 [b] 16.13 [c] 12.39 [d] 10.56

Table A2: Test for 3 cointegrating vectors: Bundesbank reaction function, trend-stationary real interest rates, bank lending cointegrates with interest rates and trend

	Total bank loans	*Bank loans small banks*	*Bank loans large banks*
$\chi^2(3)$	7.66	5.95	2.91
p-val.	0.11	0.20	0.57

Table A3: L-max statistics for the test of cointegration rank

	Interbank market			*External*			*Internal*			*Abroad*		
	Small	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*
$r = 0^a$	38.74	43.01	39.28	39.45	39.02	39.28	37.97	42.09	42.09	35.50	34.08	37.52
$r = 1^b$	27.33	30.28	24.97	22.61	27.92	24.97	31.32	31.03	31.03	26.55	27.41	25.82
$r = 2^c$	23.84	20.86	20.46	17.44	20.6	20.46	25.18	20.16	20.16	16.61	19.76	18.78
$r = 3^d$	**10.50**	12.84	15.15	12.44	18.55	15.15	**11.31**	**11.53**	**11.53**	13.42	17.07	14.60
$r = 4^e$	**8.03**	**6.13**	**7.68**	**7.05**	**8.70**	**7.68**	**8.18**	**7.86**	**7.86**	**6.46**	**5.13**	**6.74**

90% critical values: [a] 23.72 [b] 19.88 [c] 16.13 [d] 12.39 [e] 10.56

Table A4: Test for four cointegrating vectors: Bundesbank reaction function, trend-stationary real interest rates, interbank lending variables cointegrate with interest rates and trend

	Interbank market			*External*			*Internal*			*Abroad*		
	small	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*
$\chi^2(4)$	3.67	3.10	2.21	4.27	2.40	2.21	4.34	1.51	1.51	2.09	1.43	3.03
p-val.	0.45	0.54	0.70	0.37	0.66	0.70	0.36	0.82	0.82	0.72	0.84	0.55

Table A5: The maintained cointegrating vector concerning the interbank lending variable

	Interbank market			*External*			*Internal*			*Abroad*		
	small	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*
r_t	0.84 (0.06)	2.46 (0.15)	-0.60 (0.35)	0.21 (0.04)	1.12 (0.05)	0.82 (0.42)	0.71 (0.05)	1.12 (0.13)	-1.48 (0.14)	0.04 (0.02)	0.66 (0.05)	1.64 (0.43)
t	-0.02 (0.00)	-0.02 (0.01)	-0.22 (0.03)	-0.01 (0.00)	0.01 (0.00)	-0.28 (0.04)	-0.01 (0.01)	-0.04 (0.01)	0.06 (0.01)	-0.01 (0.00)	0.01 (0.01)	-0.30 (0.04)

