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The real effects of financial stress in the Eurozone

Sushanta K. Mallick[#] *Ricardo M. Sousa*[§]

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Abstract

Using two identification strategies based on a Bayesian Structural VAR and a Sign-Restriction VAR, we examine the real effects of financial stress in the Eurozone. In particular, we assess the macroeconomic impact of: (i) a monetary policy shock; and (ii) a financial stress shock. We find that a monetary policy contraction strongly deteriorates financial stress conditions. In addition, unexpected variation in the Financial Stress Index (FSI) plays an important role in explaining output fluctuations, and also demands an aggressive response by the monetary authority to stabilise output indicating a preference shift from targeting inflation as it is currently happening in major economies. Therefore, our paper reveals the importance of adopting a vigilant posture towards financial stress conditions, as well as the urgency of macro-prudential risk management.

Keywords: monetary policy, financial stress, Bayesian Structural VAR, Sign-Restrictions, Euro-zone.

JEL classification: E37, E52.

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1. Introduction

The most recent financial crisis, which began in the US in the summer of 2007 with the bursting of the sub-prime mortgage market, unleashed a full-blown systemic crisis with global risk aversion dramatically increasing, and asset markets across countries and regions plunging, in particular, after the collapse of Lehman Brothers in September 2008. Stock markets tumbled in all regions, large fiscal stimulus packages were implemented posing enormous challenges to long-run fiscal sustainability, while at the same time spreads on sovereign debt widened and currency markets came under pressure. Even market economies with sound macroeconomic and financial preconditions built-up over the previous years were strongly affected.

The initial contagion from the US to international financial markets quickly morphed into real sector problems and revealed the strength of the linkages between the financial system, the housing sector, the banking sector and the credit market (Martin and Milas, 2010). Such a rapid spillover from the financial to the real sector, whereby many countries saw their domestic industrial production, investment rates and, more generally, their GDP growth rate plunging, suggests that the nexus between monetary stability and financial stability may be strong (Granville and Mallick, 2009; Castro 2010a; Sousa, 2010a, 2010b) and that financial stress conditions can have an important impact on domestic demand and the likelihood of "boom-bust" episodes and expansion and contraction ending (Castro, 2010b).

Moreover, in the wake of the financial crisis, policy priority has apparently shifted towards stabilising the financial system and aiding economic recovery rather than targeting inflation. Financial stability has become an important explicit goal for Central banks. As monetary policies are primarily designed to promote price stability,

there could be exogenous finance shocks due to systemic risks in the financial system that could cause financial stress, which in turn can dampen macroeconomic activity.

Following a related line of thinking in the literature, the proposition that monetary innovations do not have long-run real effects is far from unequivocally established (Espinosa-Vega, 1998). In this context, long-run monetary neutrality has been a key building block of mainstream business cycle research (Taylor, 1995; Aksoy and León-Ledesma, 2005). If money is neutral in the long-run, financial shocks that could be due to build up of monetary bubbles should have no effect on the real economy. But as we have seen in the recent financial crisis of 2007-2009, the crisis or the imbalances in financial markets reflected in an unexpected financial shock do have noticeable impact on macroeconomic activity, suggesting that the monetary bubble before the current crisis has possibly led to the observed non-neutrality outcome. The turmoil in financial markets has, therefore, renewed this debate on the potential spillover effects from the financial sector to the real economy. This paper contributes to this debate by providing new evidence on the linkages between financial and monetary policy shocks, as financial innovations can obscure the relationship between monetary policy and real activity.

In this paper, we therefore aim at assessing the impact of a financial shock alongside other macroeconomic shocks in the Eurozone. A financial shock is designed here as an innovation in the Financial Stress Index (ECB, 2009; IMF, 2008, 2009), which we build using country-level information on financial stress conditions following the work of Cardarelli *et al.* (2011). Extreme values in this Financial Stress Index (FSI) indicate financial crises.

So we set up a Vector Auto-Regressive (VAR) model with 6 key macroeconomic variables: the interest rate (that is, the policy rate); a set of

macroeconomic variables that adjust to the shock with a lag (real GDP, inflation rate, and the commodity price); and a set of variables that react contemporaneously to the policy shock (the growth rate of the monetary aggregate, and the Financial Stress Index) with the goal of identifying the macroeconomic effects of a shock to monetary policy and a shock to financial stress conditions, focusing on the Eurozone as a monetary union.

Monetary policy can operate through both an interest rate and liquidity channel. A liquidity measure is included along with interest rate and FSI, as it is a key variable measuring financial stability. Monetary policy decisions to improve liquidity conditions can be unsuccessful, if decreasing interest rate to raise liquidity results in higher inflation, the so-called *paradox of credibility*. So it is the liquidity channel that must be identified and should be monitored to detect signs of instability. This requires estimating the effect of monetary or more recent quantitative easing technique to explore whether easing liquidity conditions can generate any inflationary pressure at a time of depressed real sector, along with uncovering the effect of financial shocks.

The broad concern of monetary policy in Eurozone is to maintain price stability. Any analysis of monetary policy behaviour should include both interest rates and money growth in the empirical exercise, as well as the inflation rate. The consideration of commodity prices in the VAR is explained by the need for eliminating the price puzzle by the inclusion of such forward looking variable that captures expected inflation.

We contribute to the literature in two important respects: (i) we look explicitly at the real effect of financial shocks; and (ii) we use different identification strategies to jointly identify monetary and financial shocks as both could have implications for

monetary liquidity in the system and, hence, liquidity crises may spill over to other macroeconomic variables.

We identify the monetary policy and the financial stress shocks using modern estimation techniques, namely, the Bayesian Structural Vector Auto-Regressive (B-SVAR) and the Sign-Restrictions VAR and, thereby, account for the uncertainty about the impulse-response functions. We, therefore, identify simultaneously and uniquely contractionary monetary policy shocks and an adverse finance shock to examine their real effects. We provide evidence that finance shock plays a dominant role in explaining output fluctuations relative to monetary policy shocks.

We show that a monetary policy contraction: (i) strongly deteriorates financial stress conditions; (ii) has a negative effect on output; (iii) leads to a quick fall in the commodity price, but the aggregate price level exhibits strong persistence; and (iv) produces a small liquidity effect. As for the shock to financial stress conditions, it: (i) has a contractionary effect on output; (ii) negatively impacts on the commodity price and the inflation rate; and (iii) generates a strong fall in the interest rate.

In addition, we find that episodes of an increase in financial stress demand a strong response by the monetary authority, namely, via the adoption of expansionary policies. It is evident from our results that the interest rate channel seems to have changed in the post-euro period, while the asset market channel (the financial stress effects of monetary policy) does appear more important. This means low inflation could exist alongside bubbles in house or stock markets. For example, lower interest rates could push loans, reduce the bank deposit-loan ratio and increase probabilities of turmoil events in financial markets.

Finally, the empirical results suggest that variation in financial stress conditions is largely unexpected. Nevertheless, our framework seems to capture pretty well the

developments of the 2008-2009 financial turmoil. In particular, they highlight the importance of adopting a vigilant posture towards financial stress conditions, as well as the urgency of macro-prudential risk management.

The rest of the paper is organized as follows. Section 2 presents the estimation methodologies and Section 3 describes the data. Section 4 discusses the empirical results. Finally, Section 5 concludes with the main findings of the paper and the policy implications.

2. Estimation Methodology

2.1. The B-SVAR Framework

We estimate the following Structural VAR (SVAR)

$$\underbrace{\Gamma(L)}_{n \times n} \underbrace{X_t}_{n \times 1} = \Gamma_0 X_t + \Gamma_1 X_{t-1} + \dots = \mathbf{c} + \varepsilon_t \quad (1)$$

$$v_t = \Gamma_0^{-1} \varepsilon_t, \quad (2)$$

where $\varepsilon_t | X_s, s < t \sim N(\underline{0}, \Lambda)$, $\Gamma(L)$ is a matrix valued polynomial in positive powers of the lag operator L , n is the number of variables in the system, ε_t are the fundamental economic shocks that span the space of innovations to X_t , and v_t is the VAR innovation.

