The effect of monetary policy on investors' risk perception: Evidence from the UK and Germany

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Abstract

We use vector autoregressive models to estimate the effect of monetary policy on investors' risk aversion. The latter is proxied by a variety of option based implied volatility indices for Germany and the UK. There is clear evidence of a procyclical response between monetary policy and risk aversion. Monetary policy shocks affect UK investors risk attitude for longer periods, while they have a stronger impact on German investors for a shorter period of time. There is also evidence that the Bank of England reacts to increases in risk aversion with expansionary monetary policy. In contrast, the ECB appears to tighten monetary policy, although this result may be explained by the ECB making policy decisions for a group of countries. These results are robust w.r.t. to the various risk aversion and monetary policy stance proxies.

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1. Introduction

The pre-crisis consensus view based on orthodox New-Keynesian models, was that financial market conditions, such as asset price developments have little effect on macroeconomic outcomes or the transmission of monetary policy. Three reasons can be found in the literature. Firstly, the pre-crisis view presumed that strong asset price movements or misalignments were associated with strong inflationary pressure (Bini Smaghi, 2009; ECB, 2005; Kohn, 2005). As a result, central banks controlling inflation also addressed financial imbalances. Thus there was no need for monetary policy to react to specific financial market developments or changes in asset price, except to the extent that such developments offer additional information for the forecasting of inflationary pressure (Bernanke and Gertler, 2010). The second reason often given is the inability of conventional monetary policy instruments to restrain asset bubbles (Bernanke, 2010; Bini Smaghi, 2009; ECB, 2005). The argument was that moderate rises in policy rates will hardly be effective since large capital gains in asset prices can be made during a boom. Larger rate rises are unfeasible since such policy 'shocks' would pose a serious risk to the real economy. As a result, monetary policy should be passive during the boom, focusing solely on the needs of inflation targeting, and, once the bubble has burst, the central bank should intervene by reducing interest rates aggressively in order to sustain real economic activity if the fall in asset prices looked likely to destabilise output (Greenspan, 2005; Blinder and Reis, 2005). The third reason for a 'hands-off' approach can be found in the difficulties of identifying genuine bubbles, distinguishing them from upswings based upon 'fundamentals' (Bernanke and Gertler, 2001; Bernanke, 2002; ECB, 2005).

The crisis has posed a major challenge to this orthodoxy. For example, it has been suggested that accommodating monetary policy during the boom may actually reinforce financial market imbalances in that it reduces agents' risk perceptions and increases their risk tolerance (Bodie and Zhu, 2008)[1]. A stylized example may illustrate some of the argument: excessively low policy rates stimulate economic activity, raising profits of non-financial and financial firms, providing an initial boost to asset prices, based upon improving fundamentals. But low interest rates

[1] Note that the question here is the ability of monetary policy to influence agents' perceptions of risk, not the (more obvious) one of whether policy influences the degree of risk in the system. On a simple analogy, the issue is the price of risk, rather than its quantity.

encourage credit demand and lenders become more willing to lend in view of the high value of collateral. The greater availability of credit boosts asset prices even more. In this situation, an accommodating monetary policy reinforces this loop. It contributes to lower credit standards applied by lenders and to a lower perception of risk. Evidence for the effect of greater wealth on risk tolerance lies in the procyclical estimates of default probabilities, loss given default, volatilities and correlations.

There are a number of empirical studies that have recently investigated the “risk taking channel” of monetary policy.[2] Most of the empirical work focuses on the effect of changes in short-term interest rates on the lending standards of *banks*. Jiménez *et al* (2009), using micro data from the Spanish Credit Register, find that in the short-run low interest rates reduce the probability of default, while in the medium run, banks tend to soften their lending standards. Similarly, Ioannidou *et al* (2009) observe that Bolivian banks do not only increase the number of new risky loans, but also reduce the rate they charge riskier borrowers relative to those they charge less risky ones. Alturibas *et al* (2010) find for banks operating in sixteen developed countries prior and during the financial crisis that low short-term interest rates over an extended period of time contributed to an increase in banks’ risk-taking, by leading to a reduction in their perception of default risk. By contrast, there are fewer papers that are concerned with the link between monetary policy and (non-bank) *investors*’ risk perception. Amato (2005) finds suggestive evidence that the monetary policy stance has an impact on the pricing of credit risk as measured by credit default swap spreads. Bernanke and Kuttner (2003) find that unanticipated changes in monetary policy mostly impact on perceived riskiness of shares and to a lesser extent on the risk-free rate and expected dividends. More recently, Bekaert *et al* (2010) find strong co-movement

[2] Borio and Zhu (2008) discuss three main ways through which changes in interest rate affect risk perception as well as the willingness to bear risk. The first channel works through the impact of interest rates on valuations, income and cash flows. The second one works through the ‘search for yields’ due to its impact on the relationship between market and sticky target returns (BIS, 2004; Rajan, 2006), as well as a fund performance measure, where private investors use short-term returns as a way of judging manager competence and withdraw funds after poor performance (Brunnermeier and Nagel, 2004). The third one is related to the communication policy and the perceived reaction function of the central bank on risk taking (Diamond and Rajan, 2009; Fahri and Tirole, 2010). The central bank may be perceived as behaving asymmetrically by not responding directly to the signs of the build-up of risk but only to the emergence of stress and thus providing an ex ante insurance policy. The channel has been extended for instance by Adrian and Shin (2009), Rajan, (2006); Ackerman *et al* (1999); Kouwenberg and Ziemba, (2007) and theoretical models have been developed by Dubecq et al (2009) and Disyatat (2010).

between the VIX[3] and monetary policy, with lax monetary policy decreasing risk aversion in the medium run.

This paper extends the results found for the US by testing for the effect of monetary policy on risk aversion in the UK and Germany. The motivation for this is to explore the generality of Bekaert *et al's* results. If the findings for the UK support those from the US, then we know that monetary policy has this additional 'channel' in two of the world's largest financial economies. If the results extend further – to Germany – then we know that they apply also to a major player in the Eurozone and maybe therefore to the Eurozone as a whole. Furthermore, there is the point that the German financial system differs in a number of significant respects from that of the UK and USA – being more 'bank-based' and more 'conservative'. If the Bekaert *et al* findings apply to the UK and to Germany, then there is a strong supposition that monetary policy, *in general*, has an effect on perceptions (and the pricing) of risk.

There are various empirical problems associated with testing this relationship. Firstly, 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). We use two stock market-based indicators of risk aversion, both based on implied volatility indices: the FTSE100 volatility index and the VDAX-new volatility index, as well as a constructed average risk aversion indicator for each country. Both of the equity implied volatility indices are constructed in a similar way to the VIX. These are forward-looking indices of expected future return volatility of company shares contained in the FTSE100 and DAX, respectively, over the next 30 days. The average risk aversion indicator is calculated as a simple average of risk aversion in a group of markets in order to capture the aggregate impact of variation in risk attitudes in these markets (Popescu and Smets, 2010).[4] Despite the criticism that implied volatility indices may also incorporate measures of uncertainty, they remain a commonly used indicator of risk aversion (Carr and Wu, 2009; Bekaert *et al*, 2010). Furthermore, it is investors' perceived risk that explains most of the variability in implied volatility rather than uncertainty (Popescu and Smets, 2010). Secondly, another

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[3] The VIX is an index of the implied volatilities of a wide range of call and put options on the S&P500 and represents expected future market volatility over the next 30 calendar days. The VIX has been called the 'index of fear'. The S&P500 index option market has become dominated by hedgers who are concerned about a potential drop in the stock market, so that the VIX is an indicator that reflects the price of portfolio insurance (Whaley, 2008).

[4] In addition, we estimate VARs for sub-volatility indices in an effort to account for the measurement problems.

measurement problem is related to the monetary policy stance (Bernanke and Milhov, 1998; Amato, 2005). In both the UK and eurozone (and many other regimes) the policy instrument is a very short-term interest rate at which the central bank supplies liquidity. We use a variety of interest rate measures to capture the policy stance. This includes the real short-term interest rate, the deviation from the Taylor rule and a duration-based measure to capture a prolonged lax monetary policy regime (Bekaert *et al* 2010). These various measures of monetary policy stance and risk aversion help us to get a better understanding of the general behaviour of investors in different securities markets.

We find clear evidence of a procyclical response between monetary policy and risk aversion for both countries. While monetary policy shocks affect UK investors' risk attitude for longer periods, they exert a stronger effect on German investors for a shorter period. There is also an indication that the Bank of England reacts to increases in risk aversion with expansionary monetary policy. This is apparently contrary to the ECB's reaction, which appears to tighten monetary policy in view of increased risk aversion in German security markets. This may, however, be a spurious result.

The paper is structured as follows: The beginning of Section 2 briefly introduces the methodology and explains the data used. Results are presented for the UK and Germany from a variety of VAR models. Section 3 concludes.

2. Methodology and Result Analysis

The dynamic link between risk aversion and monetary policy is estimated with a simple VAR. VARs are particularly effective when there are strong contemporaneous correlations between variables. Monetary policy may affect asset prices through its effect on risk aversion, but there may also be a feedback mechanism to the monetary policy maker through uncertainty in the market (Bredin *et al*, 2007; Sellin, 2001; Ehrmann and Fratzscher, 2004; Thorbecke, 1997). The endogeneity between price of risk and monetary policy stance, is obvious empirically in the cross-correlograms between the Taylor rule deviation (real short-term interest rate) and the average risk aversion measure for both countries (Figure 1 in the Appendix). In all cases, leads and lags of the monetary policy stance proxies are significant over most of the period. Furthermore, by tracing the dynamic response of the price of risk to a monetary policy innovation, the VAR provides a means of observing the effects of policy changes under minimal identifying assumptions. Earlier applications include Bernanke and Blinder (1992) who employed VAR in the study of credit transmission in the US and Bredin *et al*. (2007) who studied the impact of domestic monetary policy shocks on UK stock returns.

2.1 Data Description

To test the relationship between risk aversion and monetary policy, we choose a series of implied volatility and monetary policy variables for both UK and Germany. The proxies for financial risk-taking cover four markets as remuneration for different asset-specific sources of risk can be fundamentally different. They include VFTSEIX and VDAX for the stock market, Long Gilt, Euro-Bobl, Bund and Schatz futures for the government bond market, Euribor futures for the money market and two measures of spreads (corporate to government bond spread and mortgage to government bond spread). To capture the aggregated impact of variations in risk attitudes, we constructed two integrated risk aversion indicators for the UK and Germany, respectively, based on the average level of all risk aversion proxies. There are caveats in the use of spreads between corporate and government bonds. Bond spreads also reflect other factors such as credit risk in the corporate sector. In line with Popescu *et al* (2009), we assume that changes in the aggregate economy will capture most of the changes in credit risk. Also, when we account for business cycle effects, results remain stable. Furthermore, measurements of implied volatility of individual markets in the Appendix support the robustness of the findings in the text.

Table 1 in the appendix summarizes the data employed. The starting dates of the tests vary due to data availability and the time span of the average risk aversion indictor is consistent with the risk aversion proxy with the shortest observation period. The period for Germany and the UK starts in February 1992 and January 2000, respectively and ends in both cases in July 2007, just before the financial crisis. For the monetary policy stance, we use both real repo rate (for the UK)[5], computed as nominal repo rate minus CPI inflation rate, and Taylor Rule deviations.[6] The Taylor rule deviation (DTR) measures the extent to which the official bank rate differs from the rate implied by the application of a simple Taylor rule (TRR). The TRR can be estimated for both countries as:

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[5] For Germany, we combine the discount rate (before 1999) with the ECB bank rate (since EMU) to calculate the real rate.

[6] The results of the real interest rate are used as a robustness test.

TRR = Neutral bank rate +1 * (CPI - Target inflation rate) + 1.5 * Output Gap

The neutral bank rate is represented by the average real official bank rate over the sample period and the target inflation rate is assumed to be 2%.[7] The output gap is the percentage deviation of real GDP from potential GDP and the two coefficients for inflation and the output gap are taken from Martin and Sawicki (2003).[8] The Taylor rule rate is adjusted according to the changes in output gap and the actual inflation relative to the target inflation levels. A positive DTR implies a tightened monetary stance as the bank rate is higher than otherwise suggested by the TRR whereas a negative DTR suggests the condition of a looser monetary policy stance as the bank rate is lower than the TRR.

