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Risk-taking and monetary policy before the crisis: The case of Germany

Iris Biefang-Frisancho Mariscal

Department of Accounting, Economics and Finance, University of the West of England, Bristol, UK

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Risk-taking and monetary policy before the crisis: The case of Germany

Iris Biefang-Frisancho Mariscal

Centre for Global Finance, Bristol Business School, University of the West of England

Abstract

We use impulse response functions to test for the effect of monetary policy on investors' risk aversion in Germany. The latter is proxied by a variety of option based implied volatility indices. We estimate twenty-four models and find in all models that risk aversion responds to monetary policy. Furthermore, the business cycle varies mostly through changes in risk aversion and there is feedback from the business cycle to risk aversion, in that a fall in the price of risk has a positive effect on the business cycle. These responses indicate that accommodating monetary policy before the crisis may have increased risk appetite, which in turn has strengthened the business cycle with the latter feeding back into a further reduction in the price of risk.

1. Introduction

The focus of this paper is to test whether changes in the monetary policy stance affect the price of risk in German markets. In recent years, researchers have debated whether monetary policy affects risk-taking. Borio and Zhu (2008) and Rajan (2005), emphasise that excessively low policy rates stimulate economic activity, encourage credit demand and reduce investors' perception of risk.[1] Bruno and Shin (2012) developed a model of the risk-taking channel of monetary policy which shows that banks increase loans for a given Value-at-Risk the lower the policy rate is. To our knowledge, the only papers that are concerned with the relationship between monetary policy and *market* risk taking are by Amato (2005) and Bekaert *et al* (2010). The former finds suggestive evidence that the monetary policy stance has an impact on the

I am grateful to Peter Howells for helpful discussions and comments.

[1] Recent empirical work on the effect of the monetary policy stance and the riskiness of lending by banks (as opposed to markets) are by Jimenez et al (2009), Ioannidou et al (2009), Alturibas et al (2010), Adrian and Shin, 2008, 2011).

pricing of credit risk as measured by credit default swap spreads, while the latter find strong co-movement between the VIX and the monetary policy stance, with lax monetary policy decreasing risk aversion in the medium run. Furthermore, there is a literature that relates monetary policy to financial markets. Changes in monetary policy shift the yield curve and alter the prices of equity (Rigobon and Sack, 2003). Bernanke and Kuttner (2003) find that variations in monetary policy do not only affect stock market prices, but they do so mostly through perceived riskiness of the stock and to a lesser extent through expected dividend payments or the risk-free rate.

There are various empirical problems associated with testing the relationship between the monetary policy stance and the price of risk. Investors' risk attitude is fundamentally unobservable and we rely on proxies for which data are available and which we think capture best the price of risk. There is disagreement on how to measure risk aversion (for a survey see Coudet and Gex, 2008 and Illing and Meyer, 2005)[2]. We follow Popescu and Smets (2010) and construct a group of indices to capture variations in risk aversion. These include implied volatilities from the money, bond and stock markets as well as spreads from the fixed income market (corporate and government bonds). The intuition for choosing the index option markets is that they are predominantly used by hedgers who are concerned about potential movements in the underlying asset so that volatility indices reflect the price of portfolio insurance (Whaley, 2008). However, volatility indices do not uniquely measure the market price of risk. For instance, equity options indices have been interpreted as a measure for uncertainty, notably in the US (Bloom, 2009) or, they have been decomposed into a component that reflects stock market volatility, a variance premium that exhibits risk aversion and other non-linear pricing effects

[2] More recently, Bollerselev et al (2012) relate the volatility risk premium to investors' risk aversion by combining model-free realized with model-free implied volatilities.

(Carr and Wu, 2009). Bekaert et al (2009) show that in general risk premia are due to variations in the perceived uncertainty of the returns of the asset and to changes in investors' risk attitude.[3]

Individually, the implied volatility indices and spread measures do not only reflect risk attitude or macroeconomic uncertainty, but additionally remuneration for asset specific risk, such as for instance credit risk in the case of bond spreads. In order to separate the risk aversion element, a combination of the instruments should measure their common variation and thus eliminate these idiosyncratic factors. Finally, the inclusion of a measure of macroeconomic uncertainty in the empirical model should filter out its effect on asset prices.

We use a simple VAR which is particularly effective in capturing the endogenous nature of risk aversion, macroeconomic uncertainty, the business cycle and monetary policy and to trace out the relationships of the variables over time. We focus on the link between monetary policy and risk aversion and the feedback relationships between the business cycle and risk aversion. Furthermore, we trace the effect of uncertainty, risk aversion and the business cycle on monetary policy.

Our main findings are as follows. In contrast to the conventional view of the monetary policy transmission mechanism, we find strong empirical evidence of a risk-taking channel in *financial markets*: A tightening of monetary policy increases the price of risk in the medium term. The rise in risk aversion may be due to agents' expectations of lower future income and wealth and an increase probability of unemployment as in Campbell and Cochrane (1999). The implication is that the rise in risk aversion may affect the *real* economy for a protracted period of time through, for instance, precautionary savings (as in De Paoli and Zabczyk, 2011). Our results support this

[3] Asset pricing models distinguish between the price of risk and the quantity of risk. The quantity of risk is captured here by economic uncertainty and the price of risk is frequently denoted as risk aversion or risk tolerance.

linkage: The business cycle responds to shocks in risk aversion over up to 20 months. Furthermore, we find a self-enforcing loop as suggested by Rajan (2005) in that there are also feedback effects from the business cycle to risk aversion. The effect lasts up to 6 months. Changes in monetary policy do not directly affect the business cycle, but they operate via their influence on risk aversion. Thus, monetary policy seems to be most effective through changes in investors' risk aversion which in turn affects the business cycle. Results are largely unaffected by changes in the control variables, different measures of monetary policy stance and risk aversion, and changed sample periods.

