Economics Department

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Evidence from German Business Survey Data

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Michael Ehrmann[*]

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Abstract

Using business survey data on German manufacturing firms, this paper provides tests for hypotheses formulated in capital market imperfection theories that predict distributional effects in the transmission mechanism of monetary policy. Effects of monetary policy shocks on the business conditions of firms of several size classes are analysed, with the finding of considerable asymmetry. As predicted by theory, small firms are affected more strongly than large firms. To test whether these effects are reinforced when the economy is in a business cycle downturn, the paper employs a new estimation strategy: impulse response analysis conditional on Markov-switching regimes. The findings are supportive of the theoretical hypotheses: in a business cycle downturn, the distributional effects of monetary policy transmission are indeed reinforced: JEL: E52, E44, C32.

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1 Introduction

Numerous recent publications have been devoted to a theoretical analysis of the various channels of monetary policy transmission.[1] On the empirical side, the evidence is still far from complete. This paper aims to contribute further evidence on two channels of monetary policy transmission, namely the balance sheet and the credit channel.

The balance sheet channel is built on the argument that asymmetric information in the credit markets necessitates the use of collateral for borrowing. As a consequence, the availability of credit for firms is dependent on the value of their assets. If credit market conditions tighten by rising interest rates, this will affect the balance sheet positions of firms: higher interest payments reduce cash flow and higher interest rates lower the market value of assets. A monetary policy tightening can thus possibly lead to a restricted access to credit for firms. The firms which are more likely to be affected by this channel are small firms: due to higher informational asymmetries, the amount of collateral they have to pledge is relatively higher. Additionally, being small means that they do not dispose of as many collateralisable assets as large firms do. A balance sheet weakening due to monetary policy tightening can thus considerably diminish the collateral value they have at their disposal, and they might become credit-constrained. Large firms are less affected by this channel, given their overall higher level of collateralisable assets and the lower collateral requirements on their loans.

The credit channel also creates a disproportionate effect of tighter monetary conditions on firms of different sizes. To trigger off the credit channel it is necessary that the central bank have a leverage over the volume of intermediated credit in the economy. Then, a tighter monetary policy decreases the volume of credit available to borrowers. The distributional effect comes about because some firms are relatively more dependent on intermediated credit than others. Typically, it is easier for large firms to access other, non-intermediated forms of external finance, because the markets possess more information about these firms. Small

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[1] For an overview see Cecchetti, S. (1995).

firms, on the other hand, have to rely on intermediated credit to overcome their informational disadvantage. Following a monetary tightening, it is therefore relatively easy for large firms to substitute intermediated credit with other funds, whereas small firms are less flexible and hence face a restricted availability of funds.[2]

Both channels of monetary policy transmission are reflected in theories of credit market imperfections like those of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997). Several recent publications (e.g., Christiano *et al.* (1996) and Gertler and Gilchrist (1994)) have provided supportive evidence for the US economy: using firm size as a proxy for capital market access,[3] they do indeed find that small firms are affected more strongly by changes in monetary policy stance.

The strength of both transmission channels depends on the phase of the business cycle: theory predicts that both are stronger in a downturn. The balance sheet channel becomes more potent because net worth of firms falls in downturns, with a corresponding deterioration of balance sheet positions; the credit channel is strengthened because in a downturn default probabilities rise, thus increasing the cost of intermediated credit and starting a flight to quality, which restricts small firms even more than in other business cycle phases.

Gertler and Gilchrist (1994) show that, indeed, small firms' reactions to shocks to the Federal Funds Rate are dependent on the business cycle position. Perez-Quiros and Timmermann (PQT - 2000) employ a Markov-switching framework to examine the effects of interest rate increases and liquidity squeezes on stock returns for size-sorted portfolios; they confirm, firstly, that small firms are affected more strongly by tightening monetary conditions and, secondly, that these effects are reinforced if the economy is in a recession.

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[2] Another line of argument is that small firms on average have a higher growth rate (which is in contrast to Gibrat's law, but often found empirically, as e.g. by Evans, 1987), thereby creating higher capital requirements, and a stronger vulnerability to the credit channel.

[3] Watson (1999) shows that the size of a firm is a good proxy for its capital market access; other proxies could not outperform size in her study.

To date, all time series evidence has been exclusively concerned with the US economy. So far, no time series study on European economies has been performed, for a straightforward reason: time series data on small firms are extremely difficult to find for European economies. Stock returns as in PQT (2000) are not an option because in European economies, until recently, small firms typically were not traded on any exchange. Quarterly Financial Reports as in Gertler and Gilchrist (1994) are published for some countries, but generally do not span a sufficiently long time period to start an econometric analysis. Annual balance sheet data, which are available for small firms, do not allow inference at higher frequencies. Research on European economies has therefore exclusively employed panel data sets, normally confirming that firm size matters.[4] The use of panel data sets is not without drawbacks, however, because most of them are criticised for being biased towards large firms.

The present paper is therefore the first to provide time series evidence for a European economy. It uses a data set for Germany that is not subject to the shortcomings mentioned; it includes very small firms (1-49 employees), is available at a monthly frequency and goes back far enough to permit time series inference. The data set will be described in section 2 of this paper. Section 3 explores whether small firms are affected disproportionately by monetary tightenings, and to what extent firms' exchange rate sensitivity varies across size classes. Section 4 tries to identify whether the asymmetry arises due to demand or supply side factors. In a further step, section 5 checks for business cycle asymmetries of monetary policy effects. Eventually, section 6 deals with the expectation formation of firms in order to see whether they mirror the distributional effects of monetary policy. Section 7 concludes.

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[4]Rondi et al. (1998), or Watson (1999), using annual balance sheet data, find evidence that small and large firms react differently to monetary tightenings. For a comprehensive overview of the European evidence see Mojon (1999).

2 Data Description

Each month, the German *ifo-Institute for Economic Research* conducts a business survey among more than 8,000 firms. Of these, approximately 3,000 belong to the West German manufacturing industry and form the subsample used in this paper. I will use the answers to three of the questions, namely, on the business conditions of firms, the demand situation and the expectations of business conditions. Firms are invited to answer these questions in the following ways:

- "At present, we consider our business conditions to be i) good, ii) satisfactory (usual for the season), iii) bad"

- "Our demand situation, compared to the last month, has i) improved, ii) remained unchanged, iii) deteriorated"

- "With regard to the business cycle, our business conditions will, over the next 6 months, i) rather improve, ii) stay approximately the same, iii) rather deteriorate"[5]

Boxes are provided next to each answer; the firms have to tick the box according to their choice. That the questions on business conditions and expectations are put in a very general way, without restricting the potential set of criteria that can influence the answer, is intentional. The idea behind this is that firms themselves can best decide which factors are decisive for their terms of business. For each question, all answers are aggregated to an index variable by subtracting the share of "-"answers (third option) from the share of "+"answers (first option). The indices can therefore take any value between +1 and -1, with the extreme cases occurring when all firms answer with "+" or "-".

The data can be broken down according to firm size, with the following classifications:

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[5]The German original is "Unsere Geschäftslage wird in den nächsten 6 Monaten in konjunktureller Hinsicht i) eher günstiger, ii) etwa gleich bleiben, iii) eher ungünstiger."

Size Class	1	2	3	4	5
Employees	1-49	50-199	200-499	500-999	$\geq$1,000
% of sample	16%	33%	23%	13%	15%

Although the *ifo-Institute's* business survey started in 1949, this type of disaggregation can be traced back until July 1981 only. The latest observation included in the analysis here is 1998:12. As an illustration, figures 1 and 2 show the business conditions and the business expectations for the largest and smallest firms. It can be easily seen that the series vary considerably across firm size.

Tables 1 and 2 give a brief first analysis of the series. Interestingly, all the descriptive statistics (i.e., mean and coefficient of variation) exhibit a monotonic relationship between the size classes, for both the business conditions and expectations. This monotonicity will reappear in several results throughout the paper and suggests that size is an important factor in explaining firm behaviour.

Size Class	1 (smallest)	2	3	4	5 (largest)
Business Conditions	-.118	-.064	-.048	-.020	-.006
Business Expectations	-.279	-.163	-.053	-.047	-.002

Table 1: Mean of Series

Size Class	1 (smallest)	2	3	4	5 (largest)
Business Conditions	-141	-323	-425	-1095	-3917
Business Expectations	-98	-182	-536	-560	-15250

Table 2: Coefficient of Variation of Series

The questions on the current conditions of business and the expectations for the next six months form the basis for the "*ifo* business climate index", an indicator which is widely used in German business cycle analysis because of its good quality as a leading indicator. Indeed, as

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is shown in table 3 in the appendix, the correlations of the data with the business cycle is striking and clearly shows a leading pattern. Business conditions lead deviations from trend in industrial production by one quarter, and have a correlation coefficient of 0.85 for most size classes. The business expectations lead by even more, namely by two quarters, and also show a high correlation with the actual output figures. For a graphical analysis see figures 3 and 4.[6]

A priori, it is not clear whether data series of this kind actually allow for an analysis of macroeconomic issues. Firstly, it can be argued that the access to relevant information differs across size classes, thus leading to different response patterns. Secondly, the series do not report "hard" and quantifiable facts of the firms' situation, but instead only contain the perceptions of firms. Nothing guarantees that the perceptions of firms are, even when aggregated, on average correct. That the mean of the series differs across size classes could give an indication on this issue - it is possible that small firms are consistently overpessimistic, leading to a lower mean than for large firms. If this were the case, the data analysis could be easily rescued by demeaning the series. The issue would become more problematic if a perception bias varied over the business cycle. In this case evidence on business cycle asymmetries would become spurious. However, there is evidence that the data are free of such biases. The high correlation of all series with the business cycle, and especially the fact that these correlations are not significantly different across size classes suggests that the series draw a rather accurate picture of actual business conditions. I am therefore confident in assuming that the business survey data can give evidence about the effects of monetary policy on firms and do not restrict the analysis to one of the perception of firms.[7]

Since I intend to draw inferences about the size effects of monetary policy, it is necessary to check whether the data can give unbiased infor-

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[6]Figures 3 and 4 show the bandpassed quarterly series of industrial production, business conditions and business expectations. The filter uses only the business cycle frequencies (6 - 32 quarters) of the data and removes higher frequencies like seasonality and lower frequencies like trends. For a reference, see King and Watson (1996).

[7]For other recent papers which use the same kind of data successfully see Buckle and Meads (1991) and Motonishi and Yoshikawa (1999).

mation on this. If it were the case that some size class were dominated by a certain industry, inferences drawn from the data set would actually not report size effects but rather industry effects of monetary policy. However, looking at the industry breakdown of the data set it becomes clear that no such bias is present. Manufacturing industry comprises 27 subsectors according to the *ifo-Institute's* classification scheme. Even though most industries cover all size classes, this is not the case for all of them. Exceptions are the wood industry, which comprises size classes 1 to 3 only, car manufacturing (size classes 2 to 5 only), ceramics (1 to 4), paper (1 to 4), "other production goods" (3 to 5), and "other consumer goods" (1 to 3). This makes 6 out of 27 industries, most of which (with the exception of car manufacturing) have a relatively small share in the aggregate industrial production. I therefore regard any possible biases as negligible; the results obtained with the business survey data set reflect size class differences rather than industry characteristics.