2.2 Result Analysis

We deploy a series of VAR models to investigate the relationship between monetary policy and investors' risk attitude. We start by employing the Granger causality test to identify the short-term relationship between the variables. This is followed by bivariate VAR and structural VAR analysis. Then a third variable, the deviation of the 3-year moving average from the unemployment rate will be included to account for the impact of the business cycle on monetary policy and risk aversion. The trivariate VAR model will be estimated and additionally, the influence of a prolonged lax monetary policy regime to risk aversion will also be considered.

Bivariate VAR

We started with a bivariate VAR with no restriction. The risk aversion and monetary policy measures are allowed to react to each other freely. Without loss of generality, we ignore a constant. Consider the following structural VAR:

$$A\, Z_t = \phi\, Z_{t-1} + \varepsilon_t$$

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[7] Prior to monetary union, the Bundesbank placed more stress upon the growth rate of central bank money and of M3 than on an explicit inflation target. However, these 'reference rates' for money growth were calculated on an *assumed* rate of increase in the CPI of 2 per cent p.a (Deutsche Bundesbank, 1995, pp.80-1). Since then, the ECB has adopted the formulation of '...close to but less than 2 per cent'. In December 2003, the inflation target in the UK was reformulated as a 2 per cent p.a. increase in the CPI. At the time, the Bank of England stressed that this was *equivalent to* a 2.5 per cent p.a. increase in the RPI, which had been the formulation since October 1992 (Bank, 2003, 504-17).

[8] We also experimented with different, commonly used coefficients for the Taylor rule. Results remained stable and are not reported here.

where A is a 2x2 full rank matrix, and $\mathrm{E}\left[\varepsilon_t \varepsilon'_t\right] = I$. Our main interest is in the dynamic responses to the structural shocks ε_t. The reduced form VAR is:

$$Z_t = A^{-1}C + A^{-1}\phi\, Z_{t-1} + C\,\varepsilon_t$$

where $A^{-1}\phi = B$, $C = A^{-1}$

The variance and covariance matrix of the reduced-form residuals would be $\Sigma = \mathrm{E}\left[(C\,\varepsilon_t)(C\,\varepsilon_t)'\right] = C\,C'$.

The lag selections are based on Akaike (AIC) and the VAR model is subject to a stability test using the inverse roots of the characteristic AR polynomial (see Lütkepohl, 1991). We then report the VAR results in the form of impulse-response functions (IRFs) in Figure 2a and 2b for UK and Germany, respectively. We compute 95 per cent bootstrapped confidence intervals based on 500 replications over 36 periods.[9] We use a Cholesky decomposition for the estimate of the variance-covariance matrix. The result of the Granger causality tests suggests that short-run causality runs from monetary policy to average risk aversion (see Table 2 in the Appendix). Consequently, we order the monetary policy proxy first and risk aversion second to capture the fact that risk aversion responds to monetary policy changes actively, whereas the monetary policy is relatively unresponsive.

The following discussion focuses on the responsive relationship between two monetary policy proxies, the real repo rate and Taylor rule deviations, and two risk aversion proxies, the stock market implied volatility and average market risk aversion proxy. The results of the reduced form impulse response functions (IRFs) for the UK (Figure 2a in the Appendix) suggest that a one standard deviation positive shock to the real repo rate (equivalent to 31.598 bp) leads to a 4.77 bp increase in VFTSEIX after 3 months. The effect remains stable and significant up at around 3.5 bp since month 8 to the rest of the studying period. Our result confirms the positive relationship between monetary policy and risk aversion. A contractionary monetary policy is found to increase risk aversion, as measured by VFTSEIX instantly. Despite volatility in the short-run, this positive impact, which increases the risk aversion level, remains stable for a relatively long

[9] We have also tried 1000 replications and the result is similar. For Germany, our analysis is based on 24 periods since most of the results are only significant for a limited period.

period. The symmetric nature of the VAR enables us to interpret this result in that an expansionary monetary policy tends to decrease risk aversion over the long term. This is consistent with the empirical evidence that a relatively loose monetary stance in UK over 2002-03 was accompanied by a rapid raise in housing prices and higher stock market volatility over the same period and the period after.

This is unchanged when monetary policy is represented by the deviation from a Taylor rule (DTR). The Taylor rule rate is determined by reference to the output gap and the actual inflation rate relative to its target. A positive DTR implies a tightened monetary stance as the policy rate is higher than otherwise suggested by the TRR whereas a negative DTR suggests a looser monetary policy stance as the policy rate is lower than the TRR. According to the IRF results, a one standard deviation positive shock to DTRUK (equivalent to 70.399 bp) would lead to a long-term rise in risk aversion. The impact reaches a maximum of 4.79 bp in period 10 and remains significant for the rest of the 36 month testing period. It therefore confirms that an upward deviation from the Taylor rule, in other word, a contractionary monetary stance, will indeed increase market risk aversion and vice versa. The Taylor rule deviation in the UK was in practice negative from the second half of 2005. Such loosening of monetary policy effectively encouraged market risk taking and may have finally triggered the boom and bust of asset prices between 2006 and 2008.

When risk aversion is proxied by the average risk aversion level across different markets, the result remains similar. A one standard deviation positive shock to the real repo rate (equivalent to 31.51 bp) increases the integrated risk aversion proxy by 1.99 bp after 11 months. The positive impact reaches a maximum of 2.77 bp in period 20 and remains significantly up for the rest of the testing period. On the other hand, a one standard deviation positive shock to Taylor rule deviation (equivalent to 70.36 bp) has also been found to lead to an immediate rise in the average risk aversion level. The effect is peaked at 3.45 bp after 11 months and remains significant up till lag 36.

In conclusion, all the tests above suggest that a tightened monetary stance does indeed act positively on the level of risk aversion over the long term. When the interest rate goes up, investors tend to face higher risks. What is remarkable in our findings, however, is that they also re-price risk. They become more risk averse at the same time as they face higher levels of risk. Looking at it from a loosening of monetary policy, excessive risk taking may be encouraged which may then have been one of the causes of the financial crisis. The conclusions remain robust when risk aversion is proxied by government bond market volatility, long gilt; money market volatility, Euribor, and the corporate bond spread (see appendix, Figure 6 for IRF results). As suggested in the study of Altunbas *et al*. (2010) that short-term interest rate affects the risk-taking behaviour of the banks. In particular, low interest rates would increase the risk appetite of the banks, triggering them to soften the lending standards for new loans while condense the loan spread at the same time. As banks are at the core of the financial system, this effectively increases the amount of credit risk of the whole the system.

There are feedbacks from market risk aversion to monetary policy. A one standard deviation positive shock to VFTSEIX would lead to an immediate decrease in the real repo rate. The impact peaked at 10.17 bp after 8 months. Then after a year, the negative effect of VFTSEIX to real repo rate turns back to positive and remains significant till period 16. When risk aversion is represented by the integrated index, a positive shock to it is found to lead to an immediate drop in real repo rate. Despite the interest rate returning to positive territory in period 12, it is not statistically significant. Hence our evidence reveals that the central bank would react to periods of high risk aversion levels by relaxing monetary policy in the short- to medium term. This is consistent with the so called “Greenspan put” in that the investors believe that in a crisis or downturn, the central bank will step in and inject ample liquidity to rescue the market. Such belief may reinforce the risk appetite of the investors under a lax monetary environment. However, in terms of the influence of risk aversion to Taylor rule deviation, the impact is quite small and short-lived. This is as expected since according to the Taylor rule, the short-term interest rate should only be adjusted according to changes of output gap and inflation levels but not to market risk.

In the case of Germany, we report IRF results based on a 24 month period as most of the responsive relationships are significant for a limited period of time only (see Figure 2b in the Appendix). A one standard deviation positive shock to the real repo rate (equivalent to30.0 bp), after an initial 3-month lag, raises the risk aversion, as measured by the stock market volatility index (VDAX) by 7.6 bp after 4 months. The positive impact reaches a maximum of 10.47 bp in period 13 and remains significant up till the 17th period. When monetary policy is represented by the Taylor rule deviation, a positive shock to it (equivalent to 41.97 bp) is found to raise VDAX by a maximum of 6.4 bp after 4 months. Despite a puzzling negative short-run response of the VDAX to a Taylor rule deviation, the effect remains significant from period 4 to 17. These findings for the German market are consistent with those for the UK market. A tightened monetary stance increases stock market risk aversion over the short and medium term, apart from the three-month initial stagnation. In the long term, investors' risk appetite recovers gradually.

When risk aversion is measured by the average risk aversion proxy, the IRF results suggest that a one standard deviation positive shock to the real repo rate (equivalent to 29.24 bp) increases the average risk aversion level by 3.45 bp after 5 months. The positive impact reaches a maximum of 4.03 bp after 13 months and preserves at a relatively stable level of 3.5 bp thereafter. On the other hand, a one standard deviation positive shock to the Taylor rule deviation (equivalent to 40.76 bp) increases the average risk aversion level by 1.95bp after 4 months. The effect reaches a maximum of 20.44 bp in period 11 and remains significantly positive till period 30. The result again confirms our hypothesis that a contractionary monetary policy would lead to a general increase in the risk aversion level over the market. When the risk aversion is proxied by the average implied volatility of the government bond market, money market and the corporate bond and mortgage bond spreads, the result remains robust (see Appendix Figure 3 for detailed IRF figures).

On the other hand, a one standard deviation positive shock to VDAX leads the real repo rate increase by 10.26 bp after 5 months. Nevertheless, the impact is only significant for 6 periods. A similar result has also been identified when risk aversion is measured by the average risk aversion index. The impact reaches the maximum of 10.37 bp in month 4 but only remain significant for another two periods. The direction of the relationship is contrary to our expectation. While on the other hand, when risk aversion is measured by government bond, money market and currency implied volatility proxies, the central bank is found to adopt an expansionary monetary policy, as suggested by a lower real repo rate or a deduction in Taylor rule deviations, following a rise in market risk aversion (see Appendix Figure 7). Theoretically, a higher market risk aversion would trigger an increase in liquidity supply, as seen in the case of the UK market. However, since the bank rate decision of Germany is made by the European Central bank, it would be difficult for it to respond to an increase in a single country's risk aversion level by cutting the interest rate over the whole Eurozone. Such dilemma may also indicate the serious limitation of such "one size fits all" monetary policy adopted in the Eurozone. The different economic structure among different member states makes it hard for the European Central Bank to respond effectively to address the changes in a single country's market condition.

In summary, our analysis based on both UK and Germany markets clearly suggests the existence of a procyclical responsive relationship between monetary policy and risk aversion. A contractionary monetary policy stance (an increase in policy rate or Taylor rule deviation) would trigger a rise in risk aversion of investors whereas an expansionary monetary policy stance (a decrease in bank rate or Taylor rule deviation) tends to lower market risk aversion. Reactions of both UK and Germany investors' towards changes in monetary policy are quite similar. In addition, the monetary policy shock tends to influence the risk attitude of the UK investors for a longer period but exert a much stronger impact to the Germany investors (the maximum change in risk aversion towards a one standard deviation shock to real repo rate is 10.47 bp and 4.77 bp in Germany and UK respectively). Meanwhile, investors have also been found to react stronger to changes in real repo rate, as compared with that of the Taylor rule deviations. Finally, compared with the earlier study of Bekaert *et al*. (2010) based on the US market, changes in risk appetite towards a shift in monetary stance amongst UK and Germany investors are much more significant. A one standard deviation negative shock to real repo rate could only lower the risk aversion of the US investors by a maximum of 2.95 bp, although the impact remains significant for over 50 months (Bekaert *et al*., 2010). It seems that the stronger the reaction of the investors towards a change in monetary stance is, the shorter period the impact will last. After an adjustment in monetary stance, if responses from investors are relatively weak, the impact is more likely to take effect for a longer period.