Monetary policy can be characterized as

$$i_t = f(\Omega_t) + \varepsilon_t^i \quad (3)$$

where, i_t is the Central Bank rate, f is a linear function, Ω_t is the information set, and ε_t^i is the interest rate shock.

We consider a recursive identification scheme and assume that the variables in X_t can be separated into 3 groups: (i) a subset of n_1 variables, X_{1t} , which do not respond contemporaneously to the monetary policy shock; (ii) a subset of n_2 variables, X_{2t} , that

respond contemporaneously to it; and (iii) the policy instrument in the form of the Central Bank rate, i_t .

As in Christiano et al. (2005), the recursive assumptions can be summarized by

$\mathbf{X}_t = [\mathbf{X}_{1t}, i_t, \mathbf{X}_{2t}]$ and

$$\Gamma_0 = \begin{bmatrix} \underbrace{\gamma_{11}}_{n_1 \times n_1} & \underbrace{\mathbf{0}}_{n_1 \times 1} & \underbrace{\mathbf{0}}_{n_1 \times n_2} \\ \underbrace{\gamma_{21}}_{1 \times n_1} & \underbrace{\gamma_{22}}_{1 \times 1} & \underbrace{\mathbf{0}}_{1 \times n_2} \\ \underbrace{\gamma_{31}}_{n_2 \times n_1} & \underbrace{\gamma_{32}}_{n_2 \times 1} & \underbrace{\gamma_{33}}_{n_2 \times n_2} \end{bmatrix}. \quad (4)$$

Finally, the impulse-response function to a one standard-deviation shock under the normalization of $\Lambda = \mathbf{I}$ is given by:

$$\mathbf{B}(L)^{-1} \Gamma_0^{-1}, \quad (5)$$

We use a Monte Carlo Markov-Chain (MCMC) algorithm to assess uncertainty about its distribution. We construct probability intervals by drawing from the Normal-Inverse-Wishart posterior distribution of $B(L)$ and Σ

$$\beta |_{\Sigma} \sim \mathbf{N}(\hat{\beta}, \Sigma \otimes (\mathbf{X}' \mathbf{X})^{-1}) \quad (6)$$

$$\Sigma^{-1} \sim \text{Wishart}((T \hat{\Sigma})^{-1}, T - m) \quad (7)$$

where $B(L)$ is a matrix valued polynomial in positive powers of the lag operator L associated with the regression coefficients, β is the vector of regression coefficients in the VAR system, Σ is the covariance matrix of the residuals, the variables with a hat are the corresponding maximum-likelihood estimates, X is the matrix of regressors, T is the sample size and m is the number of estimated parameters per equation.

2.2. The Sign-Restrictions Approach

In this section, we describe the method in estimating the effects of unexpected shocks by means of Sign-Restrictions, following Uhlig (2005) and Mountford and Uhlig (2009). Identification via Sign-Restrictions is relevant in this context, as our objective is to investigate the effect of shocks due to surprise movements in interest rates and financial stress, by designing two shocks via restrictions on the variables in the VAR. This can help provide a better structural interpretation of shocks. Consider the reduced-form VAR that has a MA representation as follows:

$$\begin{aligned} Y_t &= A_1 Y_{t-1} + u_t \\ \Rightarrow Y_t &= (I - A_1 L)^{-1} u_t = B(L)u_t \end{aligned} \quad (8)$$

where the vector Y includes the changes in commodity price, output growth, inflation, short-term interest rate, money growth, and the financial stress index. $B(L)$ is a lag polynomial of order p . The usual SVAR approach assumes that the error terms, u_t , are related to structural macroeconomic shocks, v_t , via a matrix P : $u_t = P v_t$. The covariance matrix of the vector of reduced-form residuals u is denoted as Σ . Identification in the structural VAR literature amounts to providing enough restrictions to uniquely solve for the following decomposition of the $n \times n$ estimated covariance matrix of the reduced-form VAR residuals Σ .

$$\Sigma = E[u_t, u_t'] = P E[v_t v_t'] P' = P P'. \quad (9)$$

This defines a one-to-one mapping from the vector of orthogonal structural shocks v to the reduced-form residuals u . The j th column of the identifying matrix P , λ , is called an impulse vector, as it maps the innovation to the j th structural shock v_j into the contemporaneous impact responses of all the n variables. With the structural impulse vector λ in hand, the set of all structural impulse responses of the n variables up to the horizon k can then be computed using the estimated coefficient matrix $B(L)$ of the

reduced-form VAR.¹ Thus the Sign-Restriction approach amounts to simultaneously estimating the coefficients of the reduced-form VAR and the impulse vector. ‘Identifying restrictions’ on the responses of a subset of the variables are imposed for horizons $k = 0, \dots, K$, after the shock (Uhlig, 2005). Let Λ be an orthonormal matrix, that is, a matrix with the property: $\Lambda\Lambda' = \Lambda'\Lambda = I$. The relationship between the reduced from residuals and the structural relationship can then be described as follows:

$$\begin{aligned} u_t &= P\Lambda(\lambda)v_t \\ \text{since } E(u_t u_t') &= E(P\Lambda v_t v_t' \Lambda' P') = P\Lambda\Lambda' P' = PP' = \Sigma \end{aligned} \quad (10)$$

Identification here requires Sign-Restrictions on λ , which is restricted to be in a certain subset of $[-\pi, \pi]$. The restrictions will not give one impulse response, but a whole range of responses. The identification method searches over the space of possible impulse vectors to find those impulse responses that agree with the theoretical Sign-Restrictions. Once the impulse vector λ has been appropriated, the impulse responses are calculated as: $Y_t = B(L)P\Lambda(\lambda)v_t$.

3. Data and Summary Statistics

This section provides a summary description of the data employed in the empirical analysis. All variables are in natural logarithms and measured at constant prices unless stated otherwise.

Euro area aggregates are calculated as the weighted average of euro-11 before 1999 and, thereafter, as break-corrected series covering the real-time composition. The weights are computed using GDP at irrevocable fixed exchange rates.

For both identification procedures, the variables in X_{1t} – the ones predetermined with respect to monetary policy innovations – are the commodity price index, PCm_t ,

¹ See Dedola and Neri (2007), and Rafiq and Mallick (2008) for more details.

the real GDP, Y_t , and the inflation rate, π_t . The variables in X_{2t} – the ones allowed to react contemporaneously to monetary policy shocks – are the growth rate of broad money, $M_{3t} - M_{1t}$, and the Financial Stress Index, FSI_t . That is, the recursive assumptions defined in (3) can be explicitly represented by $X_t = [X_{1t}', it, X_{2t}']$, where $X_{1t} = [PCm_t, Y_t, \pi_t]$ and $X_{2t} = [M_{3t} - M_{1t}, FSI_t]$. We use the interest rate denoted by it as the monetary policy instrument. We include in the set of exogenous variables a constant and a time trend. The selected optimal lag length is 4, in accordance with the standard likelihood ratio tests.

The main data source is the European Central Bank (ECB). As for the Financial Stress Index, it is computed using country-level data provided by the International Monetary Fund (IMF) and, in particular, following the work of Cardarelli *et al.* (2011). The sample covers the period 1980:1-2008:4 for which data are available at quarterly frequency.

4. Empirical Results

4.1. The B-SVAR Framework

We include the growth rate of the monetary aggregate and the Financial Stress Index in the set of variables that react contemporaneously to the monetary policy shock (X_{2t}). Similarly, the GDP, the inflation rate and the commodity price are allowed to react to monetary policy only with a lag (being, therefore, included in X_{1t}).