APPENDIX 3: FIGURES

Figure A1: Net interbank positions of the various size groups

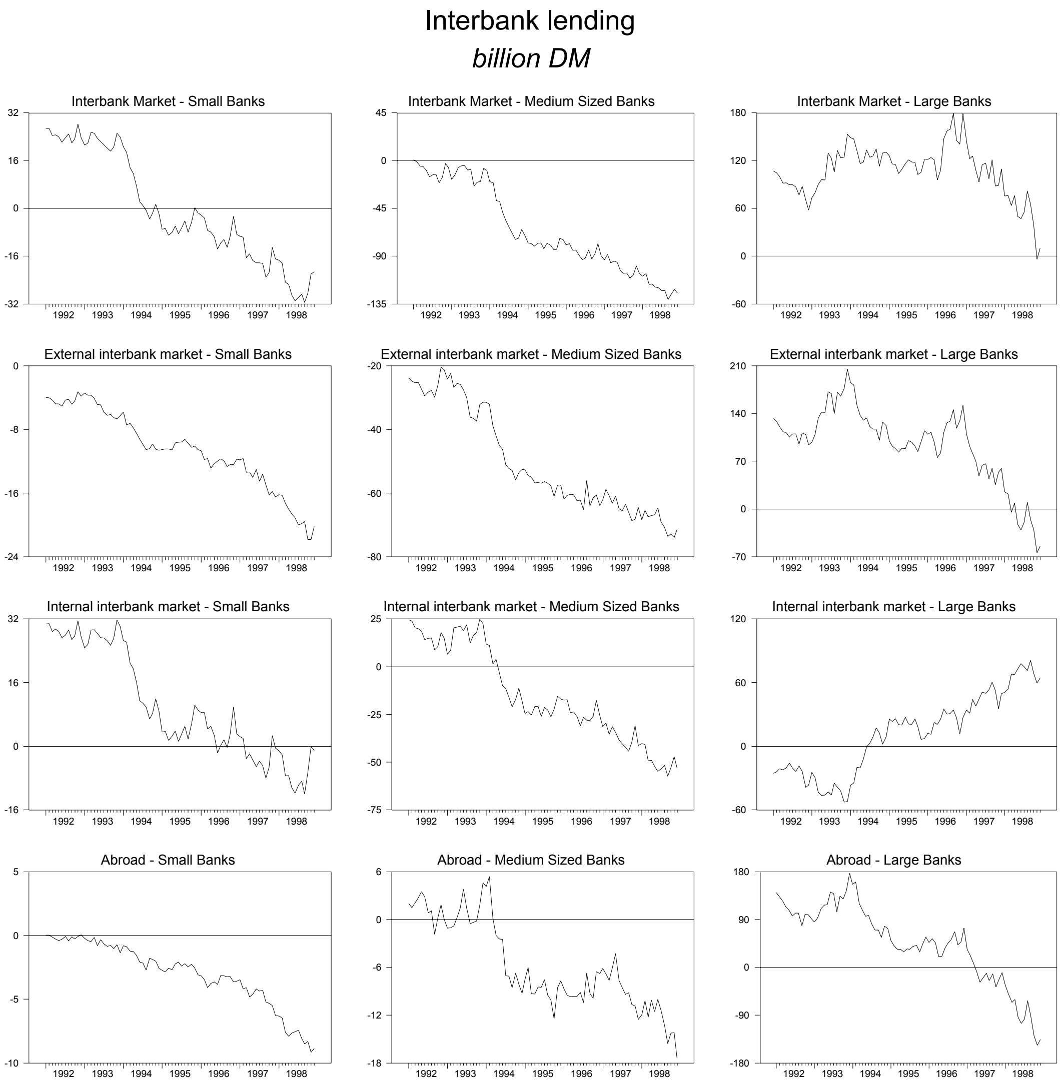


Figure A2: The effects of a monetary policy shock on bank loans to the non-financial sector