The other variables used in this paper are German producer price inflation, the growth rate of M3, the change in the logarithm of the exchange rate against the US dollar, industrial production and a three months' money market rate, all taken from Datastream. The business survey series are transformed according to $y^* = \ln\left(\frac{1+y}{1-y}\right)$, a monotonically increasing transformation that maps the data from the [-1,1]-interval to the [$-\infty$,$+\infty$]-interval; a more detailed explanation is provided in appendix A.1. All other variables, with the exception of interest rates, are in logarithms (the growth rates are annualised differences of the variables in logarithms).

3   Monetary Policy and Business Conditions

In order to analyse the effects which monetary policy can have on firms of different sizes, I employ Structural Vector Autoregressions (SVARs). In particular, I am going to use the identification approach suggested by King, Plosser, Stock and Watson (KPSW - 1991). SVAR models investigate the response of variables in the VAR to shocks. In general, monetary

policy analysis is performed by looking at the responses of output and inflation to a shock in the interest rate or a monetary aggregate. The KPSW framework allows for a more complex set-up - here, monetary policy analysis can be modelled in terms of shocks to the cointegration relations, and as such is not restricted to shocks to single variables. As a matter of fact, a monetary policy shock will be modelled as a shock to the interest rate and a shock (with opposite sign) to the money growth rate. A more detailed discussion of both SVAR models and the KPSW procedure is provided in appendix A.2.

The estimations start with a very simple baseline model, simply to ensure that monetary policy effects are properly identified. In order to investigate the differential impact of monetary policy actions on firms of different size, the model will subsequently be extended.

3.1 The Baseline Model

The baseline model consists of a four-variate VAR with $X_t = [Dm_t \quad ip_t \quad i_t \quad \pi_t]'$, where X_t denotes a vector including the growth rate of M3 (Dm_t), industrial production (ip_t), the short-term interest rate (i_t) and producer price inflation (π_t).[8] The data are monthly and range from 1981:7 to 1998:12, covering a sample of 210 observations. Since the aim of this paper is to identify effects over the business cycle, seasonality and long-run trends are eliminated by the inclusion of seasonal dummies and the use of detrended variables. The latter is achieved by simply regressing the data on a linear trend. Six lags are included in the models, which are estimated as Vector Error Correction models (VECMs) to allow for the

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[8]The choice of producer price inflation as the inflation measure has been made because producer prices, unlike consumer prices, are not affected by indirect tax increases. The consumer price index (CPI) for Germany was subject to big jumps each time indirect taxes were increased. These jumps were especially severe after German unification, when the tax increases were particularly large and, additionally, the liberalisation of East German rents in two rounds fed into the CPI. After correcting for these effects producer and consumer price inflation show a very similar pattern. The choice of producer price inflation therefore makes the introduction of correcting dummy variables unnecessary.

possibility of cointegration.

As a matter of fact, the cointegration analysis for this baseline model suggests the existence of cointegration relations (see table 4). Three possible cointegration relations come to mind: deviations of output from trend should be stationary, because they form a business cycle indicator and as such should be mean reverting; economic theory suggests furthermore that real interest rates are stationary. The third cointegrating vector assumes that in the long run, money growth (possibly money growth exceeding some constant rate) equals inflation, which imposes superneutrality of money.[9] A cointegration rank of three seems plausible *a priori*, and the test statistics can be read in this way. In the following the existence of three cointegration relations is therefore assumed.

The cointegrating vectors can be formulated as follows:

	Dm_t	ip_t	i_t	π_t
β_1' :	0	1	0	0
β_2' :	0	0	1	-1
β_3' :	1	0	0	-1

a hypothesis which cannot be rejected in a corresponding test, as shown in table 5 in the appendix.[10] With this specification of the cointegrating vectors and the cointegration rank set to $r = 3$, I can now proceed with the impulse response analysis of the system. The monetary policy shock is expected to be transitory, because after some time all four variables

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[9]This is derived and shown to be empirically relevant in Crowder (1997): He assumes an aggregate supply function of the form $\Delta y_t - \Delta y_t^f = \gamma(\Delta p_{t+1}^e - \Delta p_{t+1})$, where Δy_t is growth of real output, and Δy_t^f denotes real output growth at full employment, and money demand $m_t - p_t = f(y_t, ...)$. The equilibrium relationships are $\Delta y_t = \Delta y_t^f$ and money demand being equal to money supply. In steady state it therefore has to be the case that $\Delta m_t = \Delta p_t^e = \Delta p_t$. The underlying assumption of a stable money demand (with unit income elasticity) has found considerable support for the German case; for a recent example see Hubrich, K. (1999).

[10]In one case, the p-value of the test on the cointegration relations is on the borderline with 0.03. In small samples, there is a bias towards overrejection of the null, as shown by Podivinsky (1992). This and the fact that the p-values for the other models are clearly above the usual confidence level make me stick to the tested null.

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should return to baseline (N.B. that this already implies an identification restriction).[11] Hence it is sufficient for my purposes to identify the subsystem of transitory shocks only. To do so, additional $r(r-1)/2 = 3$ identification restrictions must be imposed. Regarding the monetary policy shock, the specification chosen here is fairly standard in assuming that monetary policy can affect neither output nor inflation within the same month.

The resulting impulse responses are provided in the first four graphs of figure 5 in the appendix. All responses are presented with $\pm\sigma$-error bounds. The monetary policy shock is found to be a combination of a shock to the money growth rate and to interest rates: a decrease in money growth plus an increase in interest rates constitute a contractionary monetary policy shock. This shock is followed by a decrease in both inflation and industrial production. All impulse responses are as expected *a priori*, which indicates that the baseline model has succeeded in identifying monetary policy innovations.[12]

3.2 Monetary Policy Transmission to Business Conditions

After having identified monetary policy shocks in the baseline model, the effects on the business conditions for firms of different size are investigated. The estimation strategy followed is to substitute one of the

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[11] Actually, the persistent shock is a nominal shock, too - it affects the nonstationary variables in the VAR, i.e. permanently alters the levels of inflation, money growth and/or interest rates. The interpretation of such a shock could be one of a changing inflation target of the Bundesbank. However, such a shock is difficult to reconcile with the actual pattern of the Bundesbank's monetary policy; I consider it more reasonable to assume that the nonstationarity of the series is a matter of the sample size rather than one of actual properties of the time series - over the short sample, the series appear to be integrated. This means that the series have to be modelled as nonstationary for econometric reasons, but that the nonstationarity of the series is more a statistical rather than an economically interpretable property.

[12] All the results in this paper are surprisingly robust. Even changes in the variables, like substituting M2 for M3, leave the results basically unaltered.

business conditions variables $(bc_{i,t})$ for business cycle variable "deviations of industrial production from trend" (ip_t), each in turn. That is, the model is re-estimated five times, with Dm_t, i_t and π_t unchanged, and the business cycle variable varying from "Business conditions for size class 1 (smallest)" to "Business conditions for size class 5 (largest)". Again, the cointegration analysis suggests three cointegrating vectors, and the hypotheses on the cointegrating vectors cannot be rejected (see tables 4 and 5).

The corresponding impulse responses are plotted in the second and third rows of figure 5 in the appendix. Not surprisingly, the business conditions for all firms worsen after a tightening of monetary policy. The pattern of responses is very similar to that of the deviations of industrial production from trend, mirroring the close correlation of the variables. This exercise is interesting in so far as we now know that a monetary tightening affects firms of all size classes negatively. However, it is not yet possible to draw any conclusions about the asymmetric impacts a monetary tightening might have on firms of different size. Thus, an extended model is called for.

3.3 Asymmetric Effects of a Monetary Tightening Across Size Classes

In order to test for possible asymmetries the SVAR models are extended. Namely, the difference of responses of firms is included as an additional variable. To give an example, the business conditions of the largest firms are subtracted from those of the smallest firms $(\Delta_{15,t} = bc_{1,t} - bc_{5,t})$. If both business conditions react in a parallel way to interest rate shocks, no significant response of the additional variable should be detectable. If small firms are hit harder by rising interest rates, then $\Delta_{ij,t}$ should become negative. The interpretation of such a finding would be that relatively more small than large firms answer that their business conditions have deteriorated, and thus that more small firms feel the effects of a tightening.

Another variable is added here, to ensure that the responses to a

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monetary policy shock and those to an exchange rate shock are disentangled properly. *A priori*, it is often believed that large firms are much more export-oriented than small firms. The behaviour of the raw data series in figure 1 is consistent with this belief. It is a well-established pattern that the German business cycle is strongly dependent on the export performance of firms. A higher export propensity could thus explain the higher variance of large firms' business conditions over the cycle. The ERM exchange rate crisis of 1992/93 can serve as an event study. During 1992/93, many ERM currencies devalued against the DM. Export-oriented firms consequently had to face a strong deterioration in business conditions - and indeed, the business conditions of large firms plummeted relative to those of small firms.

If firm sizes differ with respect to their export orientation, it is important to disentangle the exchange rate channel of monetary policy transmission from the balance sheet and credit channels. It is therefore crucial to include the exchange rate in the VAR models.

The extended VAR spans $X_t = [\Delta_{ij,t} \quad Dexr_t \quad Dm_t \quad ip_t \quad i_t \quad \pi_t]'$. The new variables are both stationary (Note that the exchange rate enters in first differences;[13] $\Delta_{ij,t}$ as the difference of two stationary variables is by definition itself stationary), which implies two new cointegrating vectors, namely, the new variables themselves. Now, a monetary policy tightening is characterised as a decrease in money growth, increasing interest rates and a simultaneous exchange rate appreciation. As before, the model is estimated several times, with $\Delta_{ij,t}$ being substituted and the other variables held constant. Ten different combinations of $\Delta_{ij,t}$ are possible, all of which are in turn included in a VAR. The combinations are:

$$
\left\{
\begin{array}{llll}
bc_{4,t} - bc_{5,t} & bc_{3,t} - bc_{5,t} & bc_{2,t} - bc_{5,t} & bc_{1,t} - bc_{5,t} \\
 & bc_{3,t} - bc_{4,t} & bc_{2,t} - bc_{4,t} & bc_{1,t} - bc_{4,t} \\
 & & bc_{2,t} - bc_{3,t} & bc_{1,t} - bc_{3,t} \\
 & & & bc_{1,t} - bc_{2,t}
\end{array}
\right\}
$$

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[13]This follows the model specification by Smets (1997).

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The results of this exercise are reported in figure 6 in the appendix. The findings are striking. A tightening of monetary policy leads to significant distributional effects. The business conditions of all size classes worsen (see above), but those of smaller size classes deteriorate significantly more. The point estimates of responses of $\Delta_{ij,t}$ are negative for every single measure. In most cases, these responses are also significantly negative. This in itself is evidence that small firms are hit harder by monetary policy tightenings than large firms.

Additionally, the impulse responses evolve monotonically across size classes. Firms become more heterogeneous when moving from the left to the right in the matrix of responses, as well as when moving up from the bottom. In both directions, and for every single row and column, the impulse responses become more pronounced step by step.