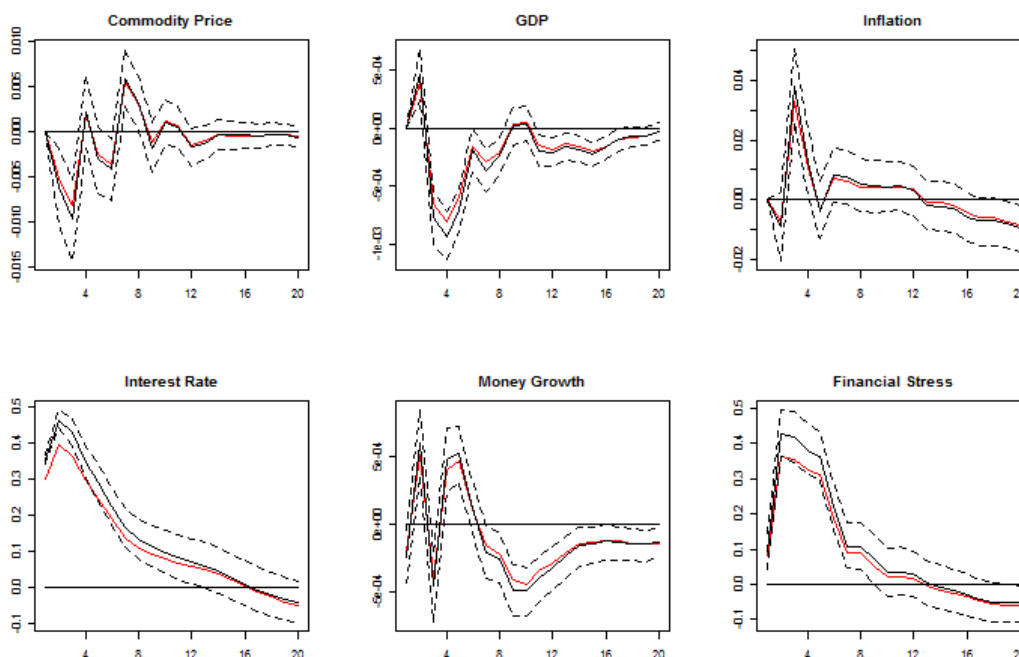
We start by analyzing the impact of a monetary policy shock (i.e. a change in the interest rate). We identify the monetary policy shock by imposing the recursive assumptions defined in (4) and estimate the Bayesian Structural VAR (B-SVAR) represented by (1) and (2).

Figure 1 plots the impulse-response functions to a positive shock in the interest rate. The solid line corresponds to the point estimate, the red line represents the median response, and the dashed lines are the 68% posterior confidence intervals estimated by using a Monte-Carlo Markov-Chain algorithm based on 10000 draws.

The results suggest that after a contractionary monetary policy, financial stress increases substantially for about 4 quarters after which it starts falling, but the positive effect persists for 12 quarters. The impact is sizeable: at the 4-quarter horizon, the 40 basis points shock in the interest rate rises the financial stress index by almost 40 points. Real GDP falls, the trough is reached after 4 quarters, and the effect persists is still significant after 10 quarters. The commodity price also decreases and the reaction is quick. In addition, the inflation rate is roughly unaffected for 12 quarters, in line with the findings of Peersman and Smets (2003).

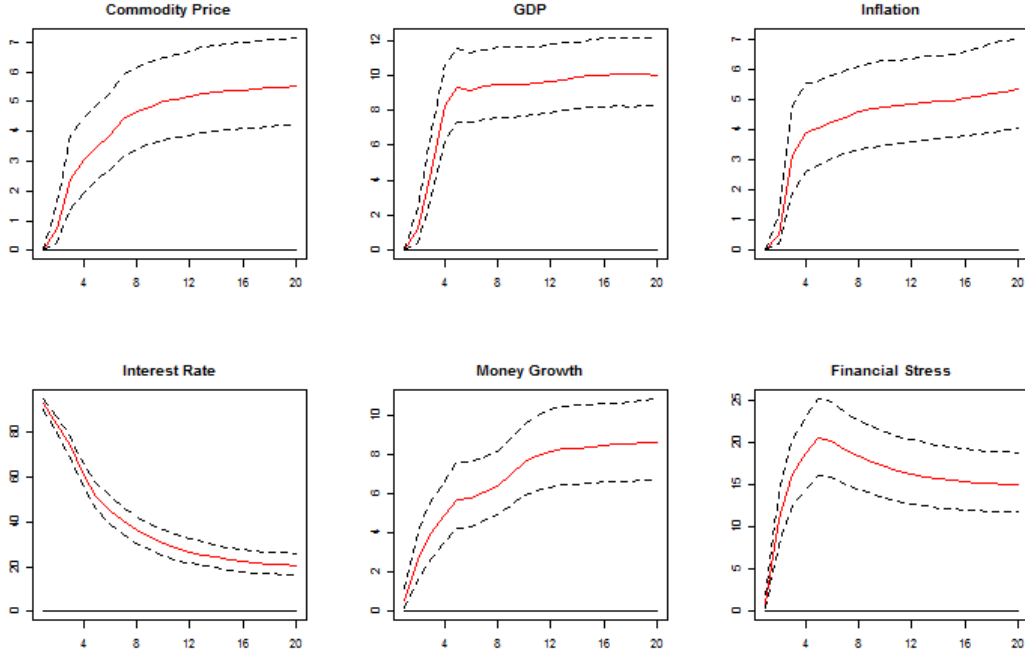
The response of the money growth rate increases, reflecting the flight towards assets that are less liquid but also earn higher rates of return. Then, as the shock to the interest rate erodes, the growth rate starts falling and even becomes negative at around after 6 quarters. Indeed, it remains persistently at a lower level even 20 quarters ahead. This is in accordance with the works of Friedman (1968), Cagan (1972) and Sousa (2010a), who describe this shape of the path of the short-term nominal interest rate following a monetary contraction as a short-lived liquidity effect that is followed by expected inflation and income effects. It is also in line with the work of Surico (2007a), who argues that, although money supply does not affect directly the ECB's behaviour, it is a good instrument to predict future inflation.

Figure 1 - Impulse-response functions using a B-SVAR framework: monetary policy shock.



The strategy for estimating the parameters of the model focuses on the portion of fluctuations in the data that is caused by a monetary policy shock. It is, therefore, natural to ask how large that component is. With this question in mind, Figure 2 displays the percentage of variance of the k -step-ahead forecast error due to an interest rate shock. Notice that policy shocks account for an impressive fraction of the variation of the financial stress conditions: the forecast-error variance decomposition suggests that the interest rate shock represents almost 20% of the variation at the 6-quarter horizon. Moreover, the monetary contraction represents only a small fraction of the variation of the inflation rate and the commodity price (about 5% of the variation 20 quarters ahead). On the other hand, monetary policy shocks are responsible for a reasonable fraction of the variation of GDP (about 10% of the variation 20 quarters ahead). A similar conclusion can be drawn with respect to the money growth: monetary policy shocks explain about 8% of the variation in the monetary aggregate 20 quarters ahead.

Figure 2 - Percentage variance decomposition using a B-SVAR framework: monetary policy shock.