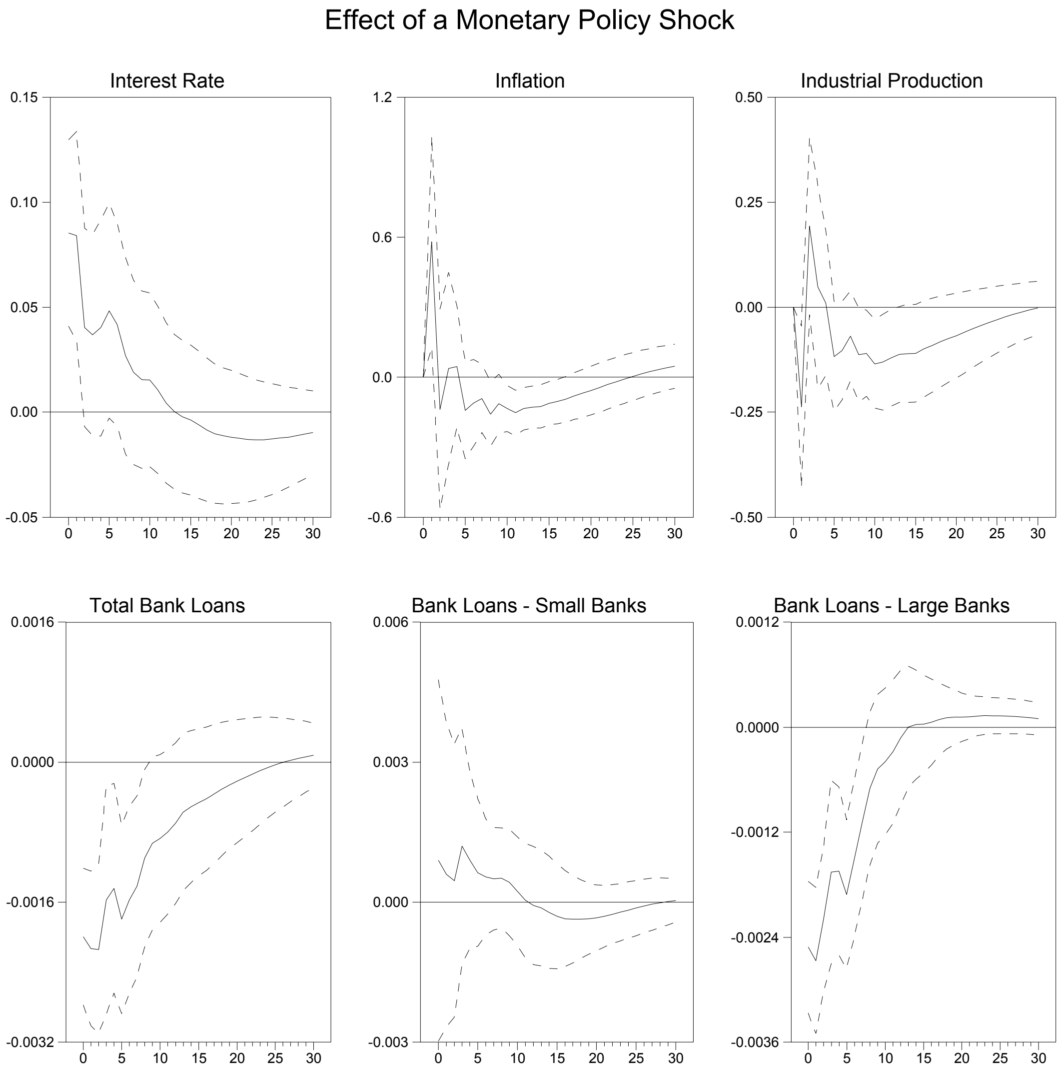


Figure A3: The effects of a monetary policy shock on interbank lending (by the various bank size groups, from different segments of the interbank market)