The paper adds to the literature that is directly concerned with the risk-taking channel of monetary policy (Rajan, 2005; Borio and Zhu, 2008; Bekaert et al (2010); Bruno and Shin, 2012). This paper extends the evidence to a major player in the Eurozone and thus explores the generality of the US results. Furthermore, there is the interesting point that the German financial system differs in a number of aspects from that of the US – being more 'bank-based' and more 'conservative'. Additionally, most of the other literature investigating the risk-taking channel of monetary policy transmission is concerned with risk-taking by banks. This paper examines the effect of monetary policy on markets.

The paper is organised as follows. Our results are couched in the form of impulse responses and are presented in Section 2. The section focuses on the relationship between risk aversion and monetary policy as well as the response of risk aversion to shocks to the business cycle and macroeconomic uncertainty. Furthermore, we trace the effect of monetary policy to the business cycle, uncertainty and their feedback effects on monetary policy. We present the results of a great number of impulse responses from VARs with differing risk aversion indices, business cycle proxies and monetary policy variables, over different sample periods, which should provide some robustness of our results. Finally, Section 3 concludes.

2. Methodology and Result Analysis

The purpose of the paper is to disentangle the dynamic relationship between monetary policy and the price of risk. Measuring the monetary policy stance, risk aversion and measuring policy shocks correctly, is difficult. We therefore estimate VARs with alternative measures and over different periods.

The VAR is particularly effective when to analyse the dynamic relationships between variables. We apply a simple structural VAR (SVAR) which we use to analyse the effects of shocks in the given variables. Generally, the first order structural VAR is defined by:

$$Bx_t = \Gamma_0 + \Gamma_1 x_{t-1} + \varepsilon_t \qquad (1)$$

which is transformed into the estimated VAR by multiplying (1) with B^{-1} to obtain:

$$x_t = A_0 + A_1 x_{t-1} + e_t \qquad (2)$$

where $A_0 = B^{-1}\Gamma_0, A_1 = B^{-1}\Gamma_1 \, and \, e_t = B^{-1}\varepsilon_t$ and where B is a 4x4 full rank matrix.

To identify the structural model from the estimated VAR (equation 2), it is necessary to impose $(n^2 - n)/2$ restrictions on the parameter matrix. The restrictions are obtained by imposing a 'timing scheme' on the shocks. For this identification scheme, it is assumed that the shocks affect a subset of variables contemporaneously whereas another subset of variables is affected with a time lag. This identification scheme is the triangular or recursive identification that was suggested by Sims (1980).

Our model comprises four variables, namely a measure of the business cycle, an indicator of the monetary policy stance, a risk aversion index and a measure of macroeconomic uncertainty for Germany from July 1997 to July 2007 and from September 2000 to July 2007.[4] With four variables, six restrictions need to be imposed to just identify the VAR. Using this simple recursive identification structure, the variables are ordered as follows: business cycle first, then monetary policy stance, uncertainty and risk aversion. The ordering of the business cycle variable and the monetary policy rate are standard. The uncertainty variable is ordered third, so that expectations of the macro-economy and the monetary policy stance are incorporated. Last is the risk aversion variable, because it is assumed that it incorporates contemporaneously macroeconomic information and expectations about the economy (Popescu and Smets, 2010, Bekaert et al, 2010). The six exclusion restrictions on the contemporaneous parameter matrix B are:

$$B = \begin{bmatrix} b_{11} & 0 & 0 & 0 \\ b_{21} & b_{22} & 0 & 0 \\ b_{31} & b_{32} & b_{33} & 0 \\ b_{41} & b_{42} & b_{43} & b_{44} \end{bmatrix}$$

[4] The sample period is determined by data availability of the components of the price of risk. The sample period of VARs that include VDAX, PC3 and AVRA3 are estimated over the longer period, VARs that include AVRAVOL, PCVOL, ARAALL and PCALL are estimations of the shorter period. For more detail, see the data appendix.

We use six measures of risk aversion:

i) A simple average of the (standardised) volatility indices of the equity, money and bond markets, namely the VDAX, the Eurodollar futures, the BOBL and the Schatz implied volatility index. We refer to this average as ARAVOL.

ii) The principal component of the (standardised) implied volatility indices (PCVOL).

iii) The simple average of the (standardised) VDAX, the mortgage and the corporate bond spread (AVRA3).

iv) The principal component of the (standardised) VDAX, the mortgage and the corporate bond spread (PC3).

v) The simple average of all (standardised) implied volatility indices and (standardised) spreads (AVRAALL).

vi) The principal component of all (standardised) implied volatility indices and (standardised) spreads (PCALL).