Checking the significance of the point estimates it seems that, actually, the firms are divided into three subgroups: the largest firms are significantly different from all the other size classes (as shown by the responses in the first row of figure 6); so are the smallest firms (as portrayed by the last column in figure 6). Firms of size classes two, three and four seem relatively homogeneous amongst themselves, and show significant differences only relative to firms of size classes one and five.[14]

How can the evidence on firm asymmetries be interpreted? Caution is warranted because the data set analysed here is of a very particular nature. It has to be kept in mind that firms only report whether conditions have improved, worsened or stayed unchanged. Hence a stronger effect of interest rate shocks on the aggregated business condition series does not give evidence about how strongly one single firm is affected - the results merely indicate how many firms of a certain size class suffer from a worsening of business conditions. However, this is nonetheless

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[14]One possible interpretation might be that the credit channel mainly affects firms of size classes 1 to 4, with size class 5 being relatively unaffected because of better access to commercial paper and other forms of external, unintermediated finance, and that the balance sheet channel is mainly significant for firms of size class 1, i.e. very small firms with very little collateral. These hypotheses cannot be tested for with the exisiting data set, however.

informative about firm size effects of monetary policy. A significantly higher number of small firms faces deteriorated business conditions when compared to large firms after an increase in interest rates.

3.4 Exchange Rate Effects on Business Conditions

The extended VAR model allows me to investigate the responses of relative business conditions to an exchange rate shock. Figure 7 in the appendix provides the corresponding impulse responses, where the shock is one of an exchange rate depreciation. Large firms are generally believed to be more export-oriented than small firms, and as such should react more strongly to exchange rate changes. Following the exchange-rate depreciation, the business conditions of all firms improve, but those of large firms do so significantly more than those of small firms (which is reflected in a significantly negative response of most $\Delta_{ij,t}$-variables). In four cases (3 vs. 5, 3 vs. 4, 2 vs. 4 and 1 vs. 4) a fairly quick reaction is found which is at odds with *a priori* beliefs, but in two out of these cases, this unexpected reaction is reversed after some time. Overall, the picture that emerges confirms that large firms are more sensitive to exchange-rate changes.[15]

4 Demand Side Effects

The original hypothesis that small firms are affected more strongly by monetary policy shocks stems from capital market imperfection theories and as such is concerned with financial factors. The evidence found in the preceding section supports this hypothesis, but cannot reveal whether the asymmetry indeed arises due to financial factors. If the business survey included questions on the financial situation of firms, the hypothesis could be tested directly. Unfortunately, this is not the case. Another question contained in the survey, namely, on the current demand situation of firms,

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[15]This is opposed to Guiso *et al.* (1999: 71), who find for Italy that size is not a good proxy for the export orientation of firms.

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can be helpful to single out other potential explanations, however. This will be done in the remainder of this section.

Potentially, both the supply side as well as the demand side situation of firms should enter the evaluation of current business conditions. The business conditions of size class i can thus be described as a weighted sum of the two factors (possibly with some intercept α_i and some error term $\varepsilon_{i,t}$):

$$bc_{i,t} = \alpha_i + \omega_i dem_{i,t} + (1 - \omega_i)sup_{i,t} + \varepsilon_{i,t}$$

The constraints imposed by the data set are that $sup_{i,t}$ is not observable - whereas $dem_{i,t}$ is. Additionally, we do not know the weights ω_i. It is easy to see, however, that regardless of the weighting, responses of $bc_{i,t}$ to monetary policy shocks that exceed those of the responses of $dem_{i,t}$ must stem from supply side factors (note that $0 \leq \omega_i \leq 1$). I will make use of this property as follows: the last model is extended to include the relative demand positions. The impulse responses of relative business conditions and demand situations are then compared: if the former are bigger than the latter, it can be concluded that supply-side issues create asymmetry, too.

Unfortunately, this does still not identify financial factors as unique driving force; other explanations can be imagined, e.g., lower import prices following a monetary tightening and the accompanying exchange rate appreciation might benefit larger firms more than smaller ones, if they have a higher share of imported goods as inputs. In any case, the evidence has to remain indirect: with no question on financial factors in the business survey, the detection of supply-side effects is as far as the analysis can go.

A model specification with a demand variable is useful for another reason, too. Sometimes the *ifo* survey data have been criticised for a bias towards the demand side. A survey conducted by the *ifo-Institute* in 1976 found that the people in charge of answering the business survey are very often in their regular business dealing with the firm's sales, and thus give a biased weight to demand factors. Financial factors, the focal point

of this paper, are therefore somewhat underrepresented. By including a demand variable in the VAR, it is possible to check whether last section's findings are robust. Once demand asymmetries across size classes have been accounted for, any asymmetries on top of this make a very strong case for supply-side and probably financial factors.

To check whether the demand variable itself responds as expected to a monetary policy shock, impulse responses are first calculated for the baseline VAR $X_t = [Dm_t \quad dem_{i,t} \quad i_t \quad \pi_t]'$, using the KPSW procedure. $dem_{i,t}$ denotes demand and is varied to cover all five size classes. The results of the cointegration analysis and the tests on the restrictions on the cointegrating vectors can be found in the appendix. A cointegration rank of $r = 3$ is maintained for all models, with the cointegrating vectors being the demand variable, the real interest rate and superneutrality of money (see tables 6 and 7). Figure 8 plots the impulse responses of this baseline VAR. Following a contractionary monetary policy shock demand declines for firms of all size classes, as expected. Interestingly, the significance of this decline is less pronounced for larger firms, whereas its size is more or less equal across size classes.

In order to test for asymmetric effects, the relative demand situation is included in the model of 3.3. The VAR now comprises $X_t = [\Delta_{ij,Dt} \quad \Delta_{ij,t} \quad Dexr_t \quad Dm_t \quad ip_t \quad i_t \quad \pi_t]'$, where $\Delta_{ij,Dt}$ denotes the relative demand position of firms, in contrast to $\Delta_{ij,t}$ which represents the relative business conditions of firms. The model is again estimated for all ten possible combinations of the delta-variables. The corresponding impulse responses can be found in figures 9 and 10. The relative demand position of firms deteriorates significantly after a monetary policy tightening, which means that again there is a bias which is unfavourable for small firms. Again, each point estimate becomes more pronounced moving up the columns or moving to the right in the rows of figure 9.[16]

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[16]This could be explained by subcontracting. If large firms have small firms as their subcontractors, then the burden of declining demand would be spread unevenly: large firms would rather keep their workforce fully employed and cut down on the subcontracted production. Small firms would then face a stronger decline in demand

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How does the picture on the relative positions of firms with respect to their business conditions change? Comparing figure 9 with figure 10, it turns out that, indeed, the responses of relative business conditions are much stronger than those of demand positions. Interestingly, the responses of relative business conditions hardly change when the model is extended: figures 6 and 10 are nearly identical. The conclusion from this exercise is that demand also reacts more strongly for small firms; however, demand tells only part of the story. We are left with another cause of asymmetry that must stem from the supply side.

5   Business Cycle Asymmetry

As stated in the introduction, theories of the credit channel maintain the hypothesis that the distributional effects of monetary policy actions should be more pronounced if the economy is in a business cycle downturn. In the following, I will test for these effects, but two caveats should be mentioned beforehand.

Firstly, the data sample ranges from 1981:7 to 1998:12 and inspection of figure 1 reveals that over this sample period the German economy was going through roughly 1.5 cycles. The evidence to be extracted from this small sample has to be taken with caution.

Secondly, the German economy is often referred to as a bank-based system. Small firms in particular very often have a close link to one bank, their "Hausbank". Theory suggests that small firms allow one single bank to gain such an influential position only because they expect advantages in other areas. For example, one of the possible gains a small firm might achieve in a close banking relationship is interest rate smoothing: a bank might be willing not to pass on a monetary-policy-induced interest rate increase to a close customer. This effect is probably strongest in times when the borrower would have difficulties with rising interest rates, i.e., in periods of low growth. Relationship lending can thus weaken the

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compared to large firms. For a discussion see Semlinger (1992).

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incidence of business cycle asymmetries to quite some extent.[17]

5.1 Estimation Strategy: Conditional Impulse Responses in a Markov-Switching Model

A new estimation approach will be employed to test for such business-cycle-related asymmetries: conditional impulse responses in a Markov-switching model.[18] The procedure consists of two stages.

In the first stage, an unrestricted VAR is estimated that allows for Markov-switching parameters. Since the hypotheses to be tested are conditional on the business cycle, it is essential that the Markov-switching regimes should capture the states of the business cycle, i.e., the regimes must be business cycle expansions and contractions, respectively. This first stage yields distinct parameter sets: one describes the economy in a business cycle expansion, the other set is valid if the economy is in a contractionary business cycle phase.

These two sets of parameters are then used in a second stage where a structure is imposed by applying the usual identification restrictions, for each regime separately, and impulse response analysis is performed. The resulting impulse responses are conditional on the state of the economy, and as such disentangle the effects of monetary policy shocks for expansionary and contractionary business cycle phases.

The Markov-switching model employed in the first stage was originally introduced by Hamilton (1989). To achieve distinctly shaped impulse responses for the two regimes, it is however necessary to extend his specification beyond a mere mean-switching model. State-dependent autoregressive parameters will give rise to different shapes of the impulse responses, whereas a state-dependent variance-covariance matrix will lead to distinct impact effects of the shocks.

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[17]The evidence for this effect is limited to date; for an overview see Mojon (1999).

[18]See Ehrmann, Ellison and Valla (2000) for a more detailed exposition of the estimation strategy. Another application is Ellison and Valla (1999).

It should be noted, however, that each additional parameter which is allowed to switch increases the computational burden of the algorithm, such that a parsimonious model is called for.[19]

Some more characteristics of this approach need mentioning here. Impulse responses conditional on the state of the economy, i.e., whether the economy is in a low or high growth state, are of course a *ceteris paribus* experiment. The economy is in a given regime when the monetary policy shock hits the system, and the effects traced by looking at impulse responses assume that, throughout, the economy does not switch regimes.[20] It is in this way possible to test the theoretical predictions, which themselves are conditional: the transmission channels are claimed to be stronger during downturns than during expansions.

Another word of caution is warranted here - the analysis is a pure thought experiment. Given a probability of staying in one regime of, say, .95, the expected probability of still being in the same regime some 48 months later is merely .09 - so one would not really expect to stay in the same regime all the time for which the impulse responses are actually being calculated. The impulse responses are nonetheless a useful tool. As long as the economy stays in the same regime, they are valid - so even if the full trajectory is not being realised, the periods up to the change in regime are characterised by the conditional impulse responses.

5.2 Model Set-up

To keep the model as parsimonious as possible, the number of regimes chosen is two. In addition, the number of variables in the VAR is reduced. It is not feasible in this context to estimate large-dimensional systems as

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[19]It turned out to be infeasible to estimate a model with mean-switching, as in Hamilton (1989). I consider the intercept-switching model as described in Krolzig (1997) to be a relatively good approximation, however.

[20]This excludes any analysis of how effective such a monetary policy shock can be in moving the economy from one state to the other. Whether a monetary loosening in a low growth period increases the probability that the economy switches to a higher growth regime is not taken into account in the conditional impulse responses.

in the preceding sections. The reduction is carried out in two steps. Firstly, it turns out that a cointegrated VAR with $X_t = [bc_{i,t} \quad i_t \quad \pi_t]'$ with the KPSW identification scheme gives reasonable impulse responses, too: business conditions deteriorate after a shock to the interest rate and inflation falls. The informational content has decreased of course, because now it is no longer possible to disentangle liquidity and exchange-rate effects of monetary policy impulses.