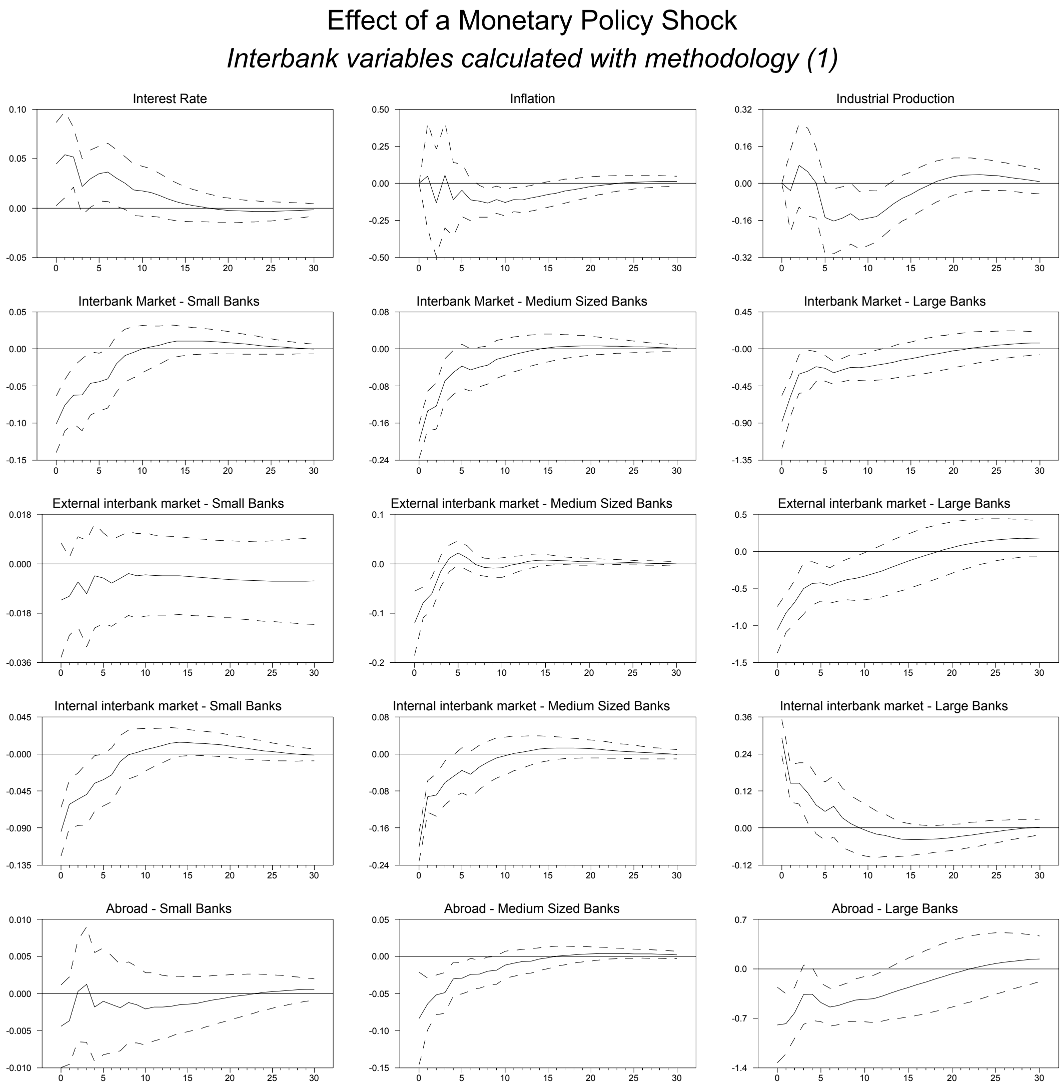


Figure A4: The effects of a monetary policy shock on the internal interbank market