Additionally, we use two different measures of business cycle fluctuations: MAUNEMP is the unemployment rate minus a 3-year moving average and Sales_cycle is the deviation of sales from trend.[5] The monetary policy stance is proxied by the real interest rate (RIR) and the deviation from the Taylor rule (DEVIATION).[6] The constructed measure of aggregate uncertainty is based on expectations of the macroeconomic outlook of 350 financial market analysts based on the ZEW (Zentrum fuer Eurpaeische Wirtschaftsforschung, Germany) Financial Market Survey. We have proportions of answers to whether agents think that in the

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[5] We used a Hodrick-Prescott filter with a power value of 4 as suggested by Ravn and Uhlig (2002).

[6] For the calculation see the data appendix.

medium term the overall macroeconomic situation will i) improve, ii) no change, iii) worsen. To quantify the qualitative data, we use the Carlson and Parkin (1975) approach as in Bekaert et al (2009). All variables are described in Table 1 in the Appendix.

2.1 Descriptive and reduced form statistics

Before we turn to the analysis of the impulse response (IR) functions, Figure 1 in Appendix 2 shows the cross correlation between the average risk aversion index (AVRAALL) and the real interest rate (RIR).[7],[8] In both cases, there are feedback effects between the risk aversion (RA) indices and the proxy for the monetary policy stance. The correlation between the lags of the policy variables and the risk aversion measures are positive and significant throughout until the 35th and 33rd period, respectively. The feedback from risk aversion to the policy rate is smaller and switches from positive to negative. It is significantly negative between periods 12 to 36 and 26 to 36, respectively.

We estimated a great number of VARs which confirm the robustness of our results. Their impulse responses (IRs) are tabulated in Appendix 3. In the following sub-sections, we present the results of two VARs in greater detail. The first VAR (VAR1) uses the comprehensive risk aversion measure covering equity, bond and money markets (AVRAALL), the real interest rate (RIR), cyclical unemployment (MAUNEMP) and SIGMA as a measure of macroeconomic uncertainty. The second VAR (VAR2) is estimated over the longer period and employs AVRA3, the average of the VDAX and the bond market indices as the risk aversion measure, the Taylor rule deviation (DEVIATION), the cyclicality of sales (Sales_cycle) and again, SIGMA.

[7] The estimation periods for AVRA3 and AVRAALL are from July 1997 to July 2007 and from September 2000 to July 2007, respectively.

[8] Due to limitations of space, we only report the Tables and Figures of the descriptive statistics and the impulse responses for VAR1. The results for VAR2 can be obtained from the author upon request.

The lag length of the VARs is determined by the information criteria Akaike, Schwarz-Bayesian and Hannan-Quinn. All three criteria suggest a lag length of one for VAR1 and the Akaike and Hannan-Quinn criteria determine a lag length of two for VAR2. The probability level of the Lagrange multiplier test for serial correlation up to order 6 (12) for VAR1 is 0.59 (0.13), and for VAR2 is 0.55 (0.05). White's heteroscedasticity tests (no cross terms and with cross terms) have a probability level of 0.57 and 0.78 for VAR1, respectively. For VAR2, the probability levels for White's tests are 0.56 and 0.28, respectively.

Summarising the results of the Granger-causality tests (Table 1) for VAR1, we find that in both models, the monetary policy stance and macroeconomic uncertainty Granger cause risk aversion. The strongest effect on risk aversion is in both models attributed to the monetary policy variable. The fact that uncertainty only causes risk aversion and none of the other variables, may reflect that the risk aversion proxies we use do not only measure the price of risk, but also macroeconomic uncertainty. As the impulse responses below show, the effect of uncertainty on the risk aversion proxies is rather weak, underlying the result by Bekeart et al (2009) that the dominant determinant of volatility indices is risk aversion. Furthermore, none of the variables in VAR1 and VAR2 Granger causes SIGMA, indicating that macroeconomic uncertainty is exogenous in both models. In turn, there are mixed results on the causation of the price of risk on the monetary policy stance, indicating possible feedback of the central bank in response to changes in risk aversion. Furthermore, monetary policy Granger causes the business cycle in VAR2, but not in VAR1. While the direct effect of the monetary policy proxy on the business cycle is mixed, there is throughout an indirect effect from monetary policy to risk aversion and from risk aversion to the business cycle.

2.2 Response of RA to policy stance, business cycle and macroeconomic uncertainty

Our main results are presented as impulse response functions, estimated in the usual way (see Figure 4). We use the Cholesky decomposition with an adjustment for degrees of freedom. The ordering of the variables is [business cycle, policy rate, uncertainty, RA], as explained above. The standard errors are calculated analytically and a 90% confidence is chosen.

Turning to the IR for VAR1 first, a positive one standard deviation shock to the real interest rate increases the RA index (AVRAALL) significantly from the third month onward over a 10-month period (see Table 3 M9 and the IRs in Figure 4). The highest response occurs after half a year with a rise of the index by 0.12. A one standard deviation shock to the uncertainty index has a small significant effect over two months, while a negative shock to the business cycle increases RA significantly for about half a year. Turning to VAR2 (see Table 6 M8 and Figure 4), here, too, shocks to monetary policy, the business cycle and to macroeconomic uncertainty significantly affect RA. Shocks to the Taylor rule deviation have a significant effect for about eighteen months. The response is highest in month 5 with a value of 0.11. Shocks to the business cycle and to uncertainty again are short-lived. A positive shock to sales reduces AVRA3 significantly in the first two months. There is weak significance on that a rise in macroeconomic uncertainty increases risk aversion over four months.