In addition, an increase in market risk aversion in UK is found to cause the central bank to adopt an expansionary monetary stance in the short-term. Similar conclusion has also been found in the US market but with a much longer significant period (Bekaert *et al.*, 2010). Under severe economic condition and a high level of market uncertainty, the central bank would lower interest rate to help the money flow into the market. However, the response of the European Central Bank to the increased risk aversion level over Germany market seems puzzling. Facing higher level of risk aversion, the European Central bank tends to employ a contractionary monetary stance over the short-term. It may therefore signify the limitations of applying such "single rule policy" among all member states of the Eurozone.

In the next section, a structural VAR will be constructed to the relationship between monetary policy and risk aversion under various restrictions.

Structural VAR

Following the work of Bekaert *et al*. (2010), we also impose three types of restrictions to obtain the structural evidence: exclusion restrictions on contemporary response, long run restrictions and short run restriction where monetary policy does not have a short-run effect on risk aversion.

Under the bivariate VAR system, the first assumption is equivalent to the restriction implied by the Cholesky decomposition studied above. The long run restriction is inspired by money neutrality. Money should not have a long run effect on real variables. The Bernanke and Mihov (1998) study on US data finds evidence in favour of money neutrality. The long-run restriction involves a long-run response matrix, see Blanchard and Quah (1989), denoted by *D*:

$$D = (I - B)^{-1} C$$

where $D D' = (I - B)^{-1} C C' \left[(I - B)^{-1} \right]' = (I - B)^{-1} \sum \left[(I - B)^{-1} \right]'$

From the estimates of B and $\sum$ in the reduced form VAR, we obtain D and $C = A^{-1}$.

The assumption of long run money neutrality in the bivariate VAR implies that $d_{21} = 0$.

$$D = \begin{array}{r} \textit{Monetary Policy} \\ \textit{Risk Aversion} \end{array} \begin{bmatrix} d_{11} & d_{12} \\ 0 & d_{22} \end{bmatrix}$$

For the third type of short run restriction, we restrict the feedback matrix, suggesting that risk aversion does not react to monetary policy in the short-term. It takes time for the market to fully digest changes in interest rate and for investors to adjust their risk attitude accordingly. The assumption of no short-run effect on risk aversion implies that $a_{21} = 0$.

$$\phi = \begin{array}{r} \textit{Monetary Policy} \\ \textit{Risk Aversion} \end{array} \begin{bmatrix} a_{11} & a_{12} \\ 0 & a_{22} \end{bmatrix}$$

We first turn to the IRF for the UK. In the model of long-run restriction, a one standard deviation positive shock to the real repo rate (equivalent to 30.93 bp) leads to an increase in risk aversion (see Figure 3 in the Appendix). The effect reaches a maximum of 2.6 bp after 12 months and remains stable and significant thereafter. A one standard deviation positive shock to the average risk aversion proxy lowers the real repo rate by a maximum of 6.7 bp in period 7. Nevertheless, the effect is only significant for 8 periods. The responsive relationship under the short-run restriction does not differ significantly from the one under long-run restriction despite a shorter significant period. Consequently, the effects of monetary policy on risk aversion uncovered in the previous reduced form analysis are preserved under appropriate assumptions. This conclusion is further confirmed when the monetary policy is represented by Taylor rule deviations. A contractionary monetary policy would cause a rise in risk aversion whereas, when facing higher level of market risk aversion, the central bank tends to apply an expansionary monetary policy to restore market confidence. Again, the Taylor rule deviation is found to respond to risk aversion weakly.

For Germany, the results under both long-run and short-run restrictions remain consistent with the reduced-form analysis. A tightened monetary policy, measured either by a higher real repo rate or an increase in Taylor rule deviation, is found to lead to a rise in risk aversion level. The effect identified under short-run restriction has a slightly longer significant period as compared with that under long-run restrictions. In addition, the effect is found to have a shorter impact on the stock market but a much longer impact on the overall average market risk aversion level. On the other hand, a higher risk aversion level has surprisingly been found to have a positive effect on the policy rate. Again, the effect is short-lived - only significant for about 7 months. This may be because the European Central Bank is unable to adjust the monetary policy stance simply in response to changes of the risk aversion level in one single member state. In these circumstances, a rise in interest rate for a short period might signal the central bank's confidence over the economic performance of the whole region. Finally, the Taylor rule deviation is again found to react weakly to risk aversion, consistent with its definition.

Consequently, the link between monetary policy and risk aversion, as suggested by the reduced-form analysis, remains under both long-run and short-run restrictions. Despite a puzzling short-lived procyclical effect of risk aversion on interest rates in Germany, other results are consistent with our expectations. A higher interest rate would increase risk aversion over long-term and on the other hand, he central bank tends to adopt an expansionary monetary stance following a higher risk aversion level. The changes in monetary stance influence the risk aversion of investors for a longer period than the impact initiated from the opposite direction.

Risk Aversion, Monetary Policy and Business Cycle

The former analysis is focused on the bivariate VAR, while this section incorporates the business cycle effects into the analysis. It has been argued that the monetary policy and risk aversion may jointly react to business cycle conditions (Bekaert *et al*., 2010). Therefore, we conduct a trivariate VAR model in which the deviation from a 3-year moving average of unemployment is used to measure business cycle changes. The risk aversion is proxied by the average level of risk aversion indicators of each country and the monetary policy stance is represented by the real repo rate. We then conduct Granger causality tests to investigate their predictive effect first. The result is presented in Table 3 in the Appendix.

The result again shows the strong predictive power from monetary policy to risk aversion. For Germany, a bi-causal relationship between monetary policy and the cyclical unemployment rate and a uni-directional from risk aversion to unemployment deviation have been identified. Therefore, in the following VAR analysis, we order the monetary policy first, risk aversion second and follow by the employment rate. The result is summarized in Figure 4 in the Appendix.

For the UK, a positive shock to real repo rate is found to increase the level of risk aversion by a maximum of 3.73bp in period 12. The effect remains significant for up to 30 periods. A positive shock to risk aversion decreases the real repo rate by 9.5bp after 7 months. Such a negative impact is quite short-lived, significant for only 9 periods. In addition, a one standard deviation positive shock to the real repo rate is found to increase the jobless rate immediately. Nevertheless, the effect is quite small, reaching a maximum of 2.3bp after 18 months. A positive shock to the unemployment rate does not influence real repo rate significantly but has a much stronger impact on the risk aversion level. Despite a surprisingly negative impact over the short-term term, a higher jobless rate indeed triggers the market risk aversion up over the long-run. Lastly, a positive shock to risk aversion is found to cause a drop in jobless rate. The negative impact moves along the baseline and remains significant for 13 months.

For Germany, the link between monetary policy and risk aversion appears unchanged when taking account of the business cycle. A contractionary monetary policy is found to increase market risk aversion over long-term while the central bank tends to increase real repo rate following a higher risk aversion level. It is surprising to find that a tighter monetary policy would lead to a drop in the jobless rate and that a higher unemployment rate lowers the average risk aversion level in the long-term. These are different from what we found for the UK market. Lastly, a positive shock to the unemployment rate is found to act negatively on the real repo rate. This is as expected since the central bank tends to adopt an expansionary monetary stance to boost the economy.

Finally, with reference to the “duration adjusted monetary policy” (DAMP) proposed in Bekaert *et al.* (2010), we also constructed similar proxies for both UK and Germany to capture the influence of a prolonged lax monetary policy regime on risk aversion. The variable DAMP can be calculated as:

$$DAMP = \ln(1 + d_t + d_t^2) * Taylor\ Rule\ Deviation$$

Where d_t represents the number of periods during which the Taylor rule deviation is negative, in other words, when the nominal policy rate is lower than the Taylor rule rate. When the policy rate is higher than the Taylor rule rate, DAMP is given by the Taylor rule deviation itself. This effectively places more weight on those periods during which the interest rate was kept at a low level for a prolonged period of time. The adoption of an expansion monetary stance over a longer period is believed to have a higher possibility of triggering excessive risk taking by the investors. We then replace the prior monetary policy proxy by DAMP and re-estimate the three-variable VAR system. The results are presented in the form of IRFs in Figure 5 in the Appendix.

In the UK, a one standard deviation positive shock to DAMP is found to increase market risk aversion level by a maximum of 3.54 bp after 11 months and lowers the jobless rate by a maximum of 6.58 bp after 14 months. It indicates that a prolonged loose monetary policy stance tends to trigger a drop in risk aversion but a rise in unemployment rate over the medium term. This responsive relationship between monetary policy and unemployment rate is different from the one identified under the prior three variable VAR system. Without taking account of the duration of a loose monetary stance, an expansionary monetary policy tends to improve the employment condition. This is because an initial cut in interest rate may release liquidity to the market, easing the financing difficulties for small- and medium-sized companies and hence creating more employment opportunities. However, when such a loose monetary stance has been maintained for a long time, it may signify that the economy has entered the period of recession and this is why a higher jobless rate is likely to be observed. On the other hand, a positive shock to average risk aversion and the unemployment rate is found to have no significant impact on the duration adjusted monetary policy. This is as expected as the long-term monetary stance is likely to be determined by the inflation rate rather than the macroeconomic condition or changes in risk appetite of the investors. Finally, a positive shock to the unemployment rate is found to increase risk aversion over the short- to medium-term.

For Germany, a one standard deviation positive shock to the duration adjusted monetary policy stance leads to a drop in market risk aversion over the long-run, apart from an initial short-term increase. The negative impact reaches a maximum of 2.06 bp after 9 months and remains significant for 29 periods. This is the first time that a contractionary monetary stance is found to trigger a drop in the level of risk aversion. For the other relationships among risk aversion, monetary policy and unemployment rate, the IRFs results remain similar to the ones obtained before. A positive shock to the jobless rate increases the average market risk aversion level in the short-term. Nevertheless, over the longer period, an unfavourable market condition tends to lead to a drop in risk aversion. This is contrary to the result obtained from the UK market.

3. Conclusion

The empirical results for the UK and Germany clearly suggest the existence of a procyclical responsive relationship between monetary policy and risk aversion. A contractionary monetary policy stance, represented by an increase in real policy rate or the Taylor rule deviation, triggers a rise in investors' risk aversion whereas an expansionary monetary policy stance tends to lower market risk aversion. The reactions of both UK and German investors towards changes in monetary policy appear to be quite similar. In addition, monetary policy shocks tend to influence the risk attitude of the UK investors for a longer period but exert a much stronger impact on German investors (in the bivariate VAR model, the maximum change in risk aversion towards a one standard deviation shock to real repo rate is 10.47 bp and 4.77 bp in Germany and UK respectively). Finally, compared with the earlier study of Bekaert *et al*. (2010) based on the US market, changes in risk appetite towards a shift in monetary stance amongst UK and Germany investors are much more significant. It seems that the stronger the reaction of investors towards a change in monetary stance is, the shorter period the impact will last for. On the other hand, it seems that the Bank of England adopts a short-term expansionary monetary policy when faced with a rise in market risk aversion. A similar result was found for the US market but with a much longer significant period (Bekaert *et al*., 2010). Such phenomena may to some extent be explained by the so called "Greenspan put". Under severe economic conditions and a high level of market uncertainty, the central bank lowers the policy rate to stimulate economic growth. However, the response of the European Central Bank to an increased level of risk aversion in the German market seems puzzling. Facing a higher level of risk aversion, the European Central bank appears to employ a contractionary monetary stance over the short-term. It may therefore signify the limitations of applying such "single rule policy" among all member states of the Eurozone.

These results appear to be robust, mostly independent from the risk aversion proxy we use for the different markets, as well as the various proxies for monetary policy. Accounting for the business cycle additionally, does not change the empirical results significantly. The results suggest overall that there is evidence that the interest rate policy as conducted by the Bank of England and the ECB before the financial crisis goes beyond the management of the path of future short-term interest rate expectations and has an impact on risk aversion: the policy rate appears to be an important variable in its own right through its impact on the price of risk.