We now build a VAR counter-factual exercise aimed at describing the effects of shutting down the shocks in interest rate. In practice, after estimating the B-SVAR summarized by (1) and (2), we construct the counter-factual (CFT) series as follows:

$$\underbrace{\Gamma(L)}_{n \times n} \underbrace{X_t}_{n \times 1}^{CFT} = \Gamma_0 X_t^{CFT} + \Gamma_1 X_{t-1}^{CFT} + \dots = c + \varepsilon_t^{CFT} \quad (11)$$

$$v_t = \Gamma_0^{-1} \varepsilon_t^{CFT}. \quad (12)$$

This is equivalent to consider the following vector of structural shocks:

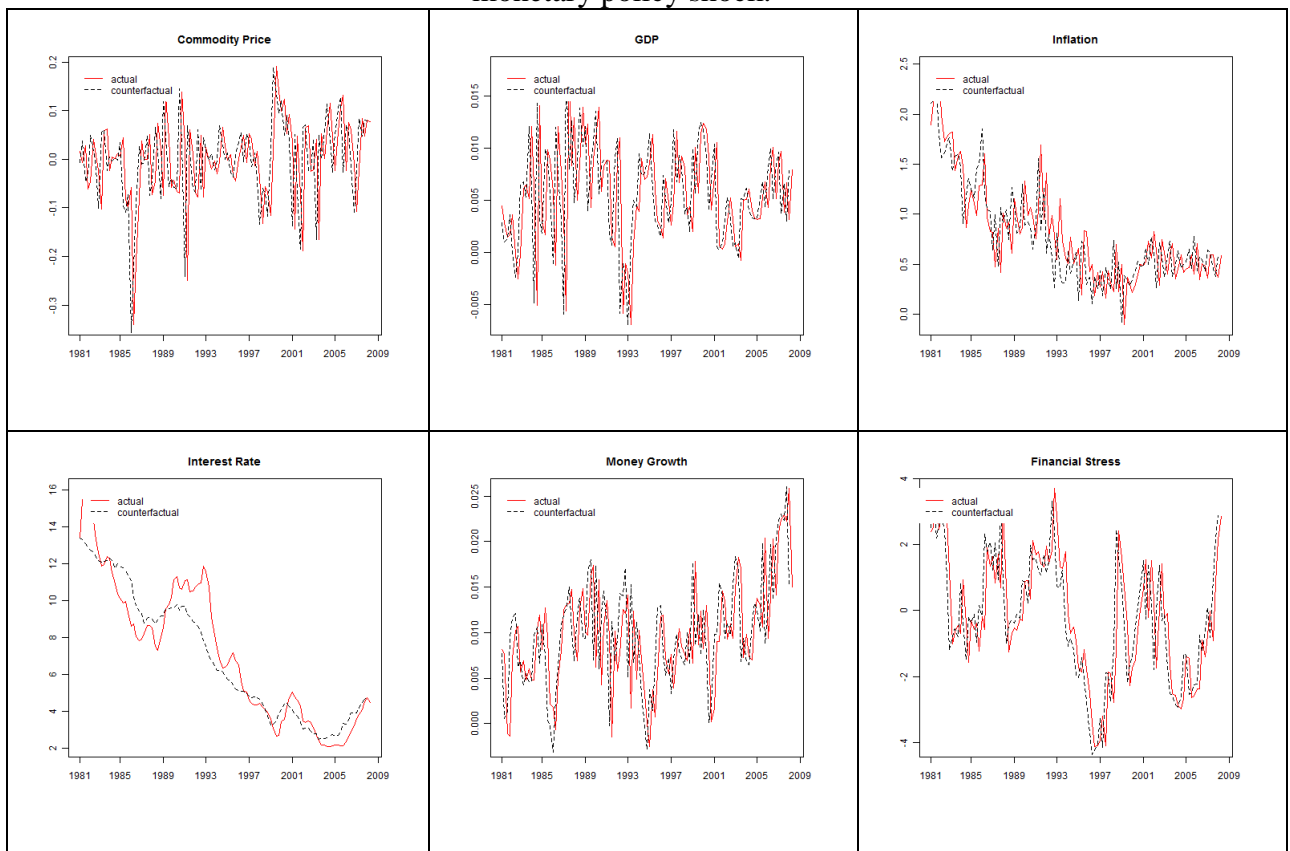
$$\varepsilon_t^{CFT} = [\varepsilon_t^{PCm}, \varepsilon_t^Y, \varepsilon_t^\pi, \varepsilon_t^i, \varepsilon_t^{M_3-M_1}, \varepsilon_t^{FSI}]' \quad (13)$$

$$\varepsilon_t^i = 0, \forall t.$$

The empirical exercise allows one to analyze the role played by monetary policy shocks, and it helps understanding what the financial stress conditions and the macroeconomic dynamics would be in the case of absence of unexpected variation in the interest rate.

Figure 3 plots the actual and the counter-factual series for the variables included in the B-SVAR, and suggests a considerable difference between the two and, therefore, the importance of interest rate shocks. Moreover, it can be seen that the role of monetary policy actions for financial stress conditions seems to be particularly significant during the recession period of 1991-1993, but also during the recent financial turmoil.

Figure 3 – Actual and counter-factual series using the B-SVAR framework: monetary policy shock.



In Figure 4, we plot the the impulse-response functions to a positive shock in financial stress conditions. It can be seen that it has a contractionary effect on output: real GDP falls for about 6 quarters. Similarly, the deterioration of financial stress conditions impacts negatively on both the commodity price and the inflation rate, although the reaction of the first one is faster and also erodes more quickly: while the

negative effect on commodity prices disappears after 4 quarters, the reaction of inflation persists for almost 8 quarters. The reaction of the money market is interesting. The interest rate gradually falls after the shock in financial stress and the trough (of almost 25 basis points) is reached after 4 quarters. Noticeably, the negative effect persists for almost 10 quarters, thereby, suggesting that episodes of financial stress demand a strong response by monetary authorities. Consequently, money growth rises. This result is similar in spirit to the work of Svensson (1999), who argues that interest rate smoothing, output stabilization and model uncertainty call for a more gradual adjustment of the conditional inflation forecast toward the inflation target.

Figure 4 - Impulse-response functions using a B-SVAR framework: financial stress shock.

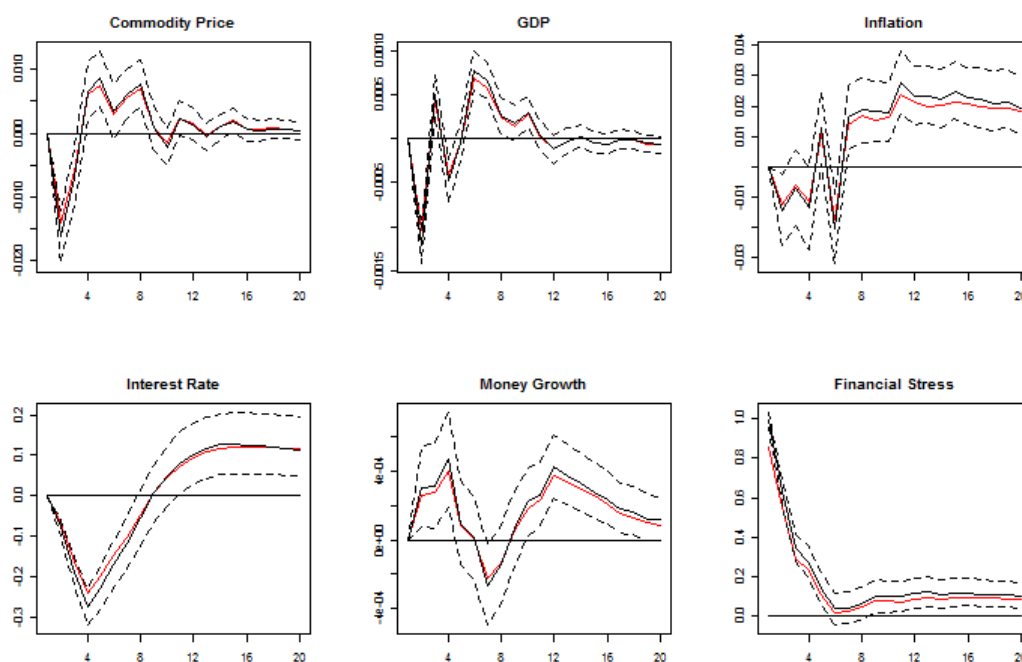
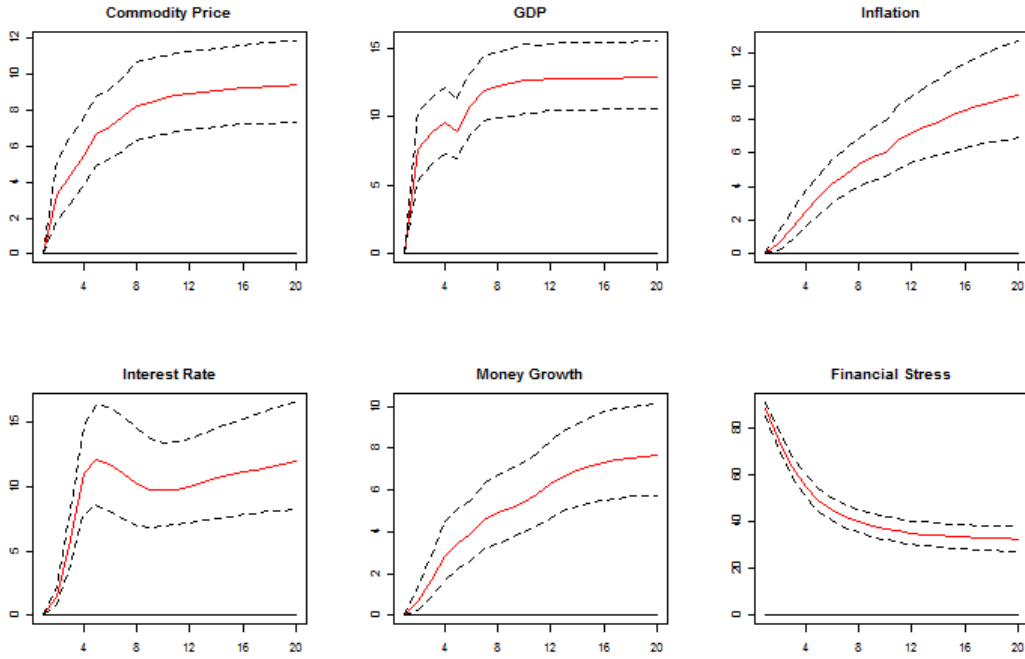