A second reduction is possible because in the very special case analysed here, where the variables of interest are stationary, the model specification can be reduced from a full-blown VECM with KPSW's identification scheme to a simple VAR with stationary variables only, where the identification scheme imposed follows a Choleski decomposition. The two models simulate the same shocks in this case: A KPSW model simulates shocks to the cointegration relations

$$
\beta' X_t = \left(\begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & -1 \end{array} \right) \left(\begin{array}{c} bc_{i,t} \\ i_t \\ \pi_t \end{array} \right)
$$

and then calculates the response of the levels of each variable. The monetary policy shock is thus a shock to the second cointegrating vector, i.e., a shock to the real interest rate. An equivalent shock can be modelled in a VAR which includes $bc_{i,t}$ and the real interest rate r_t directly. In doing so, some information is lost, however, namely, the separate response of nominal interest rates and inflation, which, in the VAR, is aggregated to the response of real interest rates.

Both in KPSW with two cointegration relations and in the stationary VAR, one identification restriction has to be imposed. The restriction that a monetary policy shock cannot affect business conditions contemporaneously is imposed in a VAR with a Choleski decomposition by ordering real interest rates last.

The business conditions of firms define the business cycle; if they fall, the economy is in a contraction; if they rise, the business cycle po-

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sition is expansionary.[21] If each model was estimated by introducing the business conditions of a certain size class, the definition of the business cycle would vary considerably across the estimates. To ensure some stability, each model therefore includes the business conditions of the largest firms and additionally those of firms of a different size class, thus leading to the model set-up

$$
\begin{pmatrix} bc_{i,t} \\ bc_{5,t} \\ r_t \end{pmatrix} = \begin{pmatrix} \beta_1(s_t) \\ \beta_2(s_t) \\ \beta_3(s_t) \end{pmatrix} + B_1(s_t) \begin{pmatrix} bc_{i,t-1} \\ bc_{5,t-1} \\ r_{t-1} \end{pmatrix} + B_2(s_t) \begin{pmatrix} bc_{i,t-2} \\ bc_{5,t-2} \\ r_{t-2} \end{pmatrix} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{pmatrix}
$$
$$(1)$$

where $\varepsilon_t \backsim iid \quad N(0, \Sigma)$. It is furthermore assumed that the state transition probabilities follow a first-order Markov chain:

$$
p_{ij} = \Pr(s_{t+1} = j | s_t = i), \quad \sum_{j=1}^{2} p_{ij} = 1 \quad \forall i, j \in \{1, 2\} \qquad (2)
$$

Note that the variance-covariance matrix is not state-dependent. The impact effects of shocks are therefore identical across regimes. This is no limitation in the application here, because the monetary policy shock has a zero impact effect on the other two variables in the system - and the shock to the interest rate itself will be normalised to one for comparability reasons anyway.

Finally, some restrictions are imposed to decrease the number of switching parameters even further: none of the autoregressive parameters in the interest rate equation is switching, given that my focus is on the impulse responses of the other two variables. The restrictions imposed are

$$b_{1.31}(s = 1) = b_{1.31}(s = 2) \qquad b_{1.32}(s = 1) = b_{1.32}(s = 2)$$
$$b_{1.33}(s = 1) = b_{1.33}(s = 2) \qquad b_{2.31}(s = 1) = b_{2.31}(s = 2)$$
$$b_{2.32}(s = 1) = b_{2.32}(s = 2) \qquad b_{2.33}(s = 1) = b_{2.33}(s = 2)$$

---

[21] This is in line with the NBER's definition: "Contractions (recessions) start at the peak of a business cycle and end at the trough", see http://www.nber.org/cycles.html.

5.3 Empirical Results

In such a set-up, it is *a priori* not sure whether the regimes picked by the algorithm are actually related to the business cycle. Any kind of regime that shows best fit, be it characterised by distinct intercepts, autoregressive parameters, or some combination, can emerge. Nonetheless, the regimes picked were indeed characterised as business cycle downturns and expansions. To take an example, in the model with $bc_{2,t}$ and $bc_{5,t}$ the estimated mean for $bc_{5,t}$ is $-.23$ in regime one, and $.09$ in regime two ($-.21$ and $.04$ for $bc_{2,t}$). Figure 11 in the appendix reports the according regime probabilities and compares them with the business conditions variable $bc_{5,t}$. The fit of regimes to expansions and contractions is relatively close: regime one spans from peaks to troughs and is therefore one of a business cycle contraction, whilst regime two is well characterised as an economic expansion. The characterisation of business cycle regimes is very close to those found in other, univariate Markov-switching models, e.g., Krolzig and Toro (1999). The matrix of switching probabilities is

$$P = \begin{pmatrix} 0.92 & 0.08 \\ 0.04 & 0.96 \end{pmatrix}$$

Two lags prove to be sufficient to achieve a well-specified VAR. This shows that the fit of the models is much better in a Markov-switching framework than when neglecting it; in the standard VAR models, a lag length of six was needed. The results of mis-specification tests[22] can be found in the appendix. The restrictions imposed on the autoregressive parameters of the interest rate equation are accepted with a p-level of 0.65.

In the second stage of the procedure, structure is given to the unrestricted MS-VAR. Figure 12 graphs the impulse responses to a monetary policy shock conditional on the state of the economy. In both regimes, a tightening of monetary policy leads to a deterioration of business conditions for firms of all size classes. The interesting feature of figure 12 is the

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[22]The tests follow Hamilton (1996).

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difference in policy transmission for the two different regimes. For some size classes, it is not very clear whether there is any difference, whereas there is a very clear cut answer for firms of size class one: the smallest firms face a much stronger deterioration of business conditions when the economy is in a downturn. The magnitude of the maximal effects more than doubles: from -3.5 to -7.7. A direct comparison across size classes is provided in the following table which demonstrates the amplification of responses in contractions relative to expansions (in the example of size class one: $\frac{-7.7}{-3.5} = 2.2$).

Size Class	1	2	3	4	5
Amplification factor	2.2	0.7	1.0	1.7	1.0

The evidence on the asymmetries over the business cycle is clear: in a downturn, the effect of an interest rate shock on business conditions is much stronger for the smallest firms, thus leading to more severe distributional effects, as is predicted by theory.

6 Expectation Formation

The *ifo* business survey includes a question on the expectations of firms about business conditions for the next six months. In this section, I will investigate whether firms are actually aware of the interest rate and exchange rate sensitivity of their business conditions. In this case, the contemporaneous interest rate and exchange rate should be significant explanatory variables for business expectations; interest rates should enter with a negative sign, exchange rates with a positive sign.

No further use of impulse response analysis will be made to test this hypothesis. Expectations should ideally incorporate all the available information instantaneously; the impulse response should hence only consist of one single reaction in the period in which new information is released.

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In order to identify the regressors properly, the information set of firms at the point in time when the expectations are formed must be determined. The questionnaires are sent out at the end of each month, with the bulk of the answers arriving at the *ifo-Institute* in the first week of the following month. That is, the expectations variable dated in period t does already include all the information available at the end of period t. The interest rate and the exchange rate should therefore enter any regression contemporaneously. The case of inflation is different. The figures for period t are normally published by the *Statistisches Bundesamt* in the second week of period $t+1$; by then, the questionnaires are already filled in and sent back. Therefore inflation enters the regression with one lag. The same is true for money growth. The earliest publication from which monetary developments can be inferred is the *Bundesbank's* analytical accounts. They are published mid month for the preceding month. Hence money growth, too, enters the information set of firms with at least one lag, which has to be reflected in the model specification.

The estimations are performed in the form of univariate error correction models using the two-step estimator proposed by Engle and Granger (1987). The first specification includes contemporaneously a firm's business conditions, the interest rate, the exchange rate and lagged inflation and money growth as explanatory variables for firm's expectations. It turns out that money growth and inflation are insignificant, hence they are dropped in the subsequent estimates (see table 9 in the appendix for the significance tests). With this new specification, the cointegration test is passed for all firm size classes (results of the cointegration tests are supplied in table 10 in the appendix). The cointegrating vectors are estimated as:

Size Class 1:	Exp_t	$-1.20bc_{1,t}$	$-.18Dexr_t$	$+4.20i_t$
		(0.07)	(0.04)	(0.43)
Size Class 2:	Exp_t	$-1.10bc_{2,t}$	$-.20Dexr_t$	$+3.75i_t$
		(0.06)	(0.04)	(0.41)
Size Class 3:	Exp_t	$-1.03bc_{3,t}$	$-.18Dexr_t$	$+2.19i_t$
		(0.06)	(0.04)	(0.42)
Size Class 4:	Exp_t	$-.73bc_{4,t}$	$-.17Dexr_t$	$+2.49i_t$
		(0.06)	(0.04)	(0.47)
Size Class 5:	Exp_t	$-.55bc_{5,t}$	$-.34Dexr_t$	$+3.74i_t$
		(0.07)	(0.06)	(0.60)

where the number in brackets are standard errors. The interest rate always enters with the correct sign, but the parameter estimates do not significantly decrease with increasing firm size. Small firms seemingly do not take their stronger interest rate sensitivity into account when they form expectations about their future business conditions.[23]

On the other hand, the parameters on the exchange rate are as expected. They all have the correct sign, and large firms do indeed attribute a larger weight to the exchange rate when thinking about the future development of their business conditions.

A second test along the same lines can be conducted with the adjustment coefficients α in the error correction models

$$\Delta Exp_t = v + \alpha ECT_{t-1} + \sum_{i=1}^{p} B_i \Delta X_{t-i} + u_t$$

ECT_{t-1} denotes the error correction term, and the vector X_t comprises all explanatory variables, in this case $X_t = [Exp_t \quad bc_{i,t} \quad Dexr_t \quad i_t]'$. The lag length p was chosen to equal six (see table 11 in the appendix for mis-specification tests). Once the expectations are out of equilibrium

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[23]The interpretation can also go the other way round, however: it is just as possible that large firms are overly aware of interest rate changes when it comes to expectations formation.

with the macroeconomic conditions, the speed of adjustment (measured by the α-coefficients) varies across size classes: small firms have the highest α, and as such get their expectations back to equilibrium the fastest.[24] The relationship is not monotonic, however, which is in line with the earlier findings. Small firms are hit relatively hard by monetary policy shocks, whereas large firms are affected relatively strongly by exchange-rate movements. It could be expected that those firms, which are the most sensitive to macroeconomic fundamentals, adjust their expectations the fastest. As a matter of fact, the estimated adjustment coefficients increase again for firms of size class 5. In detail, the estimates of α for the different models (with standard errors in brackets) are

	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Size Class 5
$\widehat{\alpha}$	-.17 (.06)	-.14 (.05)	-.08 (.05)	-.09 (.05)	-.12 (.05)

The exposure to economic fundamentals like interest rate and exchange rate developments determines the speed of adjustment: the smallest and largest firms show a higher adjustment coefficient in the equilibrium correction.

7   Conclusion

This paper has provided empirical tests for hypotheses formulated in capital market imperfection theories, claiming a higher exposure of small firms to monetary policy tightenings when compared to large firms. The data set analysed consists of firms' aggregated answers from a business survey. The data is split into a wide range of size classes, spanning firms with 1-49 employees to firms with more than 1,000 employees. In this way, a sample bias towards large firms which is present in many data sets

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[24]This is not a test of whether firms form rational expectations. Modesto (1989) has shown that such a test cannot be performed with aggregated business survey data: even if all firms are rational, the aggregated series can show autoregressive properties and thus fail rationality tests.

is avoided. The business survey is conducted on a monthly basis, which allows for an analysis at a much higher frequency than the usual data sets on small firms (mostly annual balance sheet data or quarterly financial reports). The downside of the data set is possible ambiguities, because the survey questions concern non-quantifiable items such as the general assessment of business conditions. It has been shown, however, that the series possess good leading indicator qualities and correlate closely with the business cycle components of industrial production. Therefore, the data quality can be considered as adequate for research on macroeconomic issues.