Appendix

Table 1 Description of Variables

Name	Code	Label	Description
UK			
FTSE 100 Volatility Index	VFTSEIX	LVFTSEIX	Ln (VFTSEIX / $\sqrt{12}$)
LONG GILT Future Continuous Call-Implied Vol.	LIGC.SERIESC	Long Gilt	Long Gilt / $\sqrt{12}$
3M EURIBOR Future Continuous Call-Implied Vol.	LEIC.SERIESC	MEURIBORUK	(3M EURIBOR)/ $\sqrt{12}$
Corporate Bond Spread	UKMCRPB	SCOPUK	UK Benchmark corporate bond rate minus Government bond rate
Interest Rate		IRUK	Official bank rate from Bank of England
Real Interest Rate		RIRUK	IR minus CPI inflation rate
Repo Rate		REPOUK	2-week repo rate, end month
Real Repo Rate		RREPOUK	Repo rate minus CPI inflation rate
Taylor Rule Rate		TRRUK	TR=neutral level of the nominal interest rate +1*(CPI-target inflation rate)+1.5*output gap
Deviation from Taylor Rule		DTRUK	IRUK-TRRUK
Average risk aversion Proxy of UK		AvgUK	Simple average of LVFTSEIX, Long Gilt, MEURIBORUK and SCOPUK
Unemployment Rate		UEMPUK	Unemployment rate minus 3-year moving average
Germany			
VDAX-new Volatility Index	VDAXNEW(PI)	LVDAX	Ln (VDAX/ $\sqrt{12}$)
US DOLLAR/EURO Future Continuous Call-Implied Vol.	DEXC.SERIESC	MUS/EURO	(US DOLLAR/EURO)/ $\sqrt{12}$
EURO-SCHATZ Future Continuous Call-Implied Vol.	GEBC.SERIESC	MSCHATZ	(EURO-SCHATZ)/ $\sqrt{12}$
EURO-BUND Future Continuous Call-Implied Vol.	GGEC.SERIESC	MBUND	(EURO-BUND)/ $\sqrt{12}$
EURO-BOBL Future Continuous Call-Implied Vol.	GBEC.SERIESC	MBOBL	(EURO-BOBL)/ $\sqrt{12}$
3M EURIBOR Future Continuous Call-Implied Vol.	GQEC.SERIESC	MEURIBORG	(3M EURIBOR)/ $\sqrt{12}$
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 of Government Bond		AvgGB	Simple average of MSCHATZ, MBUND and MBOBL
Average of Bond Spread		AvgBS	Simple average of SCOP and SMORG
Average Risk Aversion Proxy of Germany		AvgG	Simple average of LVDAX, MUS/EURO, MSCHATZ, MBUND, MBOBL, MEURIBORG, SCOP and SMORG
Real Interest Rate		RIRG	IRG minus CPI inflation rate
Repo rate		REPOG	Overnight rate, monthly average
Real Repo Rate		RREPOG	Repo rate 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		DTRG	IRG-TRRG
Unemployment Rate	BDUN%TOTQ	UEMPG	Unemployment rate minus 3-year moving average

Source: Thomson Datastream, Bank of England, And European Central Bank; the corporate bond spread and mortgage bond spread are employed as measures of market risk aversion as well, see Bekaert et al., (2010) for more detail.

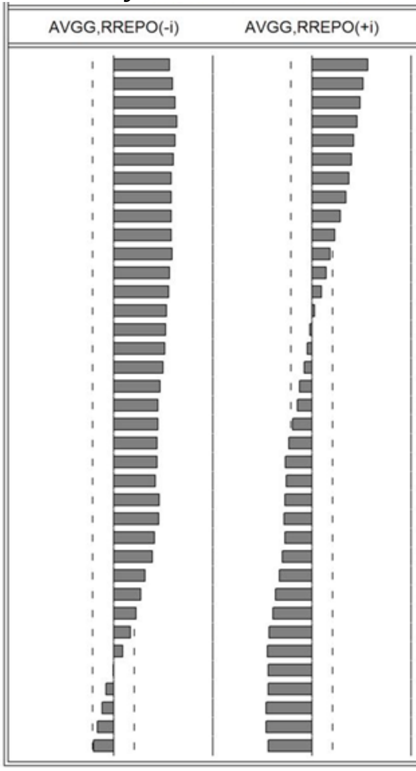
Table 2 Granger causality Test

	F-Statistic	Prob.	Causality Relationship
Germany			
AveG→Real Repo	1.38860	0.25560	Real Repo $\Rightarrow$ AveG
Real Repo→AveG	3.46925	0.03521**	
AveG→Deviation TR	0.33487	0.71647	Deviation TR $\Rightarrow$ AveG
Deviation TR→ AveG	3.33875	0.04069**	
UK			
AveUK→Real Repo	0.44188	0.72368	Real Repo $\Rightarrow$ AveUK
Real Repo→AveUK	2.75575	0.04770**	
AveUK→Deviation TR	0.32095	0.72635	Deviation TR $\Rightarrow$ AveUK
Deviation TR→ AveUK	2.76906	0.06845*	

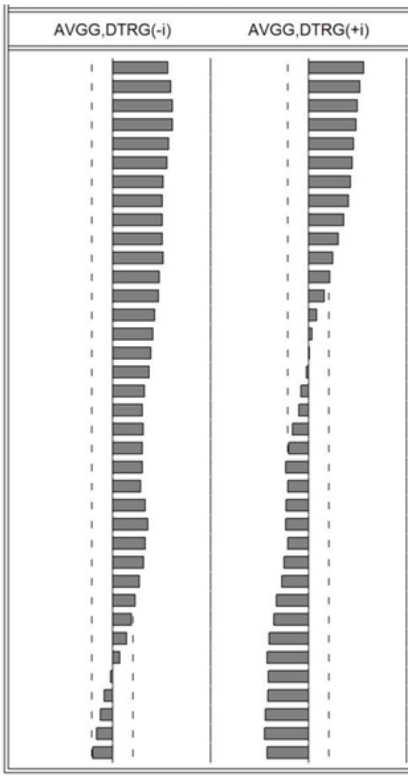
Note: ***, **, * represents that the test hypothesis is rejected at 1%, 5% and 10% levels respectively.

Figure 1 Cross-correlogram between monetary policy and risk aversion indicators

Germany:

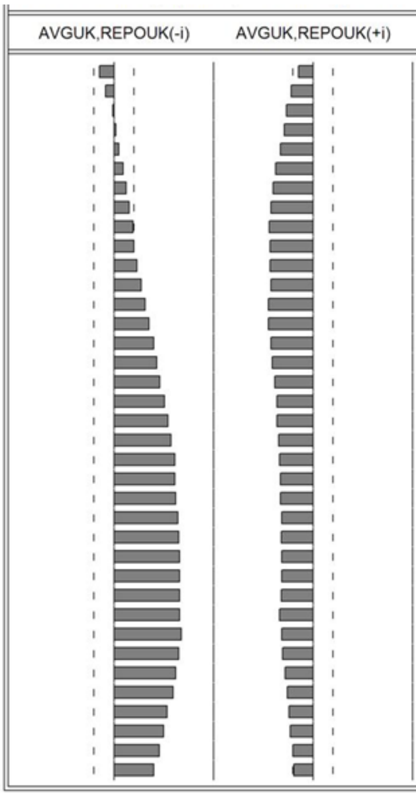


i	lag	lead
0	0.5863	0.5863
1	0.6193	0.5372
2	0.6459	0.5025
3	0.6621	0.4682
4	0.6397	0.4370
5	0.6285	0.4113
6	0.6036	0.3889
7	0.6062	0.3534
8	0.6004	0.3011
9	0.6040	0.2440
10	0.6088	0.1925
11	0.5876	0.1542
12	0.5812	0.0986
13	0.5573	0.0295
14	0.5465	-0.0243
15	0.5330	-0.0473
16	0.5175	-0.0789
17	0.4890	-0.1306
18	0.4622	-0.1528
19	0.4596	-0.2041
20	0.4538	-0.2407
21	0.4514	-0.2740
22	0.4387	-0.2685
23	0.4755	-0.2832
24	0.4716	-0.2933
25	0.4329	-0.2811
26	0.4019	-0.3115
27	0.3339	-0.3409
28	0.2796	-0.3850
29	0.2306	-0.4079
30	0.1738	-0.4458
31	0.0905	-0.4624
32	-0.0075	-0.4522
33	-0.0789	-0.4576
34	-0.1202	-0.4764
35	-0.1659	-0.4783
36	-0.2061	-0.4577

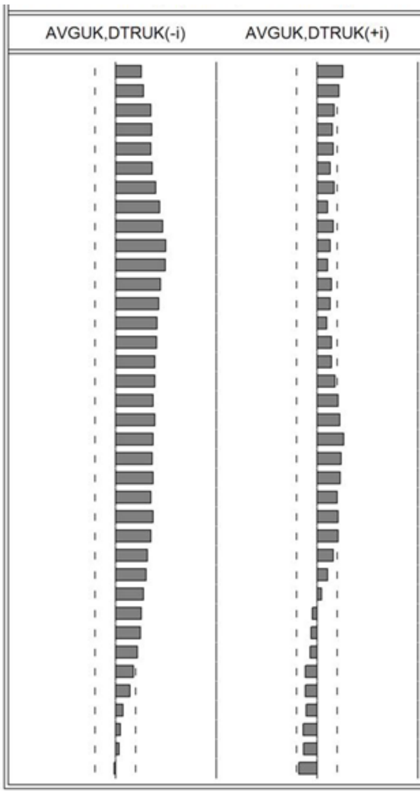


i	lag	lead
0	0.5831	0.5831
1	0.6151	0.5450
2	0.6337	0.5200
3	0.6390	0.5008
4	0.5954	0.4765
5	0.5800	0.4631
6	0.5379	0.4499
7	0.5310	0.4217
8	0.5262	0.3751
9	0.5275	0.3173
10	0.5346	0.2619
11	0.4981	0.2293
12	0.4865	0.1710
13	0.4478	0.0862
14	0.4321	0.0331
15	0.4056	0.0158
16	0.3872	-0.0172
17	0.3439	-0.0780
18	0.3127	-0.1008
19	0.3238	-0.1657
20	0.3163	-0.2071
21	0.3126	-0.2391
22	0.2992	-0.2194
23	0.3512	-0.2343
24	0.3722	-0.2421
25	0.3461	-0.2166
26	0.3345	-0.2541
27	0.2811	-0.2856
28	0.2383	-0.3391
29	0.1986	-0.3660
30	0.1505	-0.4160
31	0.0741	-0.4358
32	-0.0183	-0.4188
33	-0.0822	-0.4283
34	-0.1241	-0.4583
35	-0.1686	-0.4595
36	-0.2099	-0.4398

UK:



i	lag	lead
0	-0.1525	-0.1525
1	-0.0829	-0.2258
2	-0.0145	-0.2730
3	0.0181	-0.2986
4	0.0507	-0.3415
5	0.0942	-0.3881
6	0.1285	-0.4116
7	0.1629	-0.4425
8	0.2030	-0.4512
9	0.2124	-0.4443
10	0.2445	-0.4482
11	0.2830	-0.4389
12	0.3272	-0.4608
13	0.3607	-0.4632
14	0.4133	-0.4398
15	0.4429	-0.4220
16	0.4779	-0.3954
17	0.5303	-0.3758
18	0.5621	-0.3770
19	0.5909	-0.3591
20	0.6349	-0.3466
21	0.6320	-0.3402
22	0.6437	-0.3366
23	0.6693	-0.3279
24	0.6769	-0.3296
25	0.6848	-0.3275
26	0.6862	-0.3232
27	0.6860	-0.3335
28	0.6884	-0.3444
29	0.6975	-0.3218
30	0.6760	-0.3115
31	0.6428	-0.2915
32	0.6171	-0.2638
33	0.5565	-0.2476
34	0.5170	-0.2334
35	0.4750	-0.2077
36	0.4177	-0.2012



i	lag	lead
0	0.2626	0.2626
1	0.2913	0.2252
2	0.3621	0.1739
3	0.3763	0.1622
4	0.3646	0.1653
5	0.3790	0.1357
6	0.4122	0.1783
7	0.4550	0.1124
8	0.4868	0.1680
9	0.5229	0.1315
10	0.5119	0.1068
11	0.4666	0.1513
12	0.4464	0.1367
13	0.4279	0.1024
14	0.4246	0.1553
15	0.4028	0.1503
16	0.4018	0.1870
17	0.3886	0.2181
18	0.4058	0.2364
19	0.3856	0.2743
20	0.3782	0.2495
21	0.3860	0.2392
22	0.3673	0.2062
23	0.3929	0.2170
24	0.3620	0.2148
25	0.3293	0.1647
26	0.3139	0.1069
27	0.2911	0.0472
28	0.2703	-0.0414
29	0.2614	-0.0597
30	0.2283	-0.0706
31	0.1847	-0.1150
32	0.1534	-0.1196
33	0.0784	-0.1093
34	0.0496	-0.1395
35	0.0361	-0.1342
36	-0.0110	-0.1834