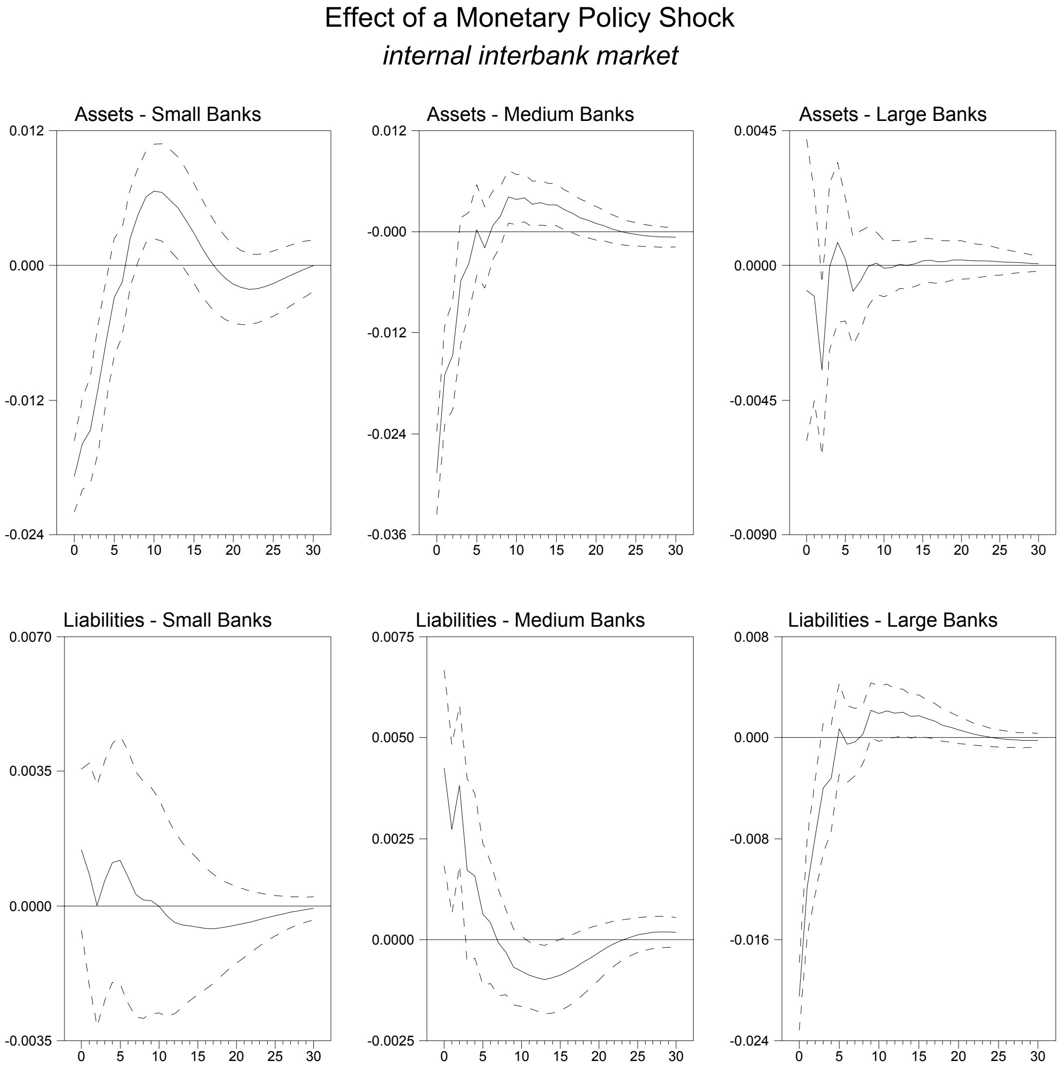
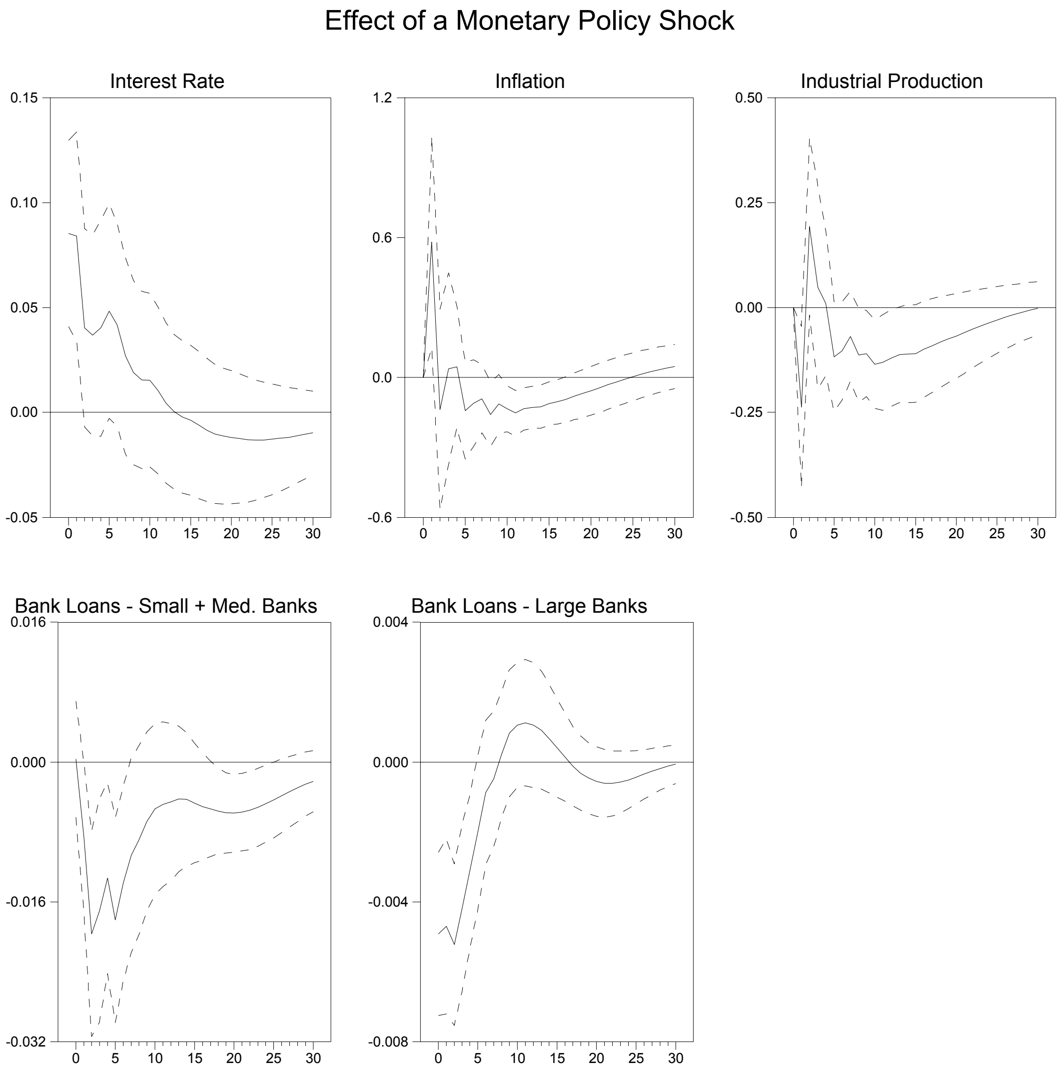