The empirical results strongly favour theories of asymmetric monetary policy effects. The business conditions of all firms deteriorate after a monetary tightening, but those of small firms do so much more. As a consequence, small firms are relatively worse off after interest rate increases; this shift in their relative position causes distributional effects of monetary policy in that the burden of adjustments is unevenly shared between firms of different size. It has furthermore been shown that these asymmetries are augmented in business cycle downturns. Compared to expansions, the distributional effects are more pronounced.

The paper has also tried to disentangle the monetary policy effects. A tightening of monetary policy is transmitted via several channels. Whereas small firms are affected disproportionately by the balance sheet and credit channel, large firms suffer more from the consequent exchange-rate appreciation. An analysis of demand-side factors has been performed in order to distinguish supply-side from demand-side effects. Demand seems to act as a discriminating device, too. However, even after accounting for differences in the responses of relative demand situations of small vs. large firms there is still a significant distributional effect of monetary policy in the data. Demand-side factors can thus tell only part of the story, with the bulk being left for supply-side factors. Even though it was not possible to test the importance of financial issues with the available data, this is the main criterion that comes to mind when thinking about uneven effects of interest rate changes. The empirical findings of this paper therefore strongly support theories which predict

asymmetric effects of monetary policy, and cannot reject theories that attribute such effects to financial factors.

Finally, some explorations of the expectations formation of firms have been performed. It is found that the importance of interest rates for business conditions is not always fully recognised, but firms which are more exposed to monetary policy shocks show a higher speed of adjustment in equilibrium corrections. On the other hand, the role of the exchange rate seems to be perceived properly by firms both in expectations formation and in the speed of adjustment.

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A   Appendix

A.1   Transformation of Business Survey Data for the Empirical Analysis

The transformation applied to the business survey data series is based on the assumption that the data follows a logistic model. Most of the time, it can be expected that the variables cluster around medium values in the range, say, $[-.5, .5]$. Only if the macroeconomic conditions become very (un-)favourable can it be expected that the series come close to their extreme values of ± 1. In order to make 100% of all firms answer that times are worse/better, the conditions must be very severe, especially because the data are not disaggregated according to industry. Indeed, the actual range of the series is far from hitting the borderline cases.

This means, however, that the trajectories of the business survey series follow the model

$$y_t = 2\frac{e^{x_t'\beta + \varepsilon_t}}{1 + e^{x_t'\beta + \varepsilon_t}} - 1, \tag{3}$$

where the x_t are the usual explanatory variables of a regression model. The multiplication by the factor 2 and the subtraction of 1 ensure that the data actually lie in the range $[-1, 1]$ (for $x_t'\beta + \varepsilon_t \to \infty$, $y_t \to 1$; for $x_t'\beta + \varepsilon_t \to -\infty$, $y_t \to -1$). Graphically, the model assumed for the business survey data looks as follows:
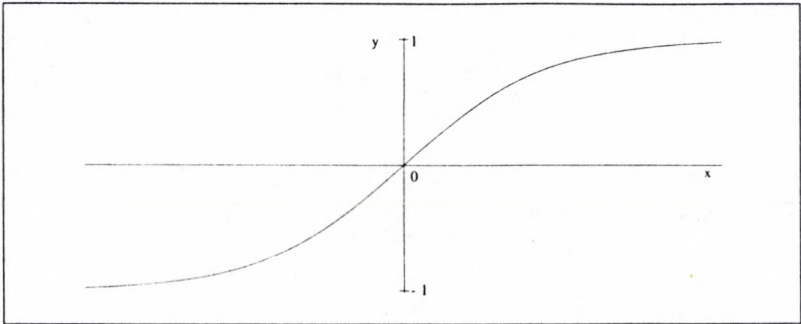
Let $a_t = e^{x_t'\beta + \varepsilon_t}$. Thus (3) simplifies to

$$y_t = \frac{2a_t}{1+a_t} - 1$$

$$y_t + y_t a_t = 2a_t - 1 - a_t$$

$$a_t(1 - y_t) = 1 + y_t$$

$$a_t = \frac{1+y_t}{1-y_t}$$

$$e^{x_t'\beta + \varepsilon_t} = \frac{1+y_t}{1-y_t}$$

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By applying the transformation $y_t^* = \ln\left(\frac{1+y_t}{1-y_t}\right)$ it is possible to estimate a linear regression model

$$y_t^* = x_t'\beta + \varepsilon_t \tag{4}$$

A.2 The KPSW-Approach to Identification in Structural Vector Autoregressions

Structural Vector Autoregressions (SVARs) go back to the seminal article by Sims (1980). They assume that the economy can be described by a dynamic, stochastic, linear model of the form:

$$A_0 X_t = A_1 X_{t-1} + \ldots + A_k X_{t-k} + \mu_t = A(L)X_{t-1} + \mu_t \tag{5}$$

with $\mu_t \sim iid \ N(0, \Sigma_\mu)$, where X_t represents an $n\mathrm{x}1$-vector of endogenous variables, including one or several instrument variables, and L denotes the lag operator. The estimation proceeds with the reduced form

$$X_t = C_1 X_{t-1} + \ldots + C_k X_{t-k} + \varepsilon_t = C(L)X_{t-1} + \varepsilon_t \tag{6}$$

with $C_i = A_0^{-1}A_i$ and $\varepsilon_t = A_0^{-1}\mu_t$. Estimates can be found for the coefficient matrices C_i and the variance-covariance matrix of the disturbances ε_t, Σ_ε. However, of interest are the parameters in the matrices A_i and Σ_μ, which are exactly identified if n^2 parameters are restricted. A first set of restrictions is found by the assumption of uncorrelated structural errors (i.e., Σ_μ diagonal) and by normalising the diagonal elements to unity, yielding $\Sigma_\mu = E(\mu_t\mu_t') = I_n$, which imposes $n(n+1)/2$ restrictions. Hence, further $n(n-1)/2$ restrictions are needed. Sims (1980) used a recursive structure to achieve identification, whereas subsequent contributions extended the range of identification schemes by restricting parameters in various matrices of the system. Amongst these are KPSW

(1991). They have shown that cointegration properties of the data can be used for identification purposes. A cointegrated VAR model, which is in its Vector Error Correction format (Johansen 1995: 45-49):

$$\Delta X_t = \alpha \beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t \qquad (7)$$

has the Granger representation

$$X_t = C \sum_{i=1}^{t} \varepsilon_i + C^*(L)\varepsilon_t + A \qquad (8)$$

where A depends on initial values, $\beta' A = 0$, and $C = \beta_\perp (\alpha'_\perp \Gamma \beta_\perp)^{-1} \alpha'_\perp$ with $\Gamma = I - \sum_{i=1}^{k-1} \Gamma_i$. Equation (8) shows that the representation in levels is composed of two parts, the non-stationary common trends $\alpha'_\perp \sum_{i=1}^{t} \varepsilon_i$ and the stationary part of $C^*(L)\varepsilon_t$.

The idea behind KPSW is to decompose the shocks ε into r shocks that have only transitory effects (on the levels of the variables), and $n-r$ shocks with permanent effects (with r denoting the number of cointegration relations). This is achieved by rotating the system by premultiplying certain matrices. The new set of variables Y is

$$Y_t = \begin{pmatrix} S X_t \\ \beta' X_t \end{pmatrix} \qquad (9)$$

The matrix S has to satisfy $SC \neq 0$. It follows that the new set of variables consists of $n-r$ non-stationary and r stationary variables. The stationary variables are identical to the cointegrating vectors; their stationarity follows because $\beta' C = 0$ and $\beta' A = 0$:

$$\beta' X_t = \beta' \beta_\perp (\alpha'_\perp \Gamma(1)\beta_\perp)^{-1} \alpha'_\perp \sum_{i=1}^{t} \varepsilon_i + \beta' C^*(L)\varepsilon_t + \beta' A = \beta' C^*(L)\varepsilon_t \quad (10)$$

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This system need not be identified fully; partial identification of either the transitory or the persistent shocks is also possible. This amounts to the imposition of $r(n-r)$ identification restrictions by setting the according covariances of the shocks to zero. These restrictions have been tested for by the test for the cointegrating rank. Instead, however, a different kind of identification restriction is needed, namely a decision in which part of the system the supposed shock is to be found (like in the context of the present paper, where the monetary policy shock is identified in the transitory subsystem). This restriction cannot be tested and has to be justified by economic theory.

To identify the subsystems, additional untested identification restrictions are necessary. If only the shocks with permanent effects are of interest, then $(n-r)(n-r-1)/2$ additional identification restrictions are needed. In particular, where there are $r = n - 1$ cointegration relations, no additional identification restrictions have to be imposed. Should the shocks of interest be the transitory ones, then $r(r-1)/2$ additional restrictions are sufficient.

A.3 Test Statistics

	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
bc1	-.69	-.66	-.52	-.26	.08	.42	.67	**.78**	.74	.60	.43	.27	.15
bc2	-.46	-.30	-.08	.20	.48	.70	.83	**.85**	.76	.61	.43	.24	.08
bc3	-.51	-.36	-.13	.15	.44	.68	.82	**.85**	.78	.64	.47	.30	.16
bc4	-.56	-.42	-.19	.10	.41	.67	.82	**.85**	.78	.64	.47	.30	.14
bc5	-.58	-.45	-.22	.08	.40	.67	.83	**.85**	.76	.61	.43	.26	.11
exp1	-.57	-.61	-.55	-.38	-.12	.17	.42	.59	**.65**	.60	.49	.36	.22
exp2	-.62	-.67	-.6	-.41	-.11	.22	.50	.67	**.70**	.62	.49	.35	.23
exp3	-.62	-.68	-.63	-.44	-.15	.19	.48	.67	**.71**	.64	.51	.37	.24
exp4	-.65	-.72	-.68	-.50	-.20	.16	.47	.66	**.71**	.64	.51	.35	.22
exp5	-.60	-.74	-.77	-.64	-.37	-.02	.32	.55	**.63**	.57	.44	.31	.19
clim1	-.56	-.48	-.32	-.07	.22	.50	.70	**.79**	.76	.65	.48	.31	.15
clim2	-.59	-.52	-.35	-.09	.22	.52	.73	**.82**	.78	.66	.50	.33	.19
clim3	-.62	-.56	-.39	-.13	.19	.49	.72	**.82**	.80	.68	.52	.35	.19
clim4	-.65	-.59	-.43	-.15	.18	.50	.73	**.83**	.79	.66	.49	.31	.16
clim5	-.69	-.66	-.52	-.26	.08	.42	.67	**.78**	.74	.60	.43	.27	.15

Table 3: Cross-correlations with industrial production, quarterly
bandpass-filtered variables

The numbers are correlations of the respective variables with industrial output. For lag k, the correlations are defined between $output_t$ and $variable_{t-k}$. A positive k indicates hence the lead of a variable with respect to the business cycle. The variables are: business conditions (bc) for firms of size class 1 to 5 (1=smallest, 5=largest), business expectations (exp) and the *ifo* business climate index (clim).