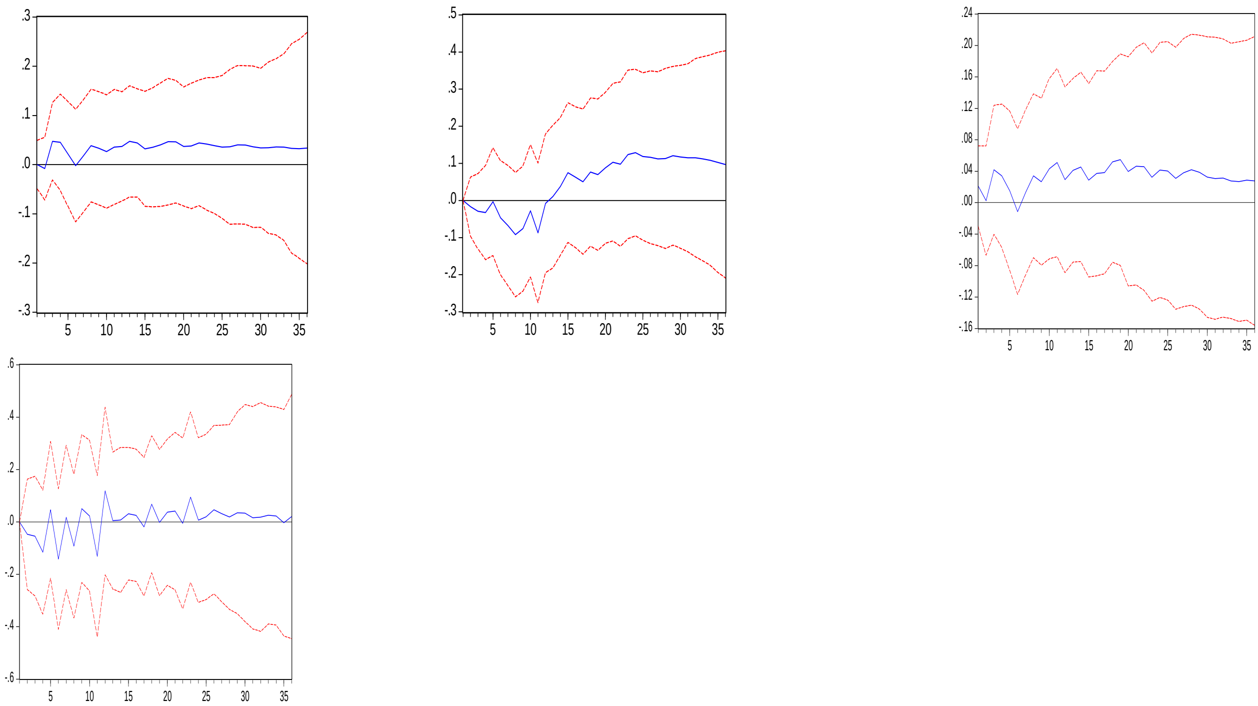
Notes: the first column of each graph presents the lagged cross-correlogram between the log of risk aversion proxy and past values of real repo rate. The second column presents the lead cross-correlogram between risk aversion proxy and future values of real repo rate. The third column presents the corss-correlation values. The index i indicates the number of months either lagged or led for the real repo rate.

Bivariate VAR

Figure 2a Reduced-form Impulse Response Functions: UK

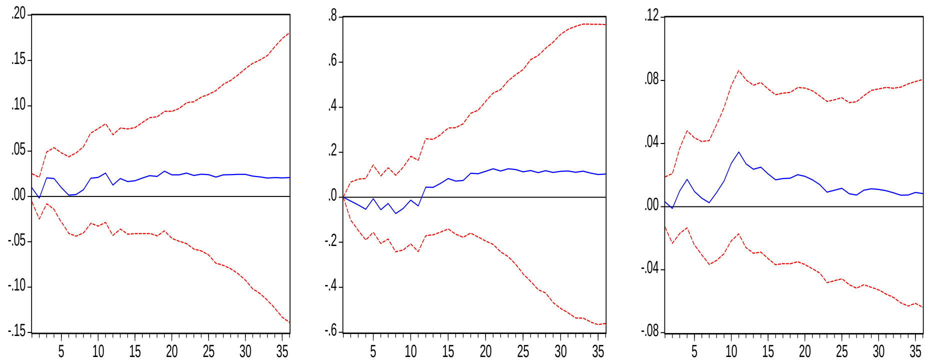
Stock market: VFTSEIX

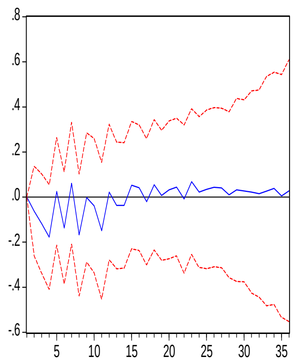
RREPOUK→LVFTSEIX LVFTSEIX→RREPOUK(16) DTRUK→LVFTSEIX LVFTSEIX→DTRUK (2)



Average Risk Aversion Proxy

RREPOUK→AvgUK AvgUK→RREPOUK(8) DTRUK→ AvgUK AvgUK→DTRUK(1)



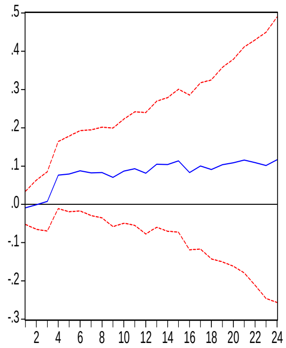


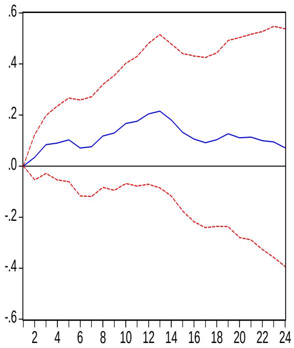
Note: The lag length is determined by the selection criteria, LR, AIC and SQ. Following the study of Bekaert et al. (2010), we choose a longer lag length as it generates a clearer IPR result and eliminates all serial correlation in the residuals. The number in the bracket represents the period of significance. Otherwise, it means that the IPR relationship is significant for the whole testing period.

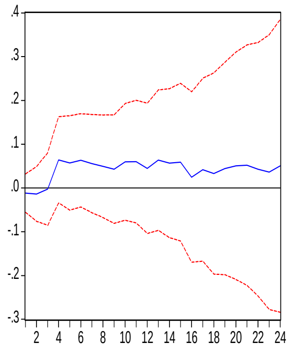
Figure 2b Reduced-form Impulse Response Functions: Germany

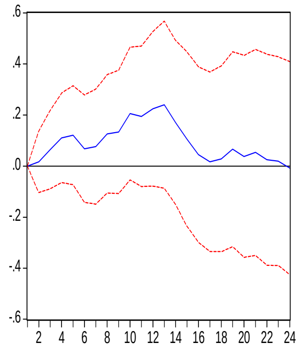
Stock Market: LVDAX

RREPOG→LVDAX(17) LVDAX→ RREPOG (6) DTRG→ LVDAX (17) LVDAX → DTRG (4)



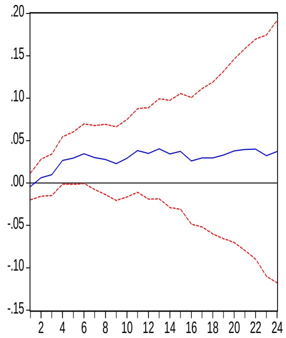


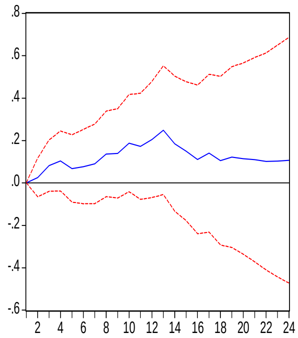


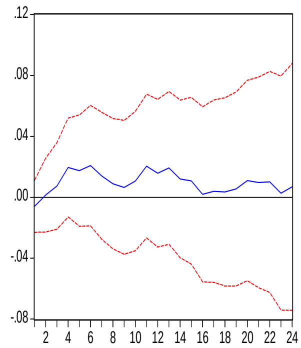


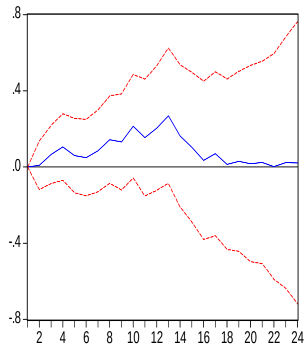
Average of Risk Aversion Proxy

RREPOG→ AvgG AvgG→RREPOG (6) DTRG → AvgG AvgG → DTRG (5)