The variance decomposition (Tables 8 and 13) shows the proportion of the error forecast variance explained by the respective shocks. The highest contribution of the explanation of the forecast error variance of the RA indices comes from the monetary policy variable. Between 22% (VAR2) and 26% (VAR1) of the 12-month-ahead forecast error of the RA index is explained by the monetary policy variable. SIGMA explains about 7% (11% in VAR1) and the business cycle variable between 5% and 8% in VAR2 and VAR1, respectively.

Turning to the results of the IRs of all the other risk aversion proxies (Tables 3 and 8), the responses of all RA measures in combination with different measures of monetary policy and business cycle, and different sample periods, show the overwhelming result that positive shocks to the monetary policy variable raises RA significantly. Out of the twenty-four models that were estimated, twenty-two models showed a significant rise in RA in response to a positive shock in the monetary policy proxy. The period over which the responses were significant varied, but they were mostly significant for over half a year, up to one and a half years. There are some significant effects from shocks to uncertainty on RA, but the results are mixed. In about forty per cent of the models, RA does not respond to shocks in macroeconomic uncertainty. In the remaining models, RA rises and this effect is significant for between two and seven months. Additionally, a deterioration of the business cycle increases the price of risk significantly in over sixty per cent of the models. The effect is significant between one to seven months.

2.3 Response of business cycle, policy stance, and macroeconomic uncertainty

There is a feedback effect between the business cycle and the RA indices AVRAALL and AVRA3. Most of the response of the business cycle comes from shocks to the RA indices and not directly from monetary policy shocks (similar results for the equity market were found by Bernanke and Kuttner, 2003). A positive shock to the RA index increases cyclical unemployment and reduces cyclical sales. In both cases, the responses are significant for 15 months. The maximum response is a rise in unemployment above the trend by 0.09 percentage points after about one and a half years. In relation to VAR2, the maximum decline in sales cycle is 0.33 which, compared with the peak in the sales cycle is decline of about 4.8 per cent. A tightening of monetary policy has a statistically weak effect on cyclical unemployment from after about a year until the 19th month. There is no significant effect from tightening of monetary policy on cyclical sales. Also, uncertainty does not have a discernible effect on the business cycle. Even though there is no significant stable response of the business cycle to shocks in monetary policy, there is a response of monetary policy to the business cycle. The rise in unemployment reduces the real interest rate for 20 months, while monetary authority responds to an increase in the sales cycle with a tightening of policy for about 13 months. A rise in uncertainty does not affect monetary policy. There is no significant response on RIR from RA, but a short-run effect from the Taylor rule deviation to AVRA3.

Turning to the results of the variance decompositions (Tables 7 and 12), RA contributes between 12 and 14 per cent of the variation in the business cycle at a forecast horizon of one year, while monetary policy only contributes between 2 per cent and per cent. Also, macroeconomic uncertainty has a negligible contribution to the variance of the forecast error. Strikingly, the highest contribution of the variance decomposition of the policy rate comes from the business cycle at all forecast horizons, indicating that the ECB responds to macroeconomic imbalances.

Turning to the results of the IRs of the business cycle, monetary policy and uncertainty of the remaining models, we find for all models that the business cycle responds to shocks in all RA proxies (Tables 4 and 9) significantly over the medium to long-term (between sixteen and twenty months). We also find in all models significant long-term monetary policy responses to shocks to the business cycle (see Tables 5, 6, 10, 11), while shocks to any of the other variables are mostly insignificant. On the other hand, there is no evidence that shocks to monetary policy directly and significantly affect the business cycle (Tables 4 and 9). The results indicate that the business cycle mainly responds to shocks in RA and monetary policy responds to shocks in the business cycle. The latter does not respond to changes in risk aversion or variations in macroeconomic uncertainty. There is some mixed evidence that the proxies for RA also contain some measure of macroeconomic uncertainty. Macroeconomic uncertainty appears to be exogenous in all models.[9]

3. Conclusion

The empirical results clearly suggest that there is procyclical responsiveness between monetary policy and risk aversion. Contractionary monetary policy, measured by increases in the real policy rate and the Taylor rule deviation, triggers a rise in investors' risk aversion. The results throughout confirm a risk-taking channel of the monetary policy transmission mechanism in Germany, implying that interest rate policy as conducted by the ECB goes beyond the management of interest rate expectations and seems to be an important variable in its own right through its effect on risk aversion.

Furthermore, a decline in risk aversion has a strong positive effect on the business cycle over a protracted period (up to 20 months) so that accommodating monetary policy reduces the price of risk, which in turn stimulates the economy. There is additionally a medium-term feedback effect from a strengthening of the business cycle to a fall in risk aversion. These results indicate the presence of a self-enforcing loop as has been suggested by Rajan (2005), where lax monetary policy increases risk tolerance which in turn stimulates economic activity and increases asset prices and reduces risk aversion even further. Also note that monetary policy seems to operate mostly through its effect on risk aversion and does not directly affect the business cycle. The

[9] Therefore, no tables for responses of SIGMA are reported.

implication for the pre-crisis period is that monetary policy may have been too lax and triggered a reduction in the price of risk in the short-term (6-9 months).