Model	ip_t	$bc_{1,t}$	$bc_{2,t}$	$bc_{3,t}$	$bc_{4,t}$	$bc_{5,t}$
$r = 0^a$	88.87	90.16	88.01	94.68	91.64	96.06
$r = 1^b$	48.53	49.25	46.29	48.66	46.86	54.50
$r = 2^c$	17.78*	21.17	20.19	22.92	21.13	25.37
$r = 3^d$	5.02*	4.27*	4.66*	4.60*	5.65*	4.75*

[a] critical values: 95%: 47.21; 99%: 53.91; [b] 95%: 29.38; 99%: 34.87; [c] 95%:
15.34; 99%: 19.69; [d] 95%: 3.84; 99%: 6.64

Table 4: Trace Statistics for the Test of Cointegration Rank of the baseline model: Dm_t, i_t, π_t and a business cycle variable

Model	ip_t	$bc_{1,t}$	$bc_{2,t}$	$bc_{3,t}$	$bc_{4,t}$	$bc_{5,t}$
$\chi^2(3)$	9.10	6.83	5.97	4.82	3.94	6.17
p-value	p.p3	0.08	0.11	0.19	0.27	0.10

Table 5: Test for three cointegrating vectors: ip_t or $bc_{i,t}$, real interest rates and superneutrality of money; baseline model: Dm_t, i_t, π_t and a business cycle variable

Model	$dem_{1,t}$	$dem_{2,t}$	$dem_{3,t}$	$dem_{4,t}$	$dem_{5,t}$
$r = 0^a$	82.84	83.55	89.81	87.04	81.69
$r = 1^b$	41.54	39.97	46.44	44.41	40.64
$r = 2^c$	20.34	20.32	19.68*	20.12	19.68*
$r = 3^d$	2.42**	3.06**	3.08**	3.81**	3.31**

[a] critical values: 95%: 47.21; 99%: 53.91; [b] 95%: 29.38; 99%: 34.87; [c] 95%: 15.34; 99%: 19.69; [d] 95%: 3.84; 99%: 6.64

Table 6: Trace Statistics for the Test of Cointegration Rank, baseline model with Dm_t, i_t, π_t and varying demand variables

Model	$dem_{1,t}$	$dem_{2,t}$	$dem_{3,t}$	$dem_{4,t}$	$dem_{5,t}$
$\chi^2(3)$	8.64	7.29	6.72	6.72	6.81
p-value	0.03	0.06	0.08	0.08	0.08

Table 7: Test for three cointegrating vectors: demand, real interest rates and superneutrality of money; model with Dm_t, i_t, π_t and varying demand variables

	Autocorrelation	ARCH	Markov chain
Equation 1	1.20 (0.31)	0.02 (0.89)	1.41 (0.23)
Equation 2	2.09 (0.08)	3.22 (0.07)	0.03 (1.00)
Equation 3	0.37 (0.83)	1.50 (0.22)	3.03 (0.02)*
System	1.03 (0.42)	1.32 (0.12)	2.01 (0.05)

Tests are for omitted autocorrelation, omitted ARCH and mis-specification of the Markovian dynamics. Numbers in brackets are p-values.

Table 8: Mis-specification tests for the MS-VAR model on business conditions: $bc_{2,t}, bc_{5,t}, r_t$

	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Size Class 5
$\chi^2(2)$	6.04 (0.05)	4.95 (0.08)	6.19 (0.05)	3.12 (0.21)	4.32 (0.12)

Table 9: Joint test for significance of money growth and inflation in the expectation formation

	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Size Class 5
t-adf	-4.65**	-4.09**	-3.28*	-3.55**	-3.11*

t-statistics from an augmented Dickey-Fuller test; Critical Values: 5%=-2.877 1%=-3.467

Table 10: Cointegration analysis for the expectation-equations

	Autoregression	ARCH	Normality	χ^2
Size Class 1	0.49 (0.84)	1.35 (0.23)	3.87 (0.14)	1.12 (0.30)
Size Class 2	0.99 (0.44)	1.88 (0.08)	0.33 (0.85)	1.07 (0.38)
Size Class 3	0.65 (0.72)	0.92 (0.49)	1.07 (0.58)	0.94 (0.59)
Size Class 4	0.65 (0.71)	1.06 (0.39)	0.18 (0.91)	0.95 (0.57)
Size Class 5	0.98 (0.45)	0.82 (0.57)	0.35 (0.84)	1.14 (0.28)

Tests are for residual serial correlation, residual ARCH, non-normality and heteroscedasticity. Numbers in brackets are p-values.

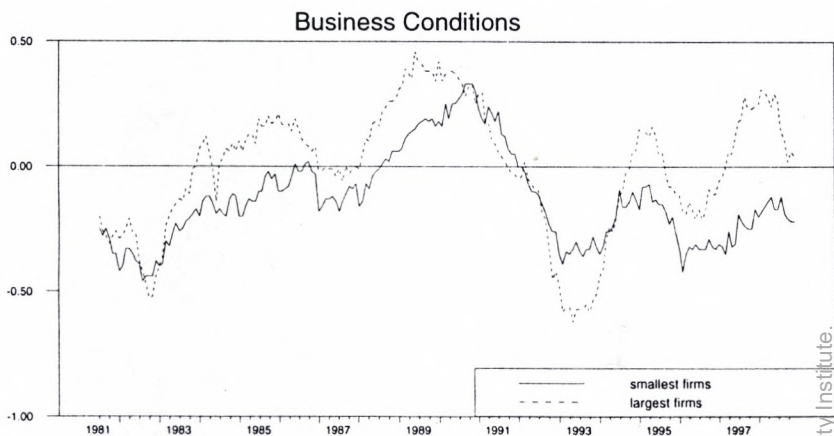Table 11: Mis-specification tests for the expectation equations

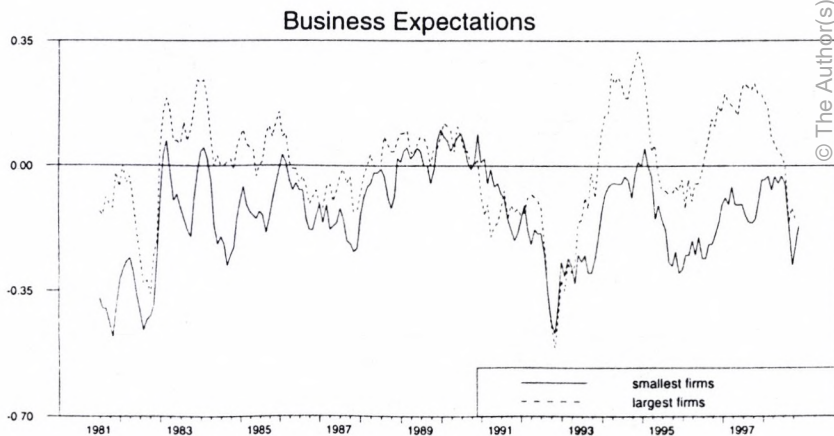Figure 1: Business conditions of firms of size class 1 (smallest) and 5 (largest)

Figure 2: Business expectations of firms of size class 1 (smallest) and 5 (largest)
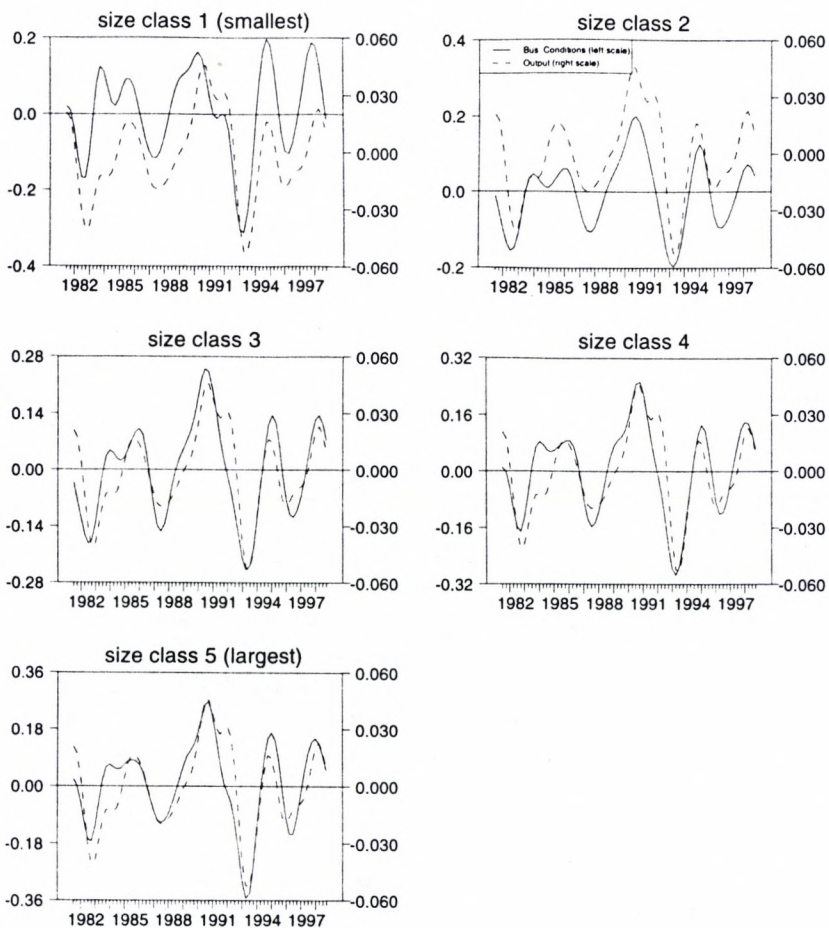
Business Conditions

Figure 3: Business conditions and industrial production, bandpass filtered quarterly series
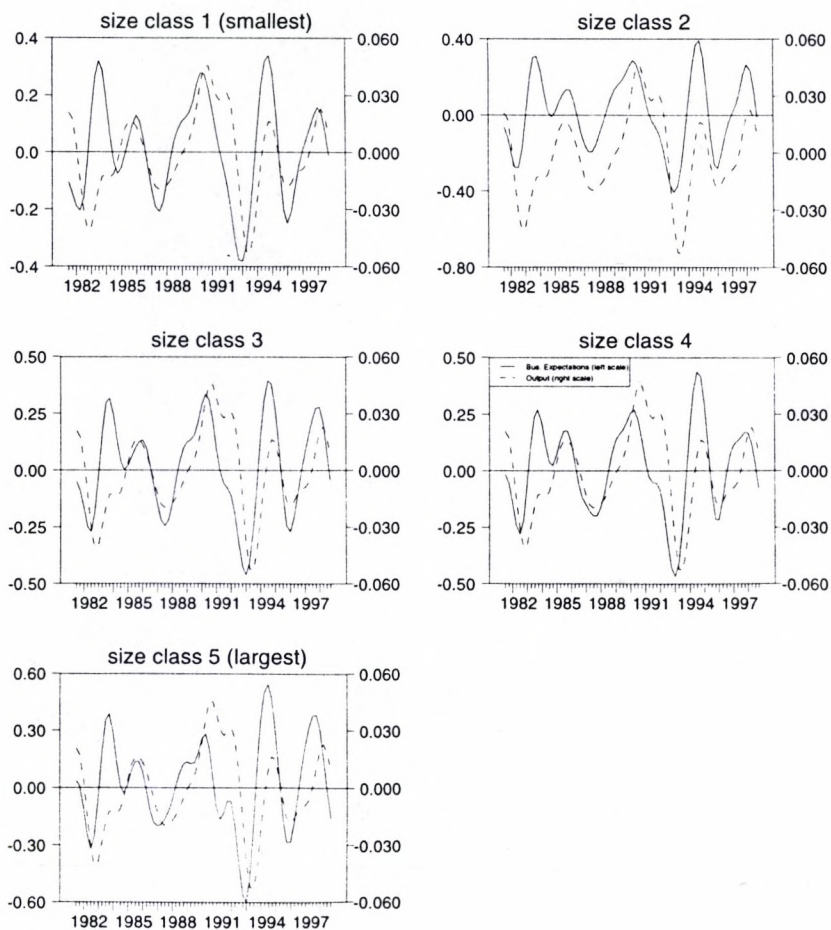
Business Expectations