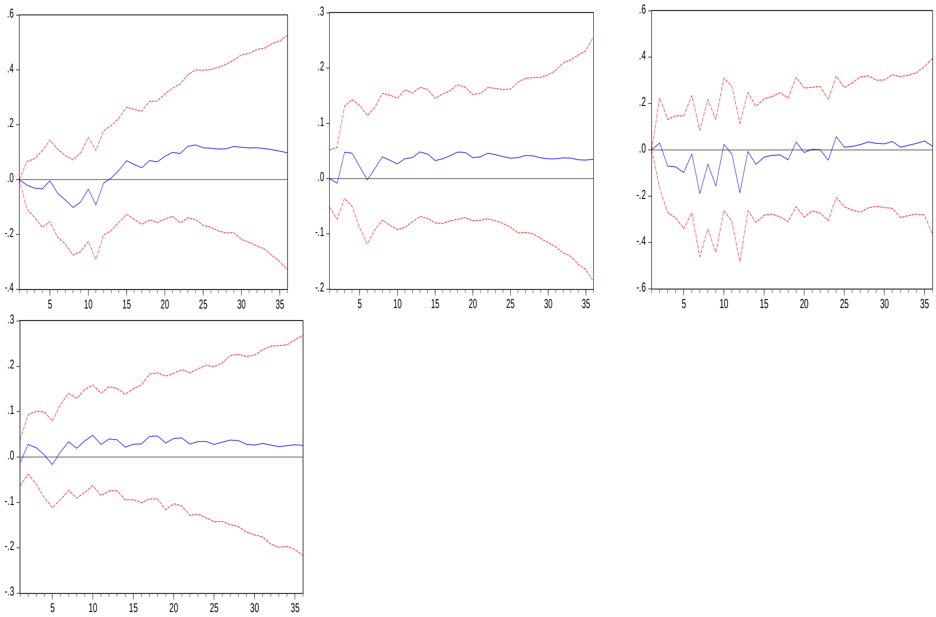
Structural VAR

Figure 3 Structural-form IRFs for UK and Germany

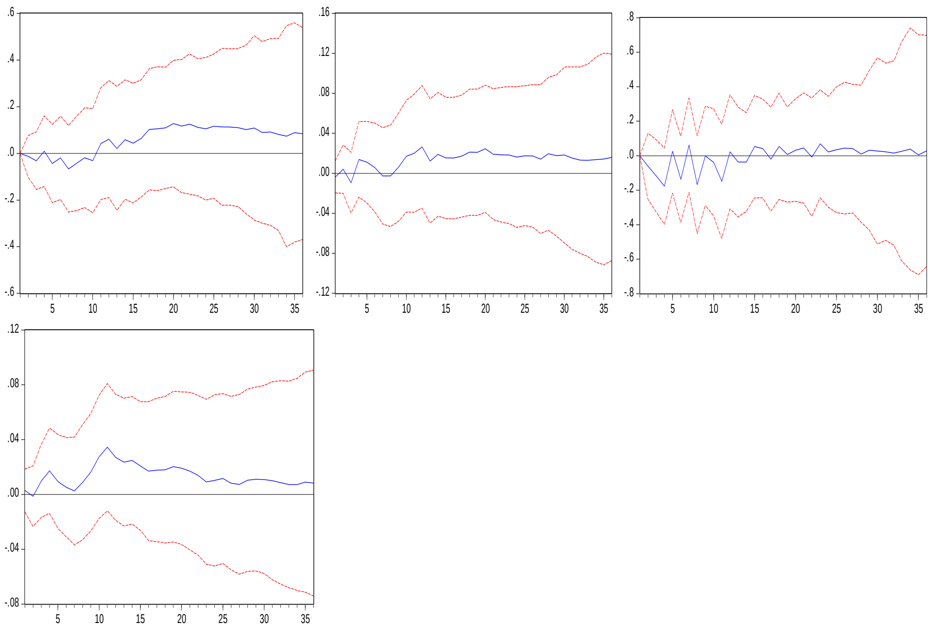
UK

Long-run restrictions

LVFTSEIX →RREPOUK(11) RREPOUK→LVFTSEIX LVFTSEIX → DTRUK(2) DTRUK→LVFTSEIX

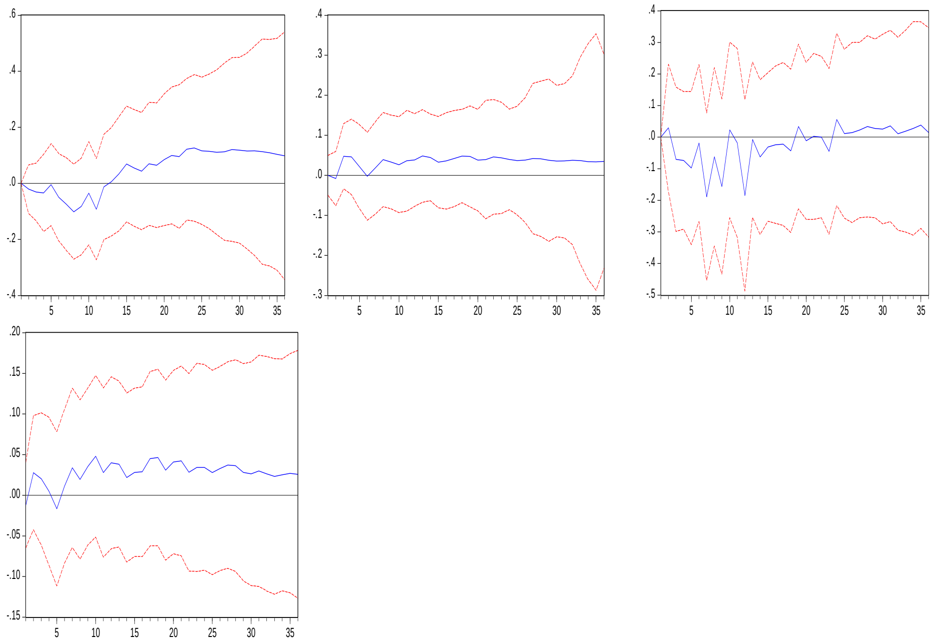


AvgUK→RREPOUK(8) RREPOUK→ AvgUK AvgUK → DTRUK(2) DTRUK→ AvgUK

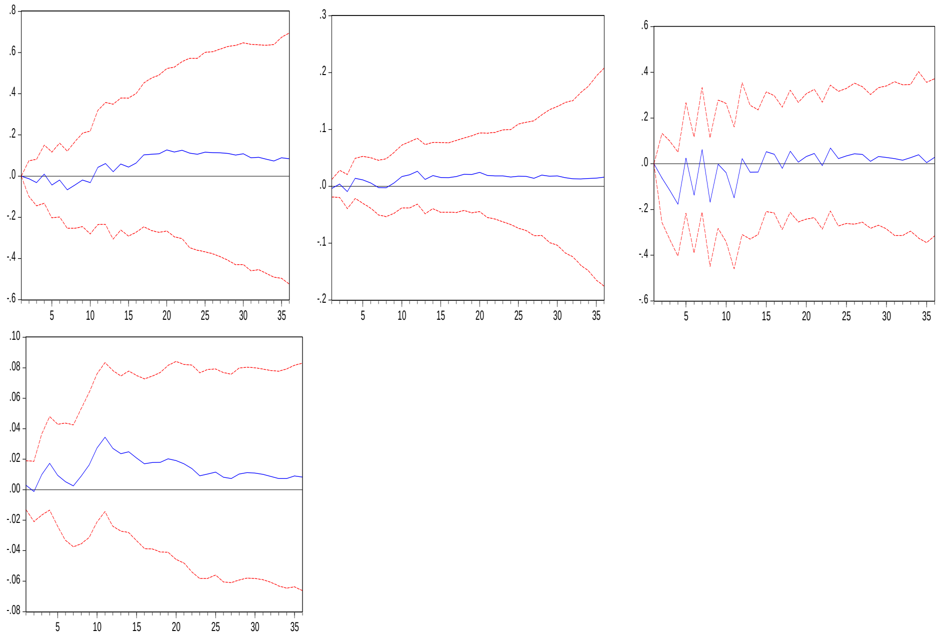


Short-run restrictions

LVFTSEIX→RREPOUK(10) RREPOUK→LVFTSEIX(30) LVFTSEIX → DTRUK(2) DTRUK→LVFTSEIX



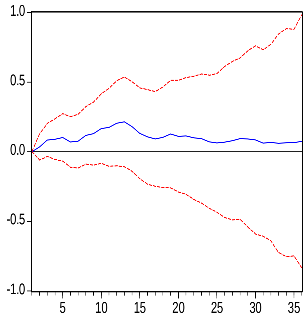
AvgUK →RREPOUK (7) RREPOUK→AvgUK(33) AvgUK → DTRUK (2) DTRUK→ AvgUK

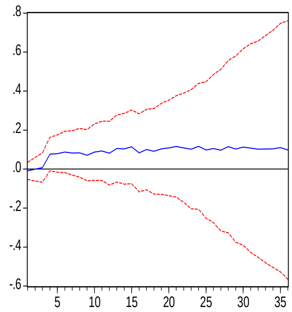


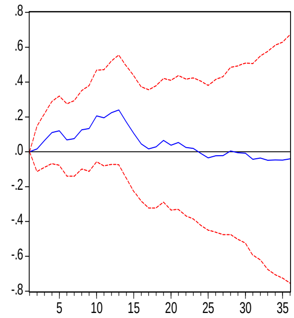
Germany

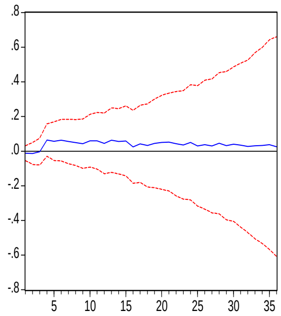
Long-run restrictions

LVDAX →RREPOG(6) RREPOG→ LVDAX(12) LVDAX → DTRG(4) DTRG→ LVDAX (17)

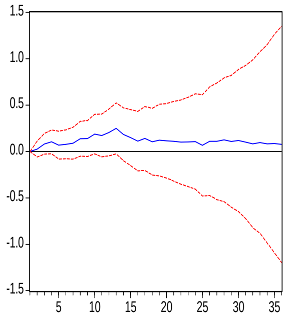


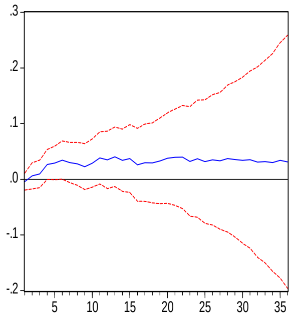


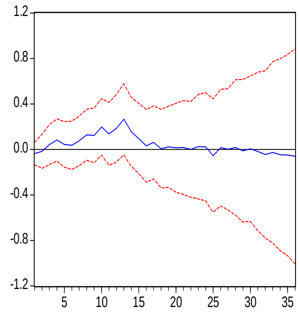


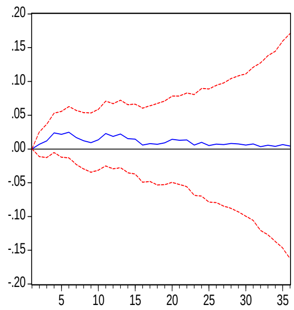


AvgG→RREPOG(7) RREPOG→AvgG (24) AvgG → DTRG(4) DTRG→ AvgG (26)



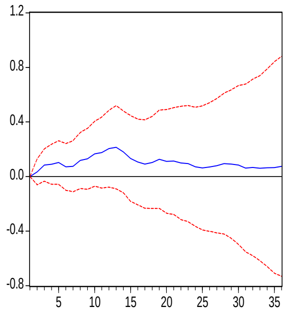


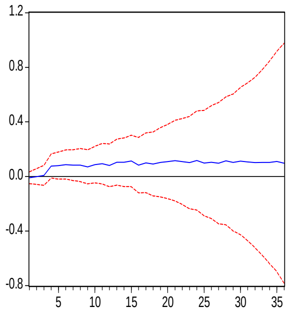


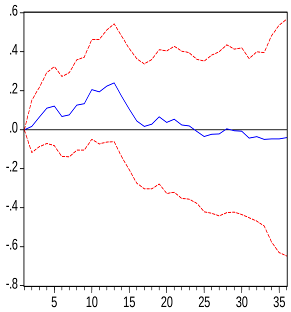


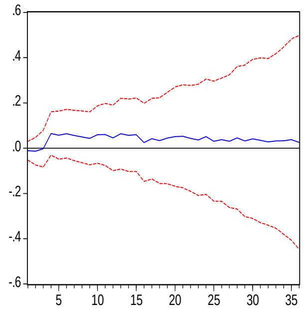
Short-run restrictions

LVDAX →RREPOG(7) RREPOG→ LVDAX(16) LVDAX → DTRG(4) DTRG→ LVDAX(17)

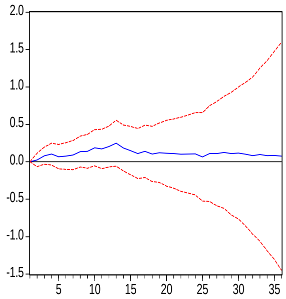


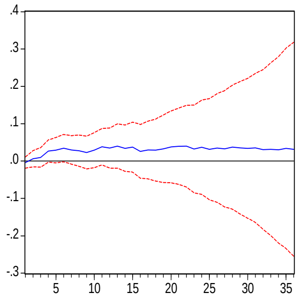


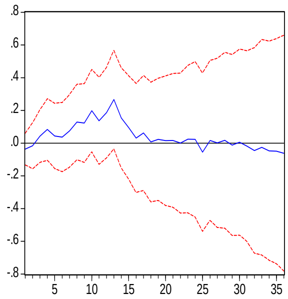




AvgG→RREPOG(8) RREPOG→ AvgG(25) AvgG → DTRG(4) DTRG→ AvgG (36)







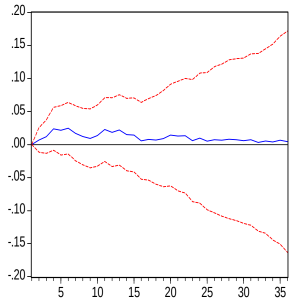


Table 3 Granger causality Test including Business Cycle Proxy

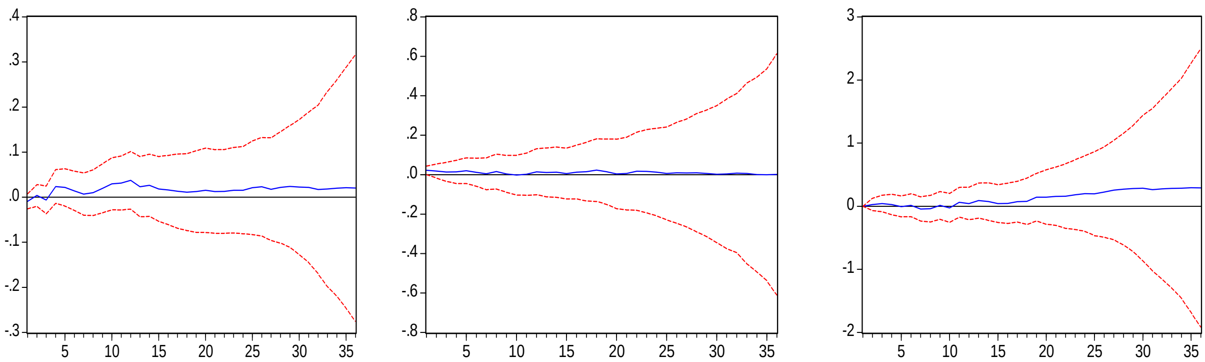
	F-Statistic	Prob.	Causality Relationship
Germany			
AveG →Real RepoG	1.38860	0.25560	X
→UnempG	7.9065	0.0062***	AveG ⇒ UnempG
Real RepoG→AveG	3.46925	0.03521**	Real RepoG ⇒ AveG
→UnempG	3.17143	0.0787*	Real RepoG ⇒ UnempG
UnempG→ AveG	1.55642	0.2158	X
→ Real RepoG	5.26561	0.0244**	UnempG⇒ Real RepoG
UK			
AveUK →Real RepoUK	0.44188	0.72368	X
→UnempUK	0.41113	0.6642	X
Real RepoUK→AveUK	2.75575	0.04770**	Real RepoUK ⇒ AveUK
→UnempUK	2.66807	0.0753*	Real RepoUK ⇒ UnempUK
UnempUK→ AveUK	0.40458	0.6685	X
→Real RepoUK	0.60051	0.5509	X

Note: ***, **, * represents that the test hypothesis is rejected at 1%, 5% and 10% levels respectively.