The result may have policy implications for the present. On the one hand, central banks have been concerned about the rise in risk aversion since the financial crisis and policies have been implemented to reduce risk premia. For instance, the ECB effectively substituted assets that differed in terms of liquidity and credit risk and thus transferred banks' risk to its own balance sheet, reducing the price of risk and accommodating financial conditions. Also, as De Paoli and Zabczyk (2011) suggest, since cyclical swings in risk appetite affect UK households' propensity to save, an accommodative policy bias in the face of persistent adverse disturbances may be justified. Similarly, Haldane (2011) has suggested that new policy approaches may be needed to stimulate risk taking. On the other hand, as argued by Durre and Pill (2010), even though the ECB's ability to absorb credit risk is substantial, it is not infinite and concerns about the strength of the ECB's balance sheet may emerge in the medium term. More recently, policy makers express concern about the excessive risk-taking effect on households and banks triggered by accommodating monetary policy.[10]

[10] "…, an overly accommodative monetary policy stance, supported by both standard and non-standard policy measures, could fuel excessive risk-taking by banks and households ..." ECB (2010, p. 71)

Appendix 1 (Data)

Germany			
VDAX-new Volatility Index	VDAXNEW(PI)	LVDAX	Ln (VDAX)
US DOLLAR/EURO Future Continuous Call-Implied Vol.	DEXC.SERIESC	MUS/EURO	(US DOLLAR/EURO)
EURO-SCHATZ Future Continuous Call-Implied Vol.	GEBC.SERIESC	MSCHATZ	(EURO-SCHATZ)/
EURO-BUND Future Continuous Call-Implied Vol.	GGEC.SERIESC	MBUND	(EURO-BUND)
EURO-BOBL Future Continuous Call-Implied Vol.	GBEC.SERIESC	MBOBL	(EURO-BOBL)
3M EURIBOR Future Continuous Call-Implied Vol.	GQEC.SERIESC	MEURIBORG	(3M EURIBOR)
Corporate Bond Spread	BDBRYLD	SCOPG	Germany Benchmark corporate bond rate minus Government bond rate
Mortgage Bond Spread	BDT4624	SMORG	Germany 9-10Y Mortgage bond yield minus Government bond rate
Interest Rate		IRG	Data before January 1999 were based on *Discount rate of the Bundesbank* and data afterwards were based on *ECB Key Interest Rate*
Average Risk Aversion Proxy of Germany		AvgG	Simple average of standardised VDAX, MUS/EURO, MSCHATZ, MBUND, MBOBL, MEURIBORG, SCOP and SMORG
Real Interest Rate		RIR	IRG minus CPI inflation rate
Taylor Rule Rate		TRRG	TR=neutral level of the nominal interest rate +1*(CPI-target inflation rate)+1.5*output gap
Deviation from Taylor Rule		DEVIATION	IRG-TRRG
Unemployment Rate	BDUN%TOTQ	MAUNEMP	Unemployment rate minus 3-year moving average
Sales			Statistisches Bundesamt

Source: If not indicated otherwise, Thomson Datastream. For the calculation of the combined indices see text.

Appendix 2 (Statistics)

AVRAALL,RIR(-i)	AVRAALL,RIR(+i)	i	lag	lead
. |*** |	. |*** |	0	0.2570	0.2570
. |*** |	. |** |	1	0.3259	0.2028
. |**** |	. |** |	2	0.4022	0.1711
. |**** |	. |*. |	3	0.4491	0.1469
. |***** |	. |*. |	4	0.4600	0.1095
. |***** |	. |*. |	5	0.4907	0.0896
. |***** |	. |*. |	6	0.4877	0.0784
. |***** |	. | . |	7	0.5079	0.0425
. |***** |	. | . |	8	0.5282	-0.0036
. |****** |	.*| . |	9	0.5740	-0.0566
. |****** |	.*| . |	10	0.6117	-0.1141
. |****** |	.*| . |	11	0.6416	-0.1341
. |******* |	**| . |	12	0.6824	-0.1752
. |******* |	**| . |	13	0.6775	-0.2236
. |******* |	***| . |	14	0.6612	-0.2467
. |******* |	***| . |	15	0.6515	-0.2635
. |****** |	***| . |	16	0.6358	-0.2904
. |****** |	***| . |	17	0.6077	-0.3107
. |****** |	***| . |	18	0.6057	-0.3413
. |****** |	****| . |	19	0.6164	-0.4010
. |****** |	****| . |	20	0.6154	-0.4206
. |****** |	****| . |	21	0.6154	-0.4409
. |****** |	****| . |	22	0.6050	-0.4324
. |****** |	****| . |	23	0.6252	-0.4287
. |****** |	****| . |	24	0.6374	-0.4111
. |****** |	****| . |	25	0.5886	-0.4095
. |****** |	****| . |	26	0.5650	-0.4266
. |***** |	****| . |	27	0.5092	-0.4104
. |***** |	****| . |	28	0.4777	-0.4108
. |***** |	****| . |	29	0.4816	-0.4192
. |***** |	****| . |	30	0.4523	-0.4045
. |**** |	****| . |	31	0.4157	-0.3848
. |*** |	****| . |	32	0.3492	-0.3598
. |*** |	***| . |	33	0.2921	-0.3364
. |** |	***| . |	34	0.2511	-0.3312
. |** |	***| . |	35	0.1967	-0.3188
. |*. |	***| . |	36	0.1481	-0.3118