Figure 4: Business expectations and industrial production, band-pass filtered quarterly series
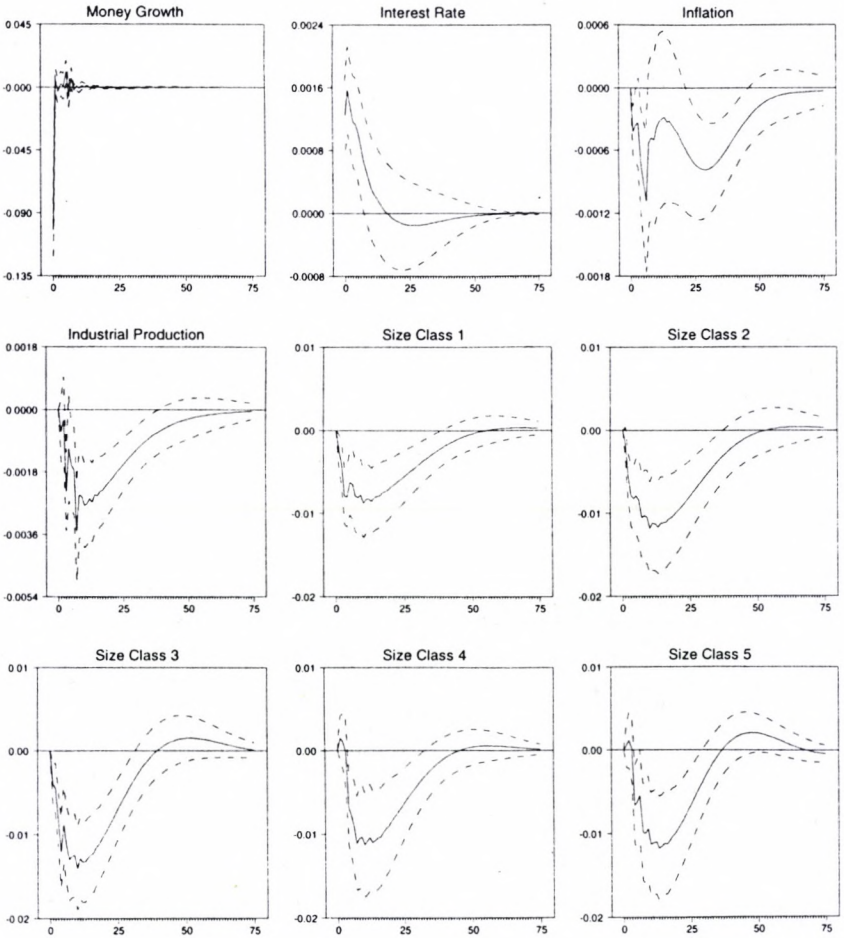
Effect of a Monetary Policy Shock

Figure 5: Responses to a monetary policy shock, baseline model

Response of Relative Business Conditions to a Contractionary Monetary Policy Shock
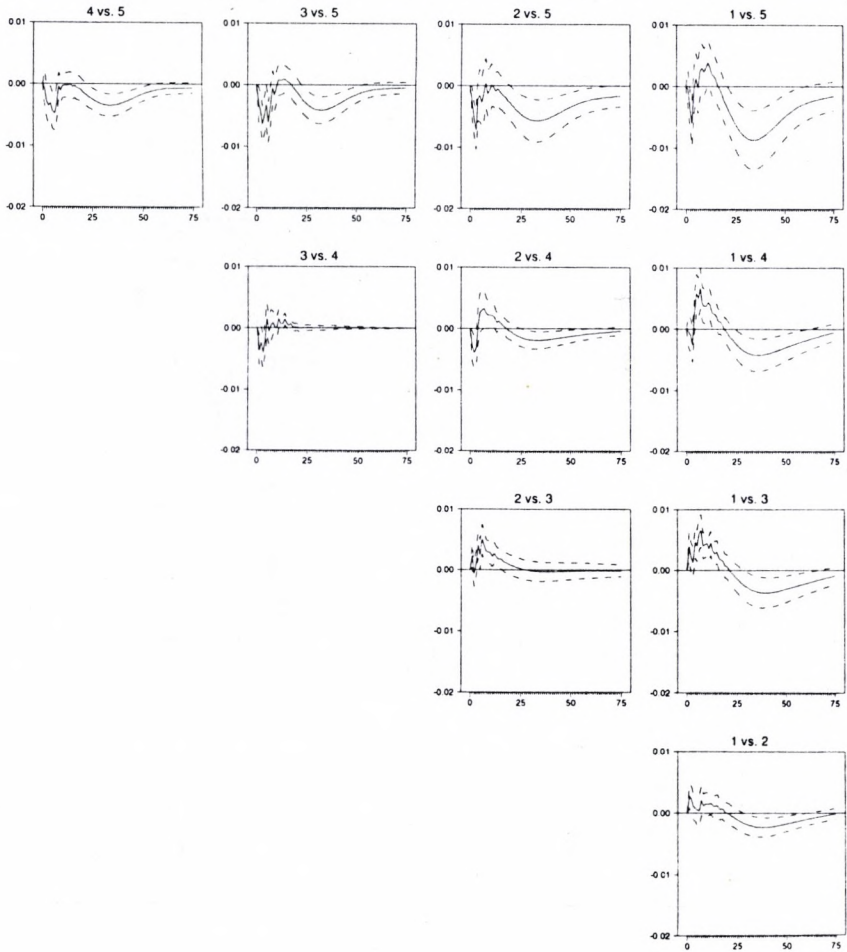
Figure 6: Responses of the relative business conditions of firms $(\Delta_{ij,t})$ to a contractionary monetary policy shock

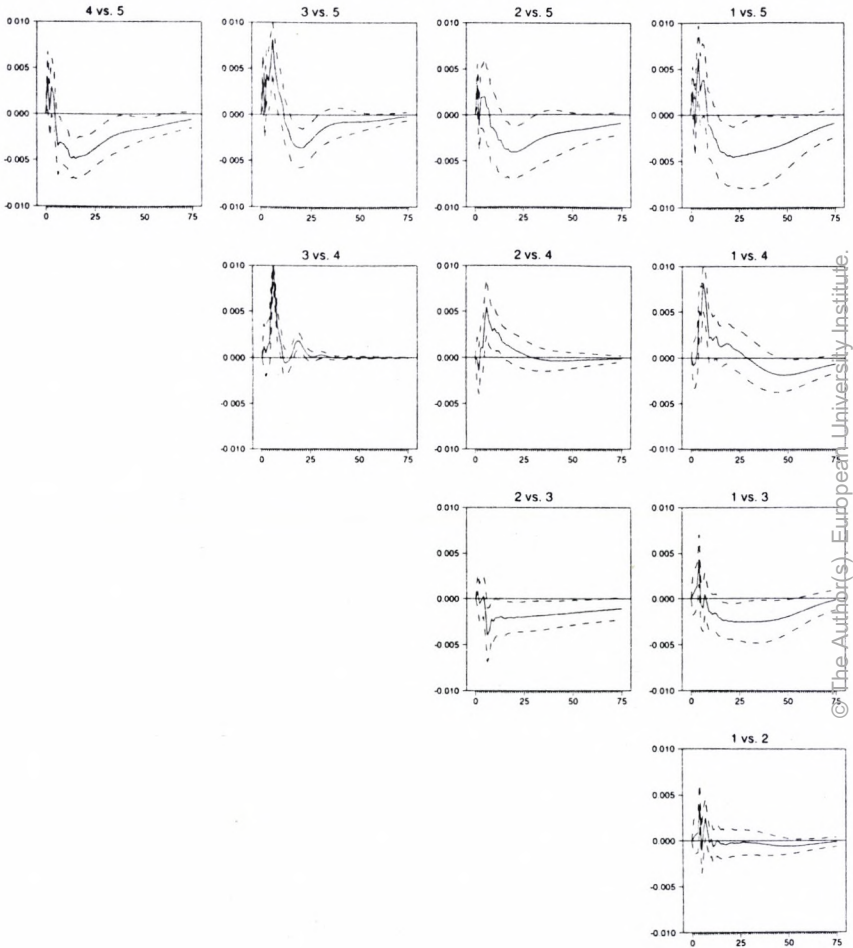Response of Relative Business Conditions to an Exchange Rate Shock (Depreciation)

Figure 7: Responses of the relative business conditions of firms $(\Delta_{ij,t})$ to an exchange rate shock (depreciation)

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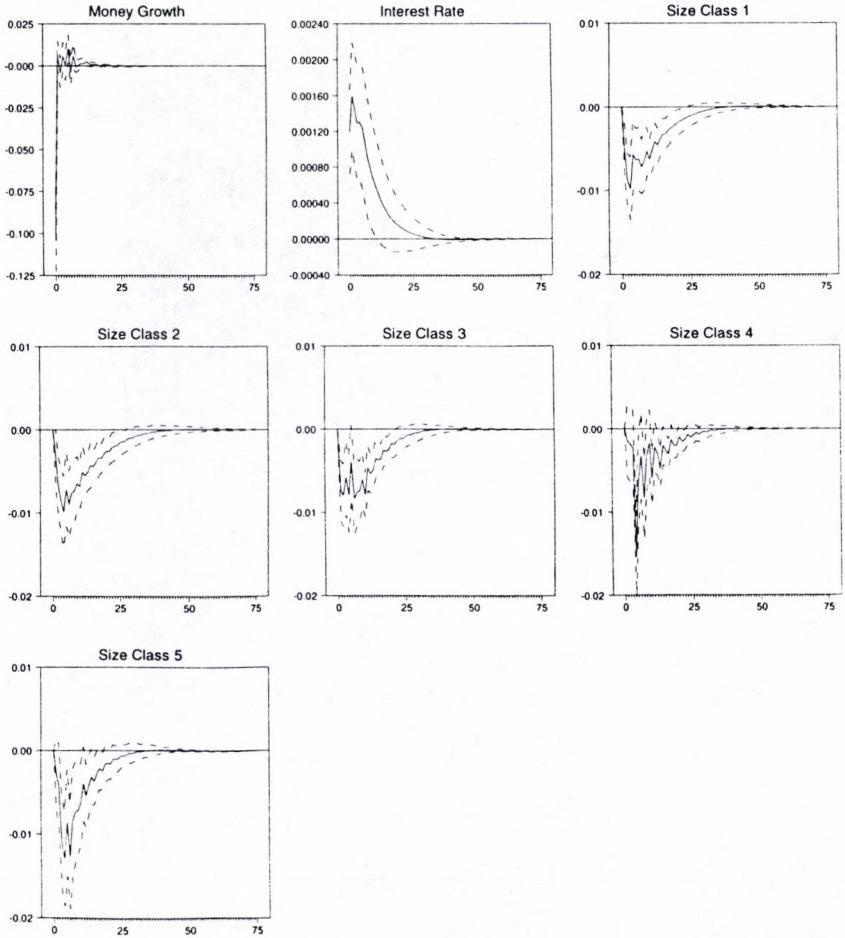Effect of a Monetary Policy Shock on Demand