Figure 5 also reveals the important macroeconomic role played by financial stress conditions: at the 20 quarter horizon, the shock to financial stress explains about 10% of the variation in real GDP, inflation and commodity price, and near 8% of the change in money growth. Interestingly, it exhibits a major role on monetary policy

conduction, as the fraction of variation in the interest rate that is explained by the financial stress shock is almost 15%. Similarly, the episodes of deterioration of financial stress tend to be relatively persistent and long-lasting: they represent almost 40% of their own variation after 20 quarters.

Figure 5 - Percentage variance decomposition using a B-SVAR framework: financial stress shock.



Finally, we estimate the B-SVAR summarized by (1), and then construct the following counter-factual (CFT) series

$$\underbrace{\Gamma(L)}_{n \times n} \underbrace{X_t}_{n \times 1}^{CFT} = \Gamma_0 X_t^{CFT} + \Gamma_1 X_{t-1}^{CFT} + \dots = c + \varepsilon_t^{CFT} \quad (14)$$

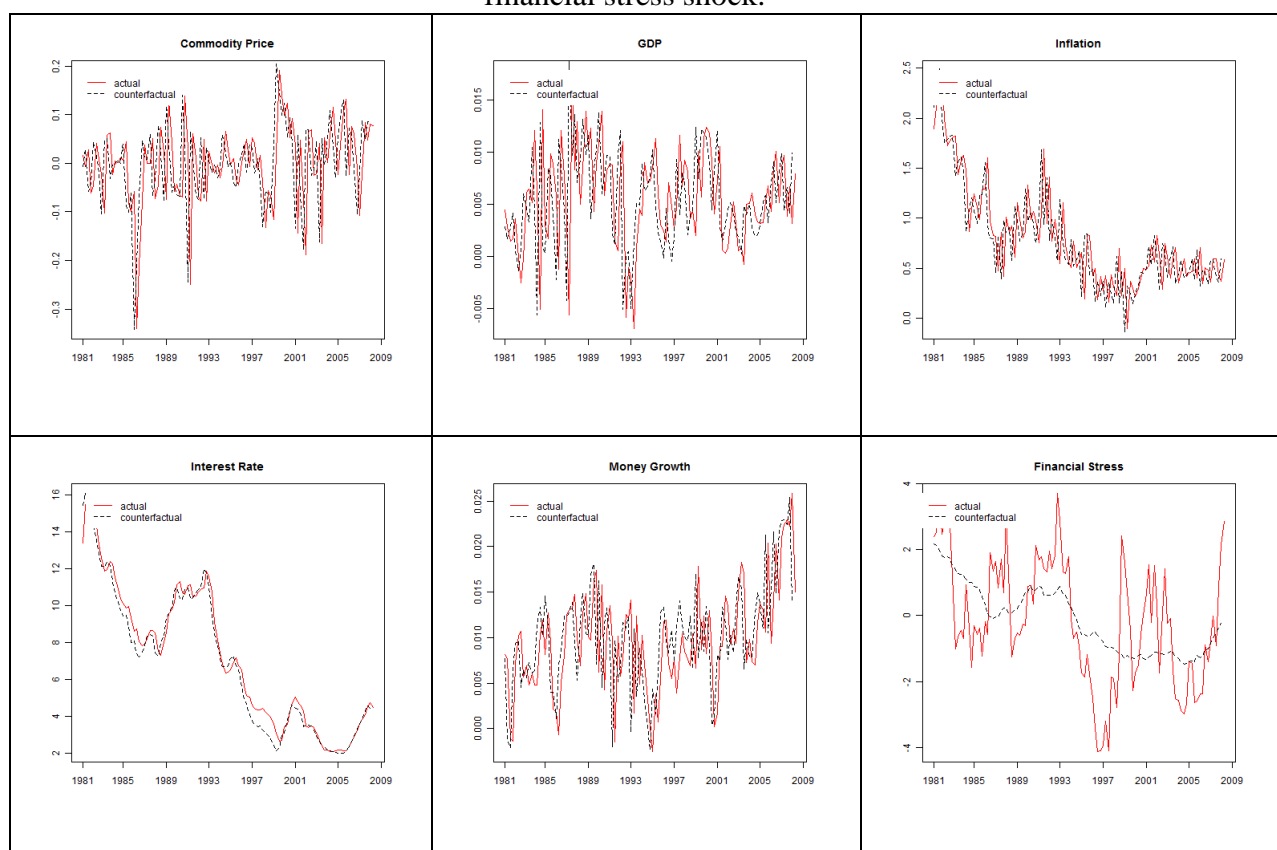
$$v_t = \Gamma_0^{-1} \varepsilon_t^{CFT}, \quad (15)$$

where we shut down the shocks in financial stress, that is, we consider the vector of structural shocks:

$$\varepsilon_t^{CFT} = [\varepsilon_t^{PCm}, \varepsilon_t^Y, \varepsilon_t^\pi, \varepsilon_t^i, \varepsilon_t^{M_3-M_1}, \varepsilon_t^{FSI}]' \quad (16)$$

$$\varepsilon_t^{FSI} = 0, \forall t.$$

Figure 6 – Actual and counter-factual series using the B-SVAR framework:
financial stress shock.



It can be seen that changes in financial stress conditions are largely unexpected: the differences between the actual and the counter-factual series for the Financial Stress Index are substantial. In particular, our framework tracks pretty well the developments of the 2008-2009 financial turmoil: while the counter-factual series (where shocks are annihilated) reveals a small deterioration in financial stress conditions, the actual series has actually “over-shot”. This clearly suggests that the financial turbulence observed in recent times was strongly unexpected. Nevertheless, the counter-factual series exhibits a gradual pick-up in the Financial Stress Index since 2005, which highlights that the monetary authority should keep a vigilant posture towards tracking financial stress conditions in order to guarantee monetary and financial stability. In this context, our work corroborates the findings of Hakkio and Keeton (2009) and Davig and Hakkio

(2010) for the US. This, therefore, gives rise to the urgency of macro-prudential risk management.