Figure 1: Cross-correlation between the average risk aversion index of all markets and the real interest rate. The first column shows the correlation between the lagged real interest rate and the risk aversion index. The second column depicts the correlation between the real interest rate and the lagged risk aversion index. The dotted vertical lines indicate 95% confidence intervals for the cross correlations. The last two columns show the size and direction of the correlations of the first and second column, respectively and i denotes the number of months RIR was lagged or led.

Dependent variable: MAUNEMP

Excluded	Chi-sq	df	Prob.
RIR	0.025537	1	0.8730
AVRAALL	4.637776	1	0.0313
SIGMA	0.127270	1	0.7213
All	8.043832	3	0.0451

Dependent variable: RIR

Excluded	Chi-sq	df	Prob.
MAUNEMP	4.931322	1	0.0264
AVRAALL	0.158363	1	0.6907
SIGMA	0.375247	1	0.5402
All	6.287355	3	0.0984

Dependent variable: AVRAALL

Excluded	Chi-sq	df	Prob.
MAUNEMP	5.394149	1	0.0202
RIR	8.267696	1	0.0040
SIGMA	3.052977	1	0.0806
All	11.60380	3	0.0089

Dependent variable: SIGMA

Excluded	Chi-sq	df	Prob.
MAUNEMP	0.116458	1	0.7329
RIR	0.269242	1	0.6038
AVRAALL	0.059703	1	0.8070
All	0.659547	3	0.8827

Table 1: Granger causality tests for VAR1

Appendix 3 (IR Responses)

1. **Business cycle: MAUNEMP**

Model	Responds to	RIR	DEVIATION	MAUNEMP	SIGMA
M1	AVRAVOL	M3-M12	--	M3-M8	no
M2	AVRAVOL	--	M3-M10	M3-M6	no
M3	PCVOL	M3-M9	--	M1-M2	M2-M8
M4	PCVOL	--	M3-M7	M1-M2	M2-M8
M5	AVRA3	M2-M11	--	no	M2-M5
M6	AVRA3	--	M2-M12	M1	M2-M5
M7	PC3	M3-M10	--	no	M3-M6
M8	PC3	--	M3-M9	no	M3-M5
M9	AVRAALL	M3-M12	--	M2-M6	M4-M5
M10	AVRAALL	--	M2-M11	M2-M6	no
M11	PCALL	M3-M9	--	M1-M2	M2-M8
M12	PCALL	--	M3-M8	M1-M2	M2-M8

Table 3: Shows the months during which the risk aversion measures (AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL) respond significantly to shocks in the variables listed in the first row (RIR, DEVIATION, MAUNEMP, SIGMA). The significance level is <5% (one-sided test).

MAUNEMP responds to shocks in:									
Model	AVRAVOL	PCVOL	AVRA3	PC3	AVRALL	PCALL	RIR	DEVIATION	SIGMA
M1	M2-M16	--	--	--	--	--	no	-	no
M2	M2-M21	--	--	--	--	--	--	no	no
M3	--	M2-M17	--	--	--	--	no	--	no
M4	-	M2-M21	-	-	-	-	-	no	no
M5			M2-M18	-	-	-	no	-	no
M6			M2-M20	-	-	-	-	no	no
M7			-	M2-M18	-	-	no	-	no
M8			-	M2-M19	-	-	-	no	no
M9			-	-	M2-M16	-	no	-	no
M10			-	-	M2-M21	-	-	no	no
M11			-	-	-	M2-M18	no	-	no
M12						M2-M21		no	no

Table 4: Shows the months during which the business cycle variable (MAUNEMP) responds significantly to the variables listed in the first row, namely the risk aversion indices (VDAX, AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL), the monetary policy stance (RIR, DEVIATION) and the uncertainty index (SIGMA). The significance level is <5% (one-sided test).

RIR responds to shocks in:								
Model	MAUNEMP	AVRAVOL	PCVOL	AVRA3	PC3	AVRALL	PCALL	SIGMA
M1	M6-M25	no	-	-	-	-	-	no
M3	M6-M25	-	no	-	-	-	-	
M5	M3-M25	-	-	M2-M4	-	-	-	no
M7	M3-M25	-	-	-	M2-M4*	-	-	no
M9	M5-M25	-	-	-	-	no	-	no
M11	M5-M25	-	-	-	-	-	no	no

Table 5: Shows the months during which the real interest rate (RIR) responds significantly to the variables listed in the first row, namely the business cycle variable (MAUNEMP), the risk aversion indices (AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL) and the uncertainty index (SIGMA). The significance level is <5% (one-sided test).