Figure 8: Responses of demand to a monetary policy shock

Response of Relative Demand Positions to a Contractionary Monetary Policy Shock
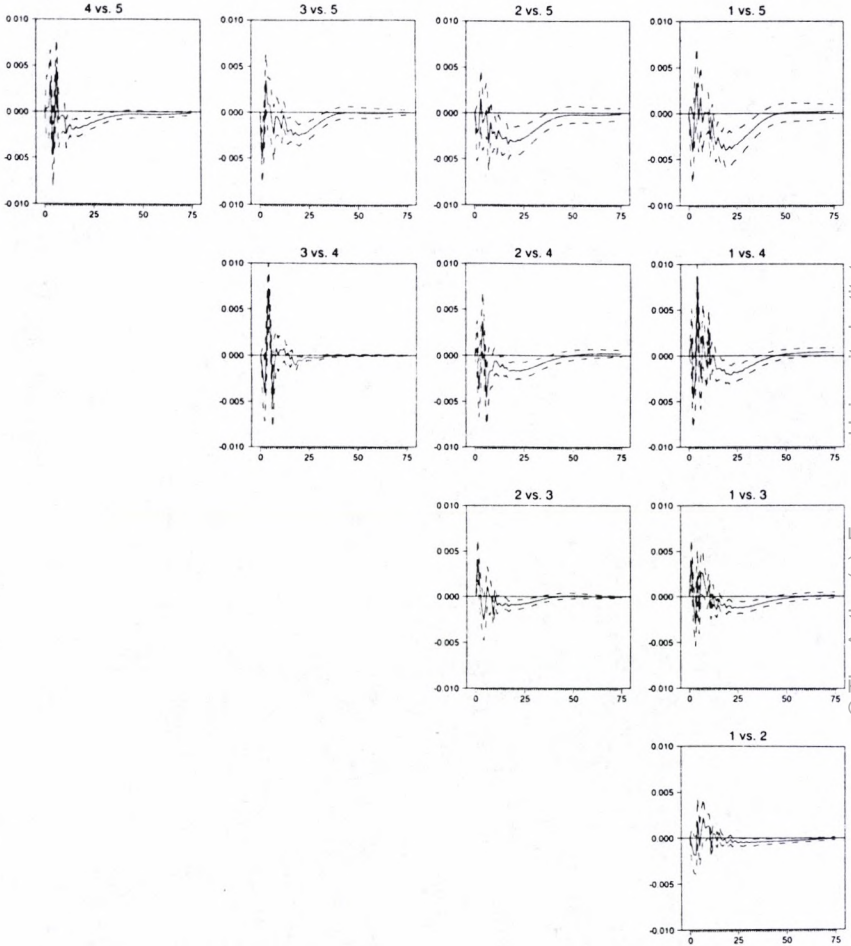

Figure 9: Responses of the relative demand positions of firms $(\Delta_{ij,Dt})$ to a contractionary monetary policy shock

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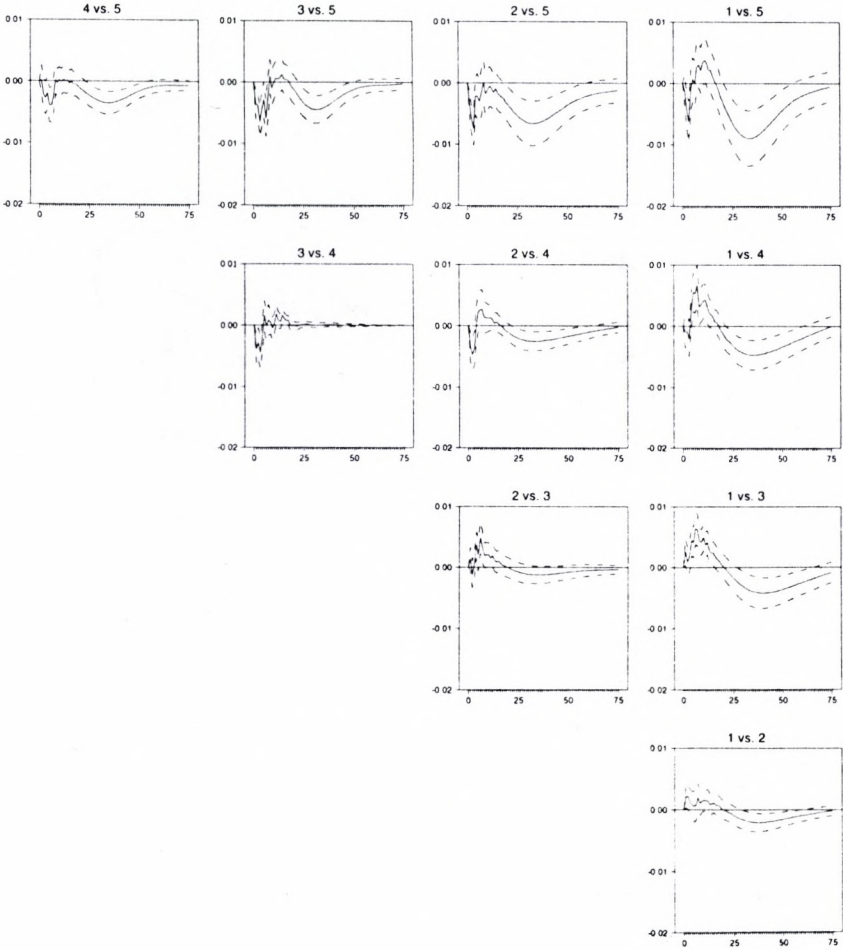Response of Relative Business Conditions to a Contractionary Monetary Policy Shock

Figure 10: Responses of the relative business conditions of firms $(\Delta_{ij,t})$ to a contractionary monetary policy shock in a model with demand
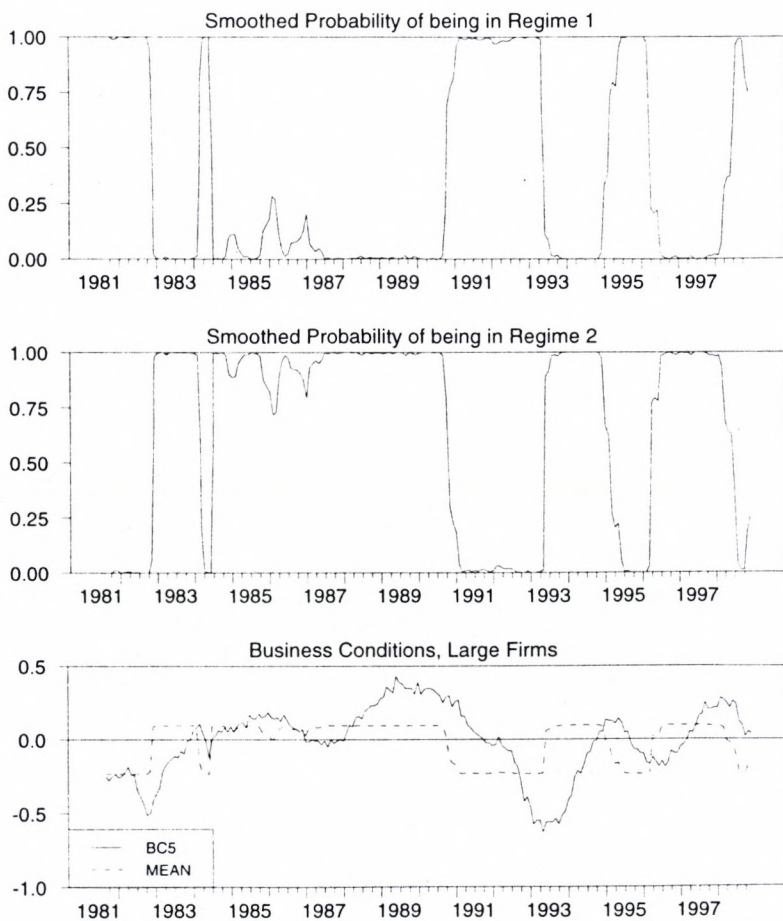
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Estimated Regimes

Figure 11: Regime probabilities for the Markov-switching VAR with business conditions

Business Conditions, State-Dependent Responses to a Monetary Policy Shock

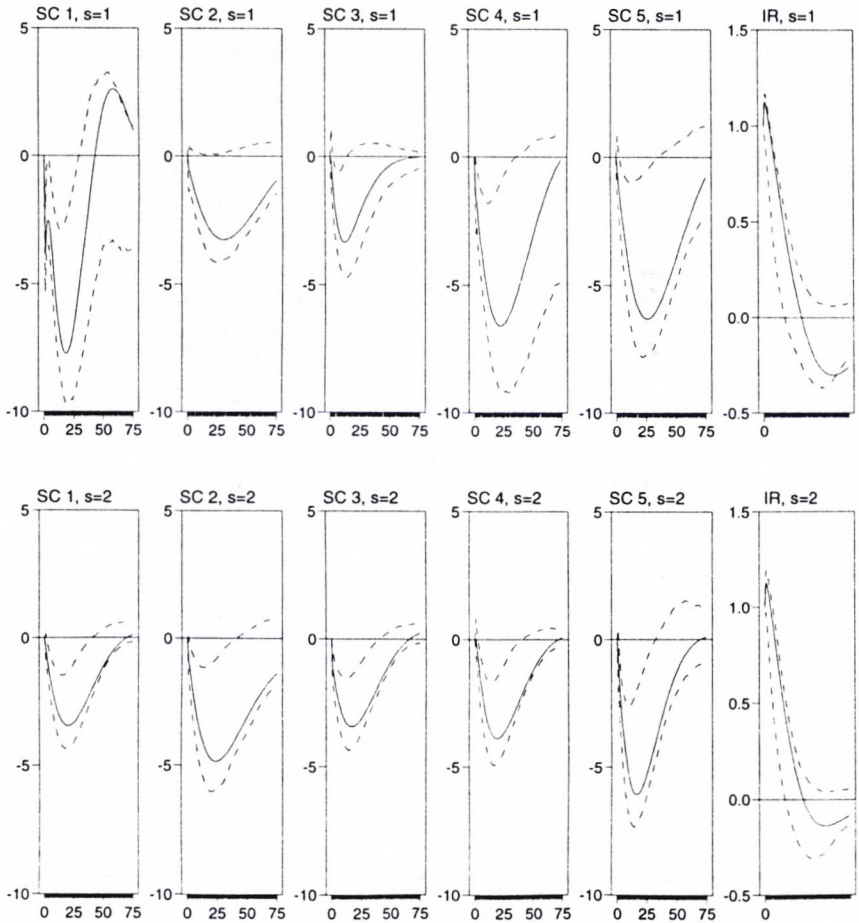Figure 12: State-dependent responses to a monetary policy shock

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