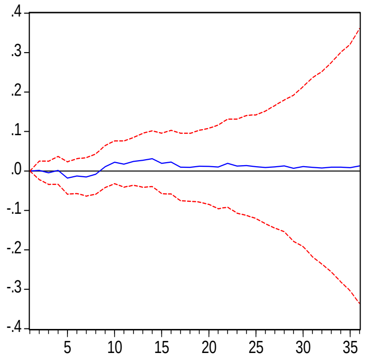
Figure 4 Impulse Response Functions taking account of Business Cycles: UK and Germany

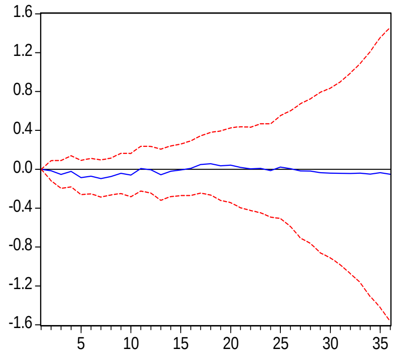
UK

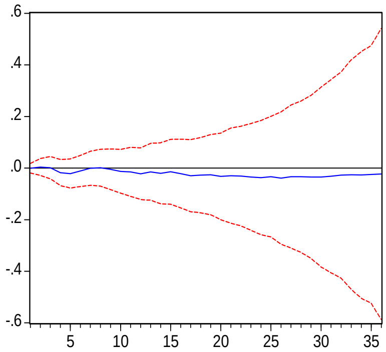
RREPOUK→ AvgUK(30)　　RREPOUK→UnempUK(23)　　UnempUK→RREPOUK(6)



UnempUK→ AvgUK(24) AvgUK→RREPOUK(9) AvgUK→ UnempUK(13)

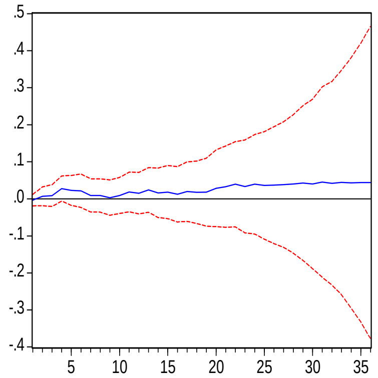


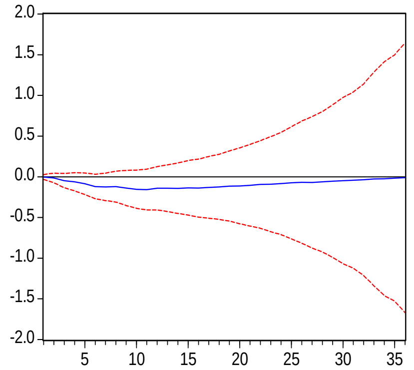


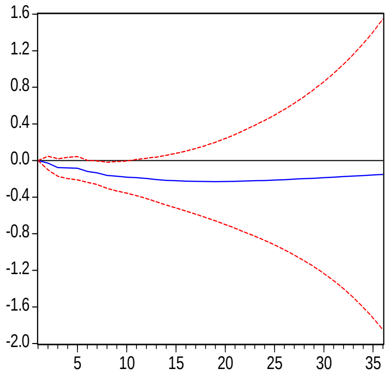


Germany

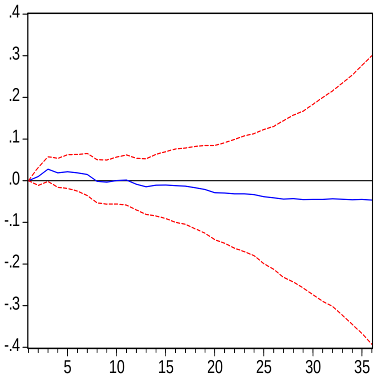
RREPOG→ AvgG(29) RREPOG→UnempG(8) UnempG→RREPOG(10)



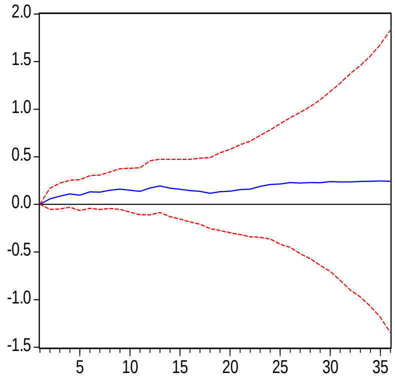




UnempG→ AvgG(25)



AvgG→RREPOG(6)



AvgG→ UnempG(7)

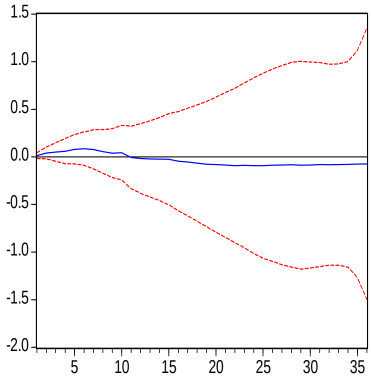
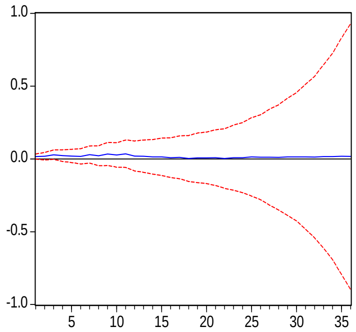


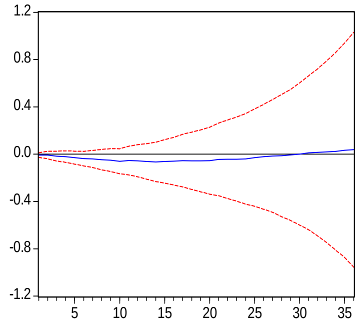
Figure 5 Impulse Response Functions-- DAMP: UK and Germany

UK

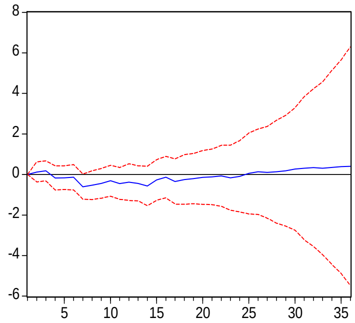
DAMPUK→ AvgUK(19)



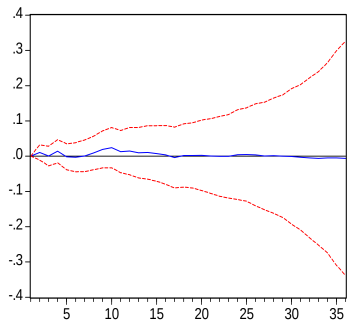
DAMPUK→UnempUK(15)



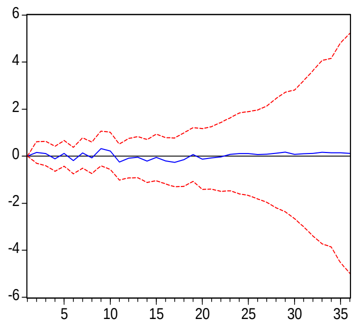
UnempUK→ DAMPUK (1)



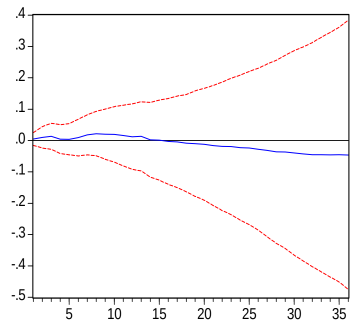
UnempUK→ AvgUK(28)



AvgUK→ DAMPUK (1)

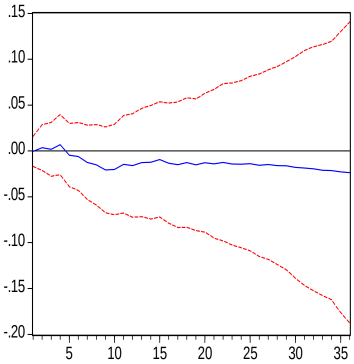


AvgUK→ UnempUK(20)

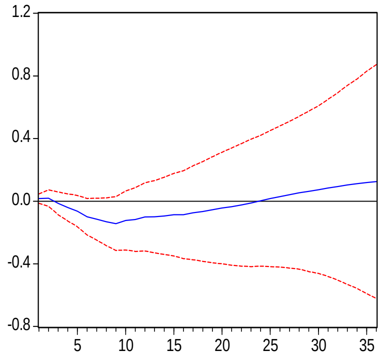


Germany

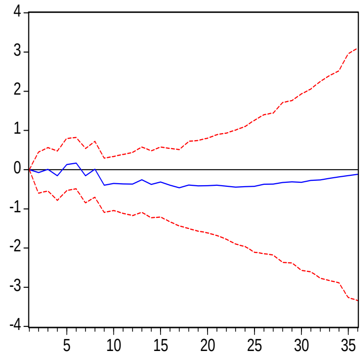
DAMPG→ AvgG(29)



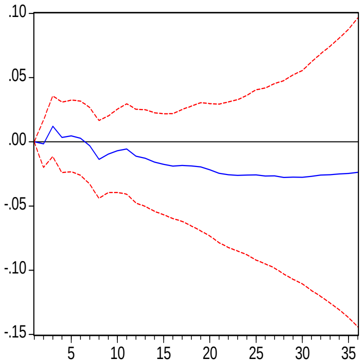
DAMPG →UnempG(9)



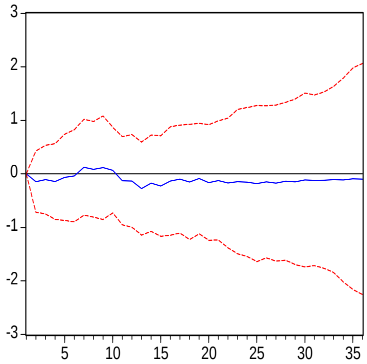
UnempG→ DAMPG (1)



UnempG→ AvgG(36)



AvgG→ DAMPG (1)



AvgG→ UnempG(12)

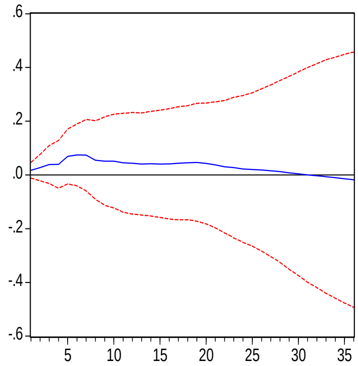
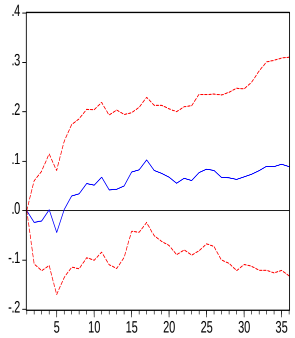
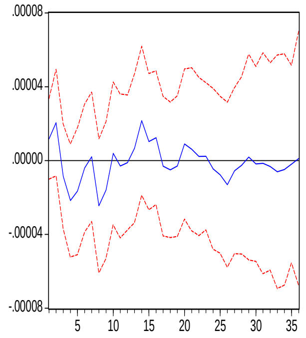