DEVIATION responds to shocks in:								
Model	MAUNEMP	AVRAVOL	PCVOL	AVRA3	PC3	AVRALL	PCALL	SIGMA
M2	M8-M25	no	-	-	-	-	-	no
M4	M6-M25	-	no	-	-	-	-	no
M6	M5-M25			M2-M4*				no
M8	M3-M25			-	M2-M7	-	-	no
M10	M8-M25			-	-	no	-	no
M12	M6-M25			-	-	-	no	no

Table 6: Shows the months during which the Taylor deviation (DEVIATION) responds significantly to the variables listed in the first row, namely the business cycle variable (MAUNEMP), the risk aversion indices (AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL) and the uncertainty index (SIGMA). The significance level is <5% (one-sided test). '*' indicates that response is wrongly signed.

Variable	MAUNEMP	RIR	AVRAALL	SIGMA
Horizon				
Contribution to AVRAALL (in %)				
6	6.48	16.26	68.76	8.49
12	7.89	25.93	55.22	10.96
18	8.54	28.45	51.61	11.41
24	8.92	29.18	50.37	11.53
Contribution to MAUNEMP (in %)				
6	90.52	0.97	7.20	1.31
12	78.44	5.47	12.13	3.97
18	70.55	9.74	13.98	5.73
24	65.66	12.74	14.80	6.80
Contribution to RIR (in %)				
6	3.04	95.76	0.09	1.11
12	15.14	82.77	1.00	1.10
18	28.59	65.95	3.80	1.67
24	37.51	52.78	6.75	2.96
Contribution to SIGMA (in %)				
6	1.97	2.68	0.15	95.20
12	2.00	3.60	0.31	94.10
18	2.02	3.86	0.35	93.77
24	2.02	3.94	0.37	93.68

Table 7: Variance decomposition for VAR1

2. Business cycle: Sales_cycle

Model	Responds to	RIR	DEVIATION	Sales_cycle	SIGMA
M1	AVRAVOL	M2-M9	--	M2-M9	no
M2	AVRAVOL	--	M2-M9	M2-M8	no
M3	PCVOL	M3-M8	--	no	M2-M7
M4	PCVOL	--	M3-M7	no	M2-M8
M5	AVRA3	M2-M8	--	M2-M3	M3-M6
M6	AVRA3	--	M3-M19	M1-M2	M3-M6
M7	PC3	no	--	no	no
M8	PC3	--	no	no	no
M9	AVRAALL	M2-M8	--	M2-M7	no
M10	AVRAALL	--	M2-M10	M2-M6	no
M11	PCALL	M3-M9	--	no	M2-M8
M12	PCALL	--	M3-M7	no	M2-M8

Table 8: Shows the months during which the risk aversion measures (VDAX, AVRA3, AVRAVOL, PCVOL, PC3, AVRAALL and PCALL) respond significantly to shocks in the variables listed in the first row (RIR, DEVIATION, Sales_cycle, SIGMA). The significance level is <5%.

Sales_cycle responds to shocks in:									
Model	AVRAVOL	PCVOL	AVRA3	PC3	AVRALL	PCALL	RIR	DEVIATION	SIGMA
M1	M2-M16	--	--	--	--	--	no	-	no
M2	M2-M15	--	--	--	--	--	--	no	no
M3	--	M2-M14	--	--	--	--	no	--	no
M4	-	M2-M13	-	-	-	-	-	no	no
M5			M2-M3	-	-	-	no	-	no
M6			M3-M16	-	-	-	-	no	no
M7			-	M2-M11	-	-	M2-M4*	-	no
M8			-	M2-M10	-	-	-	no	no
M9			-	-	M2-M14	-	M2-M3*	-	no
M10			-	-	M2-M13	-	-	no	no
M11			-	-	-	M2-M14	no	-	no
M12						M2-M13		no	no

Table 9: Shows the months during which the business cycle variable (Sales_cycle) responds significantly to the variables listed in the first row, namely the risk aversion indices (AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL), the monetary policy stance (RIR, DEVIATION) and the uncertainty index (SIGMA). The significance level is <5% (one-sided test). '*' indicates wrongly signed IR.

RIR responds to shocks in:								
Model	Sales_cycle	AVRAVOL	PCVOL	AVRA3	PC3	AVRALL	PCALL	SIGMA
M1	M4-M19	no	-	-	-	-	-	no
M3	M4-M18	-	no	-	-	-	-	no
M5	M2-M19	-	-	M2-M5	-	-	-	no
M7	M3-M17	-	-	-	M2-M3	-	-	no
M9	M5-M18	-	-	-	-	no	-	no
M11	M3-M18	-	-	-	-	-	no	no

Table 10: Shows the months during which the real interest rate (RIR) responds significantly to the variables listed in the first row, namely the business cycle variable (Sales_cycle)), the risk aversion indices (AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL) and the uncertainty index (SIGMA). The significance level is <5% (one-sided test).

DEVIATION responds to shocks in:								
Model	Sales_cycle	AVRAVOL	PCVOL	AVRA3	PC3	AVRALL	PCALL	SIGMA
M2	M6-M11	no	-	-	-	-	-	no
M4	M4-M12	-	M2-M3	-	-	-	-	no
M6	M8-M20	-	-	M3-M6	-	-	-	no
M8	M4-M10	-	-	-	M2-M5	-	-	no
M10	M7-M8	-	-	-	-	no	-	no
M12	M4-M12	-	-	-	-	-	M2-M3	no

Table 11: Shows the months during which the Taylor deviation (DEVIATION) responds significantly to the variables listed in the first row, namely the business cycle variable (MAUNEMP), the risk aversion indices (AVRAVOL, PCVOL, AVRA3, PC3, AVRAALL and PCALL) and the uncertainty index (SIGMA). The significance level is <5% (one-sided test). '*' indicates that IR shows an unexpected sign.