4.2. The Sign-Restrictions Approach

In order to further validate our BVAR results, we carry out the above ‘pure Sign-Restriction’ identification strategy due to Uhlig (2005) using the following Sign-Restrictions, not only upon impact, but for a few periods after the shock's impact, which are shown in the impulse responses in Figures 7 to 14.

We jointly identify a finance shock alongside a monetary policy shock in order to check any difference in these shocks. In the case of monetary policy shock, no restriction is placed on the output, as we want it to be determined by the model because several factors may influence economic activity. Also we do not determine a priori the effect on financial stress, as we wish to know whether monetary policy generates financial stress by allowing the impact to be determined by the model. Monetary policy shock is identified as an increase in interest rate (short rate) that will lead to a decline in monetary liquidity and a decline in inflation. To identify an exogenous finance shock, we impose three restrictions that financial stress increases exogenously that can tighten monetary liquidity in the system and thereby reduce economic activity. However we do not pre-judge the inflation outcome as it can either go up or down depending on whether supply shock (innovations in commodity prices) or demand shock (innovations in output) dominates. These restrictions seem reasonable in the light of the observed pattern in the data. We keep those impulse vectors whose impulse response functions satisfy the Sign-Restrictions and discard the others. The Sign-Restrictions imposed here are those in Table 1.

Table 1: Identifying Sign-Restrictions.

		CMP	GDP	INF	INT	MGR	FIN
Monetary Shock (tightening)	Policy	?	?	-	+	-	?
Finance shock (Increase in stress)		?	-	?	?	-	+

The sign restrictions approach only requires a minimal set of economically meaningful restrictions as in Table 1 in order to identify contractionary monetary policy shocks and finance stress shocks. The responses in Figures 7 and 8 satisfy the sign-restrictions. The results show how restricting the signs of the impulse responses leads to a shaped distribution for the initial response, representing the initial responses when drawing the orthogonalised impulse vectors.

Figure 7 - Histogram for initial impulse-response: monetary policy shock.

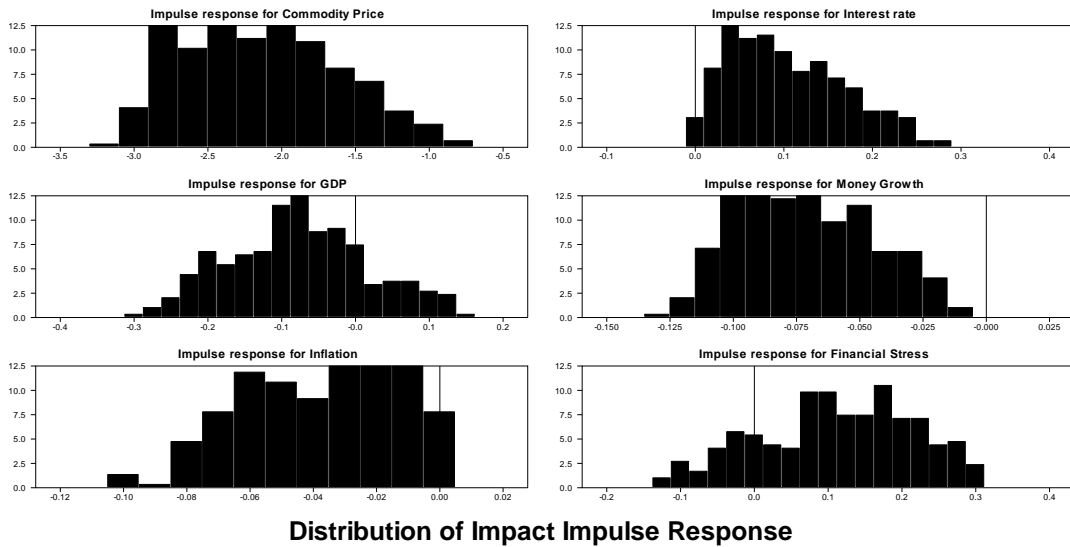
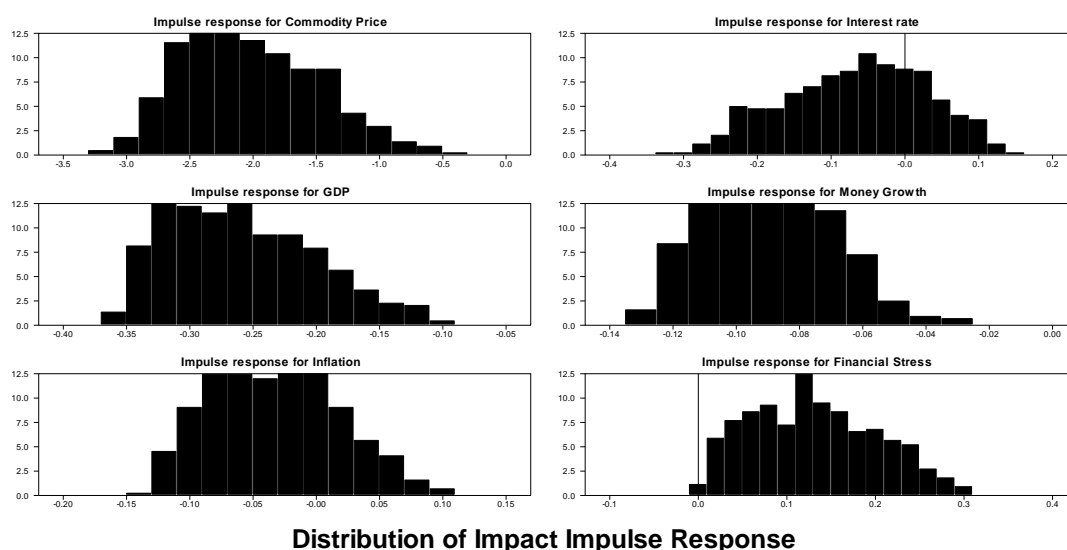


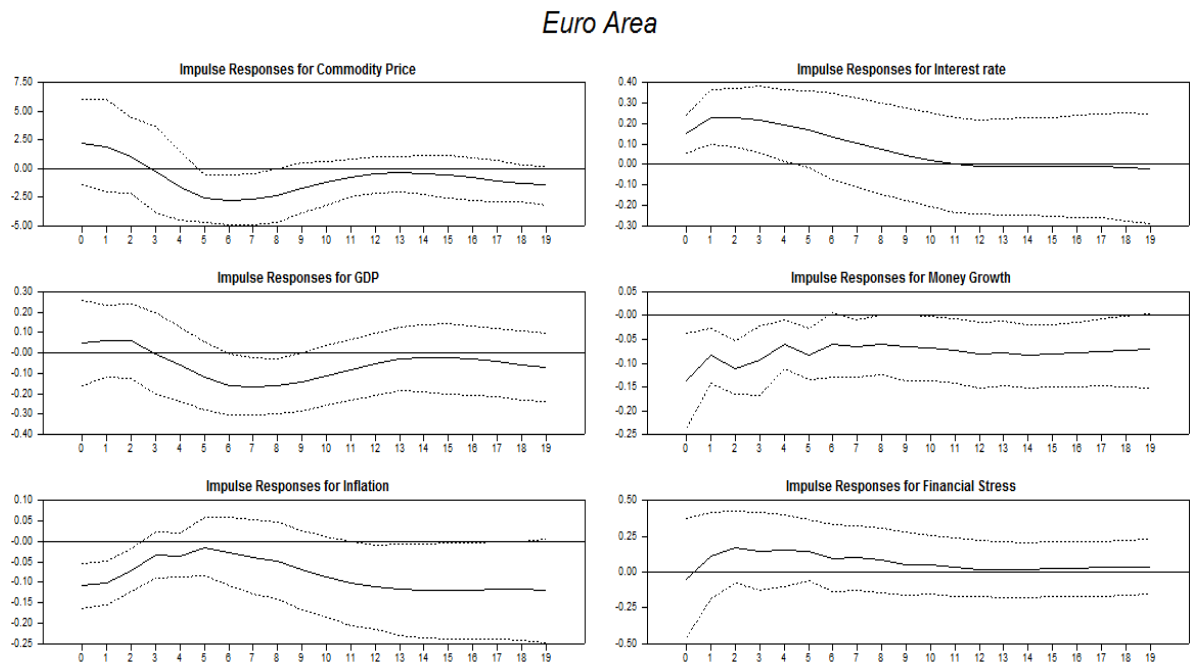
Figure 8 - Histogram for initial impulse-response: financial stress shock.