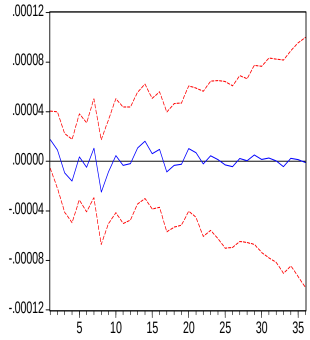
Figure 6 Reduced-form Impulse Response Functions of risk aversion and monetary policy: UK

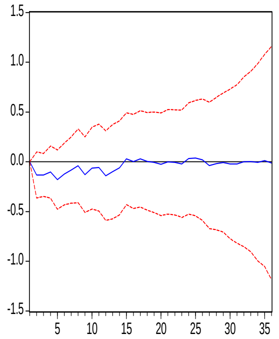
Government bond: Long Gilt

RREPOUK→Long Gilt | Long Gilt→RREPOUK | DTRUK→ Long Gilt | Long Gilt→DTRUK (1)



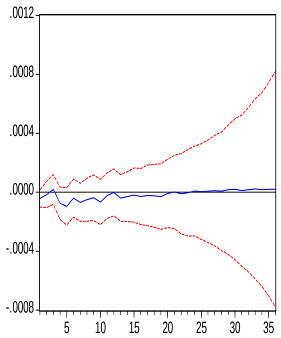


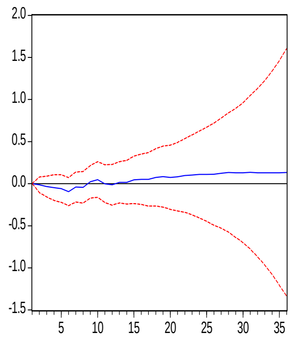


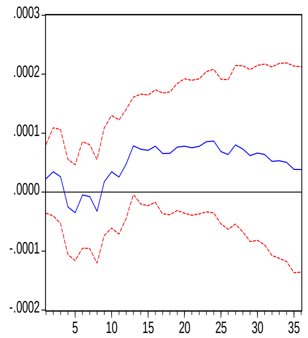


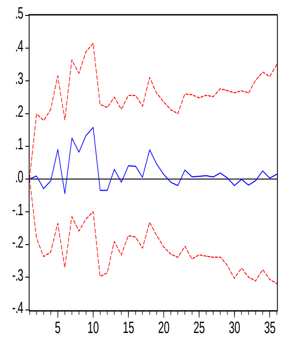
Money Market: EURIBOR

RREPOUK→ Euribor | Euribor→ RREPOUK (7) | DTRUK→Euribor | Euribor → DTRUK (2)









Spread of Government Bond and Corporate Bond

RREPOUK→SCOP (21) SCOP → RREPOUK (8) DTRUK→ SCOP SCOP → DTRUK (2)

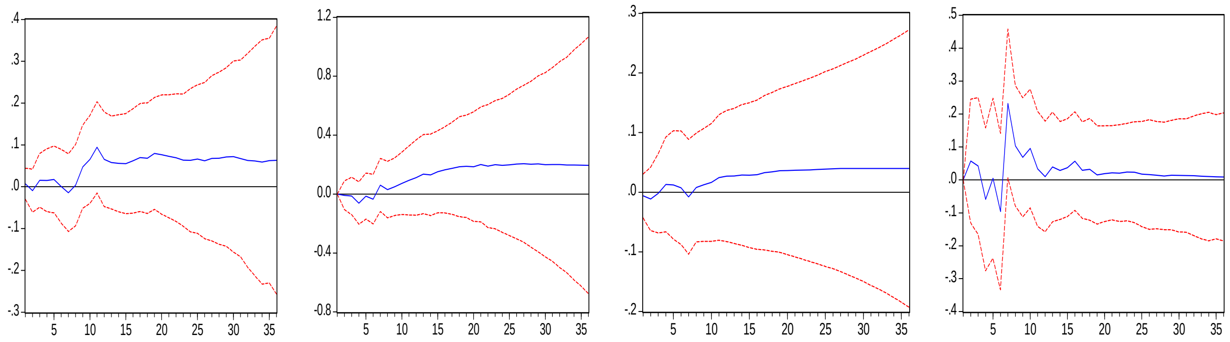
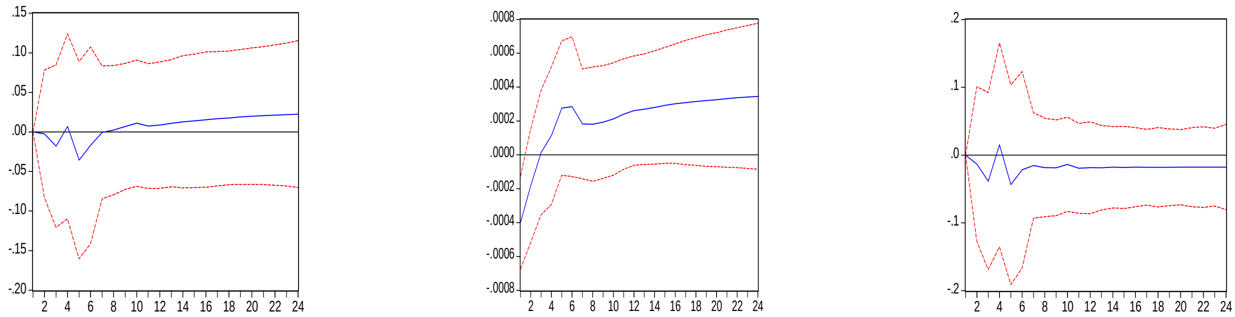


Figure 7 Reduced-form Impulse Response Functions of risk aversion and monetary policy: Germany

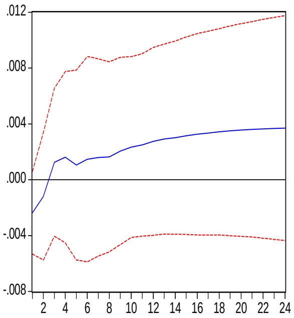
Government Bond: AvgGB

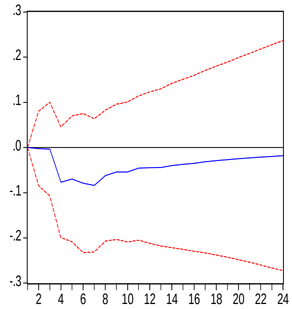
AvgGB→ RREPOG RREPOG→ AvgGB AvgGB → DTRG DTRG→ AvgGB

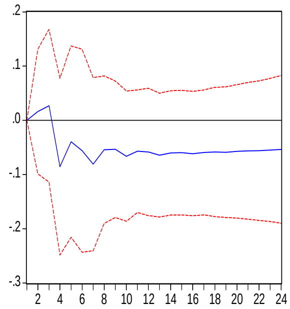


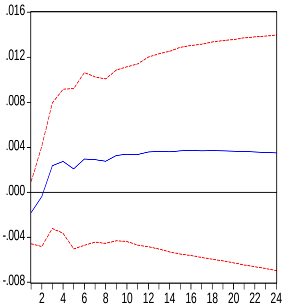
Money Market: EURIBOR

RREPOG→ Euribor   Euribor→ RREPOG (20)   Euribor → DTRG   DTRG→ Euribor



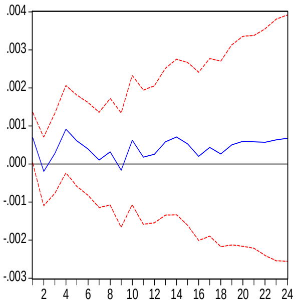


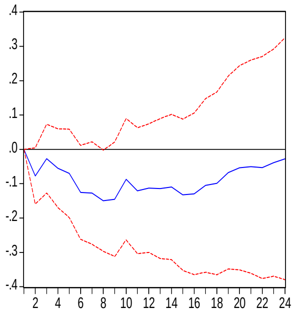


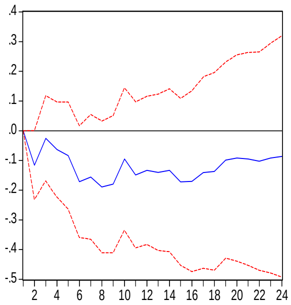


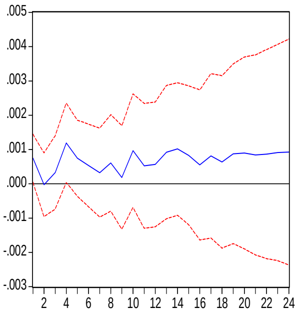
Currency: DOLLAR/EURO

RREPOG→Dollar-Euro Dollar-Euro→RREPOG (12) Dollar-Euro→DTRG (7)   DTRG→ Dollar-Euro



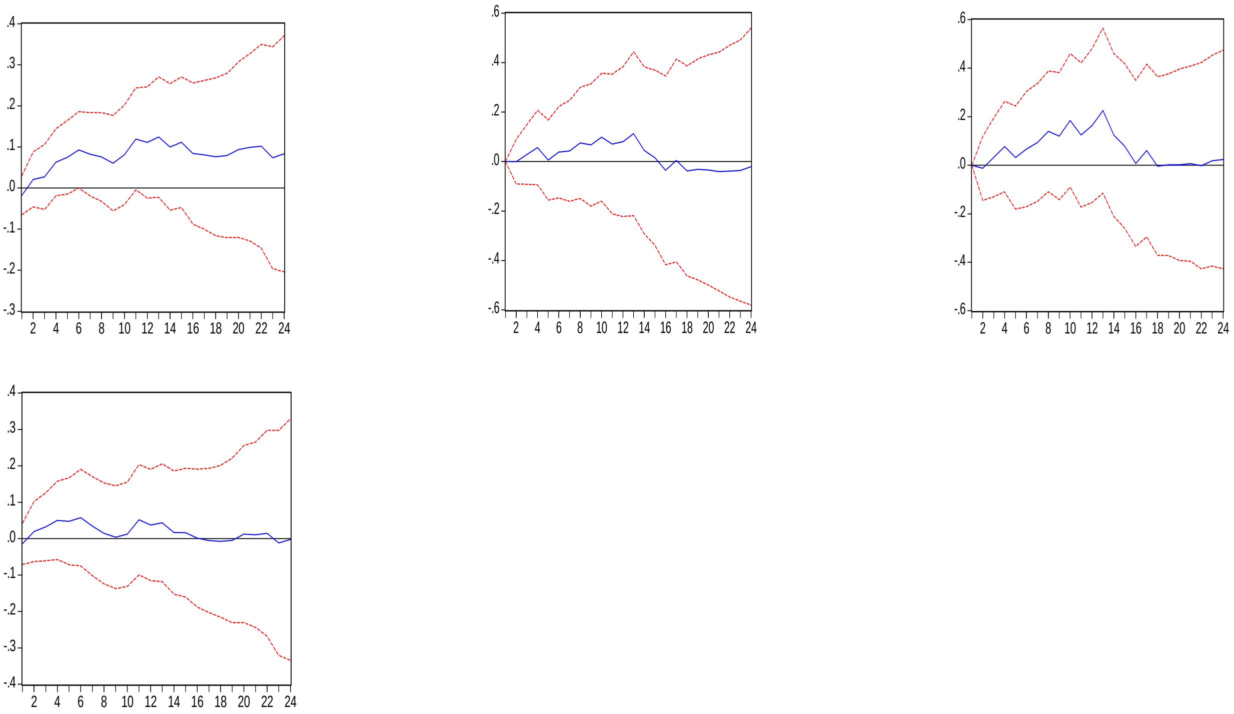






Average Spread over Government Bond

RREPOG→ AvgS (18)   AvgS → RREPOG (10)   AvgS → DTRG (4)   DTRG→ AvgS(16)



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