Variable	Sales_cycle	Deviation	AVRA3	SIGMA
Horizon				
Contribution to AVRA3 (in %)				
6	4.98	13.51	75.44	6.06
12	5.11	22.36	65.61	6.93
18	7.92	25.12	60.04	6.92
24	11.52	25.42	56.29	6.77
Contribution to Sales_cycle (in %)				
6	88.60	1.48	8.94	0.98
12	82.81	1.72	14.28	1.20
18	80.73	1.57	16.50	1.20
24	79.69	1.43	17.70	1.18
Contribution to Deviation (in %)				
6	2.21	90.82	6.27	0.71
12	8.93	83.48	6.48	1.10
18	17.08	75.79	5.59	1.54
24	23.67	68.88	5.71	1.74
Contribution to SIGMA (in %)				
6	1.24	0.69	2.52	95.55
12	1.45	0.99	2.48	95.09
18	1.50	1.12	2.56	94.82
24	1.50	1.19	2.59	94.72

Table 12: Variance decomposition for VAR2

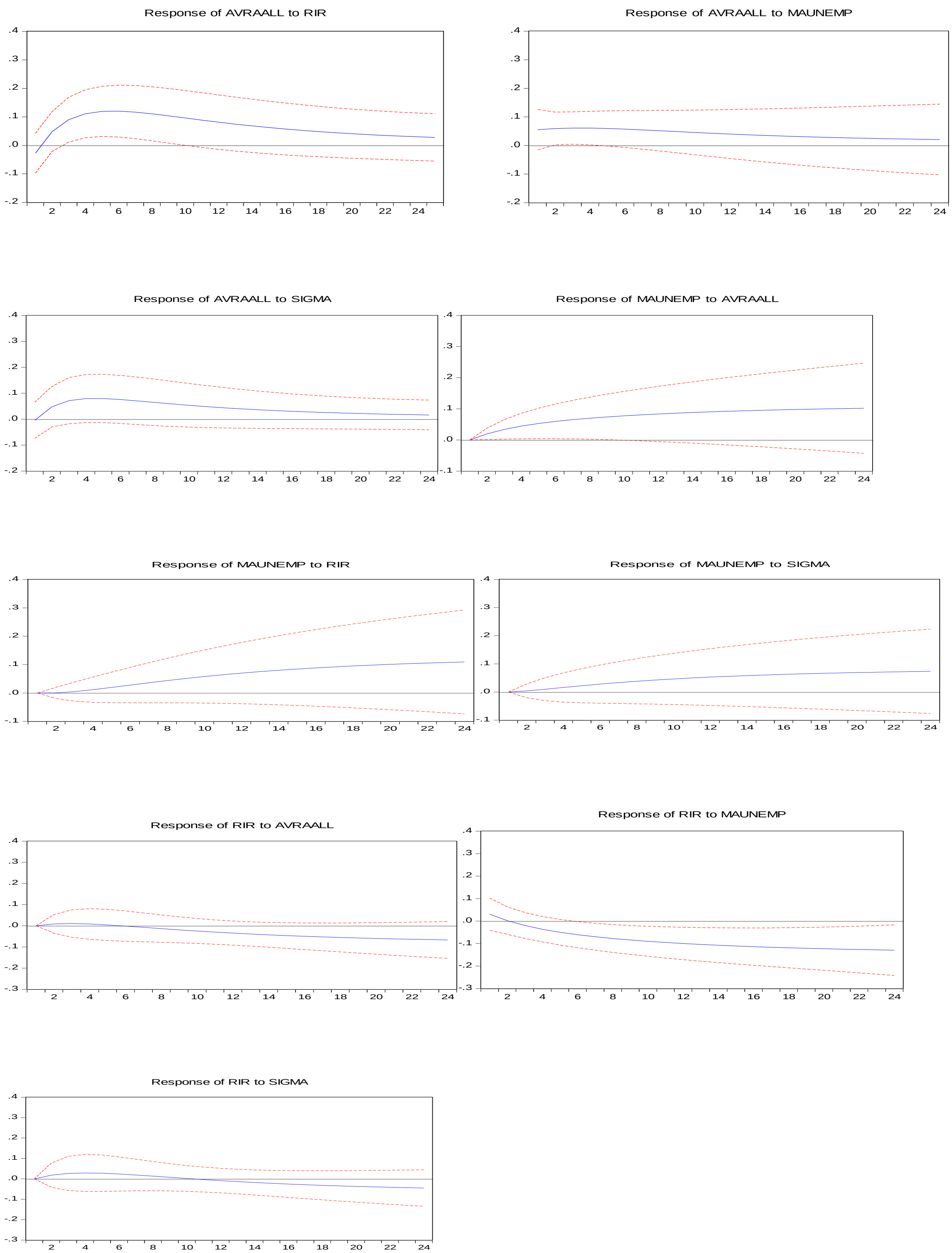

Figure 4: IRs for VAR1

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