The responses do satisfy the Sign-Restrictions even in the long run (see Figures 9 and 10), although they are required to satisfy the Sign-Restrictions for $k = 2$ quarters (i.e., 2 quarters shock), which implies that the shock lasts for at least 2 quarters. The error bands are illustrated as the dotted lines above and below the response line (the thick line), which are composed of the 16th, 84th and median percentiles of the impulse responses for each shock, from a sample of 10000 draws from the posterior. The dotted lines also indicate the slope of the posterior distribution of the impulse responses.

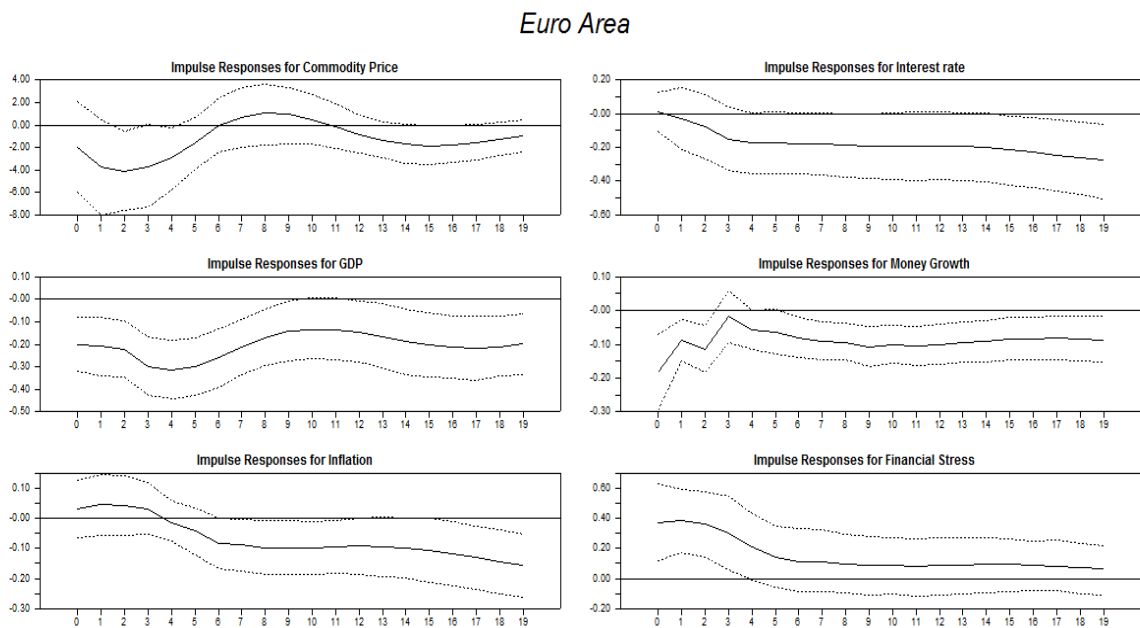
The impulse responses show that a positive shock to financial stress leads to permanent decline in output, monetary liquidity, and inflation in the euro area, along with a decline in interest rate. Monetary policy innovations on the other hand play a modest role in output fluctuations for the Euro area in line with the earlier results in the literature, for example, Rafiq and Mallick (2008) for the three largest Euro area countries.

Figure 9 – Impulse-response functions using a Sign-Restrictions approach: monetary policy shock ($IR > 0$, $DM < 0$, $DP < 0$), with monetary shock identified first and then financial stress shock.



Impulse Responses with Pure-Sign Approach

Figure 10 - Impulse-response functions using a Sign-Restrictions approach: financial stress shock ($FS > 0$, $DM < 0$, $GDP < 0$), with monetary shock identified first and then financial stress shock.



Impulse Responses with Pure-Sign Approach

We also carry out forecast-error variance decomposition (FEVD) of the monetary and finance shocks identified on the basis of Sign-Restrictions in order to find the percentage variation in each variable explained by each shock. This information can be found in Figures 11 and 12. The results suggest that finance shocks explain output growth more than the monetary policy shocks. This provides relatively limited importance of monetary policy shocks in the Eurozone on average. Besides, we supplement the above analysis that uses impulse responses and variance decomposition by undertaking historical decomposition to provide further evidence on (i) whether the underlying structural shocks have actually occurred in reality and (ii) whether the actual developments of the variable of interest, real output, could be explained by them.

Figure 11 - Percentage variance decomposition using a Sign-Restrictions approach: monetary policy shock.