Figure A5: The effects of a monetary policy shock on bank loans to the non-financial sector by banks that are not part of a bank network



APPENDIX 4: SENSITIVITY ANALYSIS (INCLUSION OF A LINEAR TREND IN THE REAL INTEREST RATE COINTEGRATING VECTOR)

Table A6: Test for overidentifying restrictions of the four cointegrating vectors, with and without a linear trend in the vector on real interest rates; interbank variables calculated with methodology (1), defined as ratios

(a) real interest rates trend-stationary

	Interbank market			*External*			*Internal*			*Abroad*		
	small	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*
$\chi^2(4)$	4.92	4.60	1.79	4.09	3.43	1.69	5.08	2.02	2.02	2.25	1.89	2.31
p-val.	0.30	0.33	0.77	0.39	0.49	0.79	0.28	0.73	0.73	0.69	0.76	0.68

(b) real interest rates stationary

	Interbank market			*External*			*Internal*			*Abroad*		
	small	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*	*small*	*med.*	*large*
$\chi^2(4)$	7.83	12.37	7.61	11.62	11.59	7.74	7.77	8.40	8.40	11.23	10.18	7.95
p-val.	0.10	0.01	0.11	0.02	0.02	0.10	0.10	0.08	0.08	0.02	0.04	0.09

Figure A6: The effects of a monetary policy shock on interbank lending, sensitivity to the inclusion of a linear trend in the real interest rate cointegrating vector