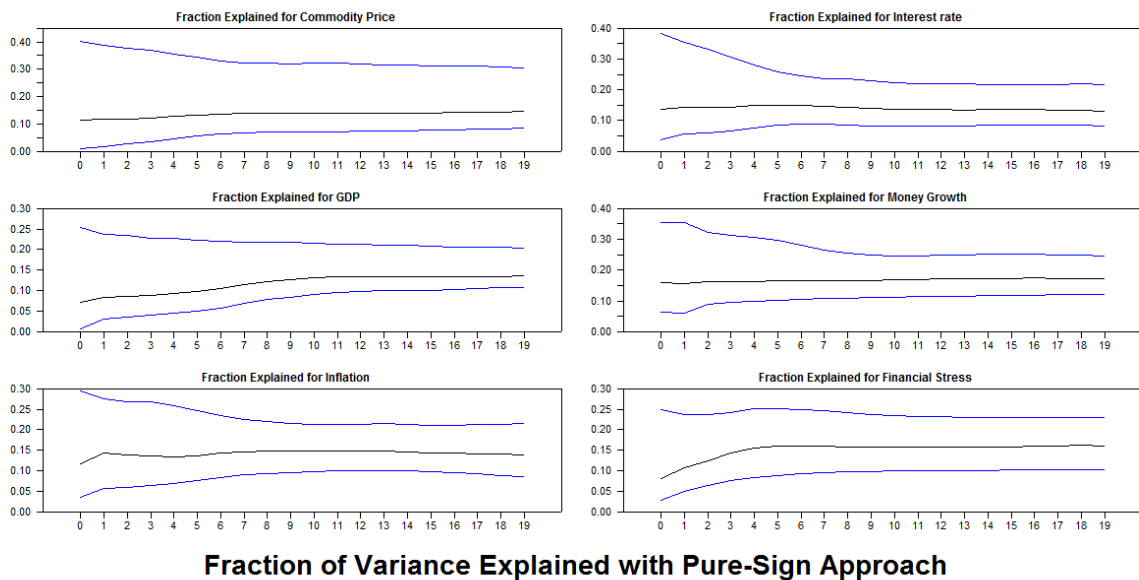
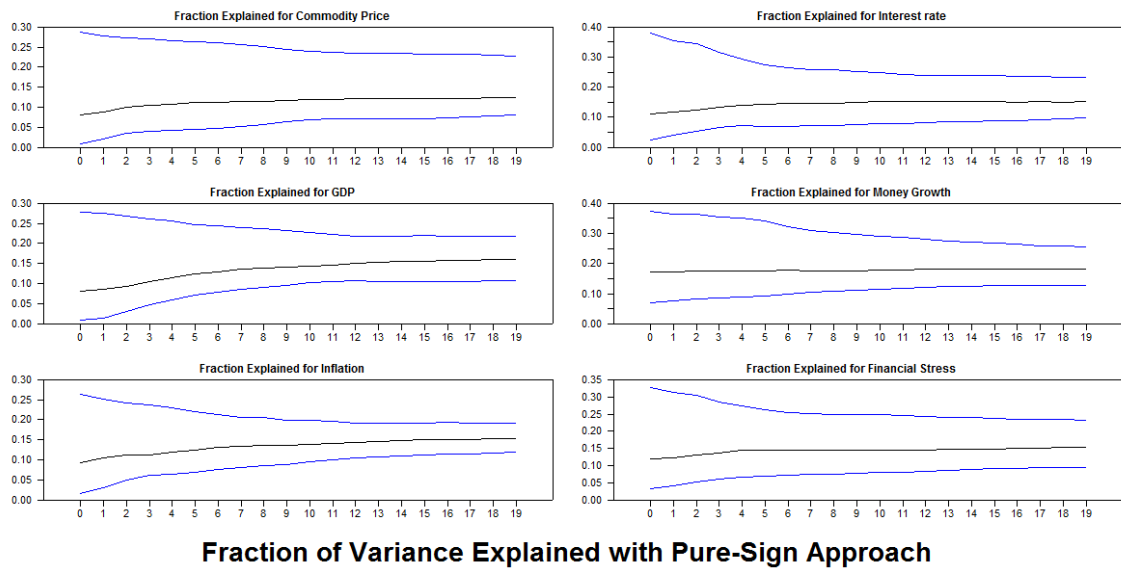
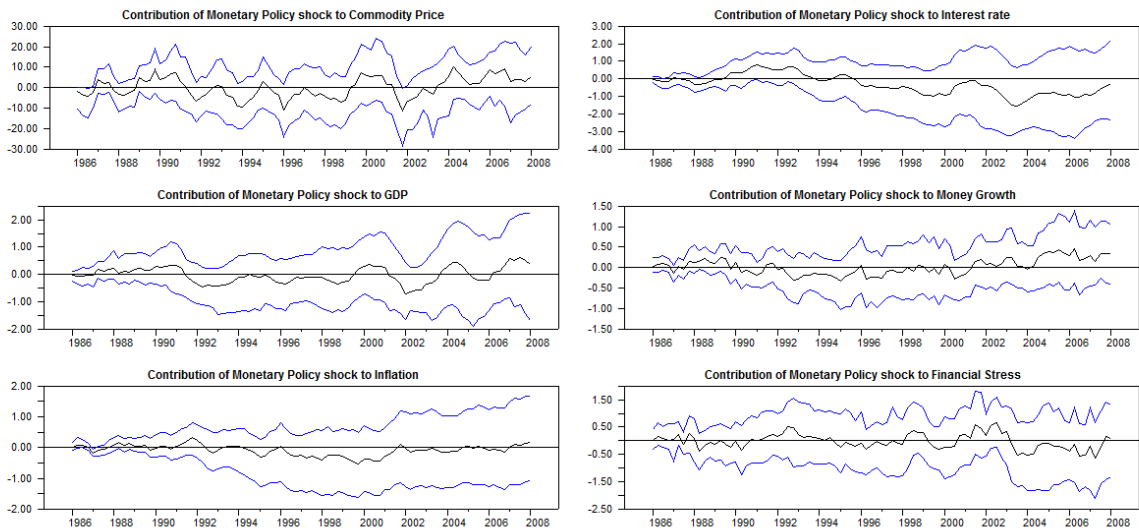


Figure 12 - Percentage variance decomposition using a Sign-Restrictions approach: financial stress shock.



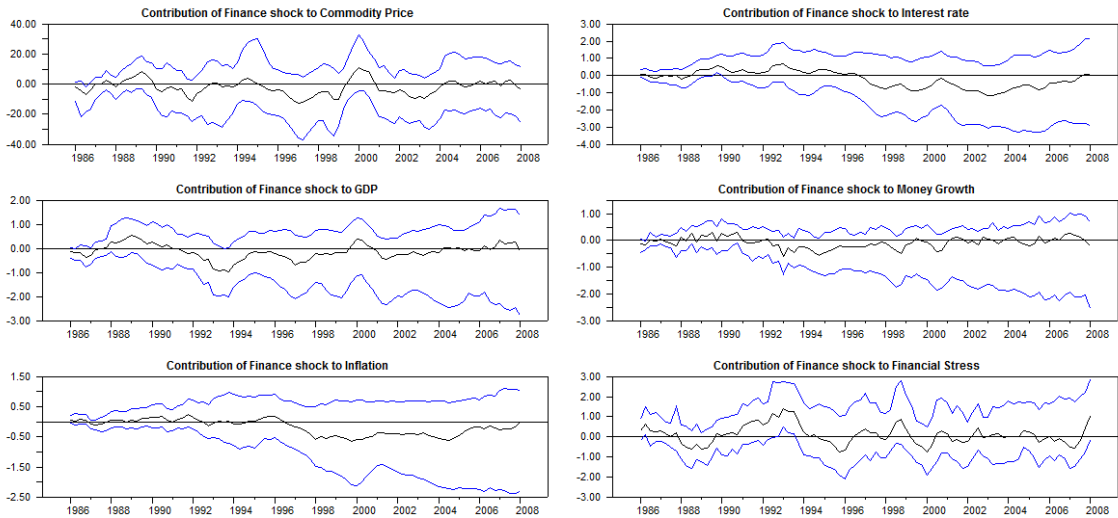
Figures 13 and 14 display the historical decomposition results, which validate the stabilizing properties of monetary shocks by picking up the turning points accurately. On average, the negative effect of an interest rate tightening on output is greater in recessions than in booms as in Peersman and Smets (2005). We also find that in the post-euro period the monetary policy shock has generated greater output fluctuations, while the output effects of finance shocks have been smaller over the same period.

Figure 13 - Historical decomposition using a Sign-Restrictions approach:
monetary policy shock.



Historical Decomposition with Pure-Sign Approach

Figure 14 - Historical decomposition using a Sign-Restrictions approach:
financial stress shock.



Historical Decomposition with Pure-Sign Approach

4.3. Sub-sample analysis

We now look at the impulse-response functions for different sub-samples. We consider two periods: 1981:1-1998:4 (before the introduction of the Euro) and 1999:1-2007:4 (after the introduction of the Euro).

We start by considering a monetary policy shock (Figures 15 and 16). The major differences between the two sub-samples lie on the responses of real GDP, commodity price, money growth and financial stress. In what concerns the reaction of real GDP, one can see that, although in both samples, there is a contractionary effect, this was more pronounced in the past, in accordance with the lack of restructuring of the housing finance system, the existence of a regulated banking sector dominated by savings, loans and mutual savings banks, and a lower competitiveness in the primary mortgage market. As for the commodity price, it is now much more sensitive to monetary policy actions than it used to be in the past: in the period 1981:1-1998:4, the positive interest rate shock has no significant impact on the commodity price, while, in the period 1999:4-2007:4, it leads to a large (in magnitude) and quick fall of the price of commodities. Regarding monetary growth, the results suggest that in the period before Euro's introduction the monetary contraction was responsible for a fast portfolio reallocation, typically characterized by a flight towards assets that are less liquid but also earn higher rates of return (an increase in the M_3 growth). In contrast, after the introduction of the Euro, an unexpected increase of the interest rate generates a fall in the M_3 growth, which suggests that the policy action has an important liquidity effect that erodes after 4 quarters. In this context, Rudebusch and Svensson (2002) argue that the predictive role of nominal money for output and inflation has disappeared after the eighties. Finally, the reaction of the financial stress index to the monetary policy shock is interesting: while in both sub-samples there is a deterioration of financial stress

conditions, this is now less persistent than in the past. This result seems to be linked to the behavior of monetary policy itself: policy shocks were more persistent before the introduction of the Euro, possibly reflecting a stronger inertia of the conduct of monetary policy.

Figure 15 - Impulse-response functions using a B-SVAR framework: monetary policy shock, 1981:1-1998:4.

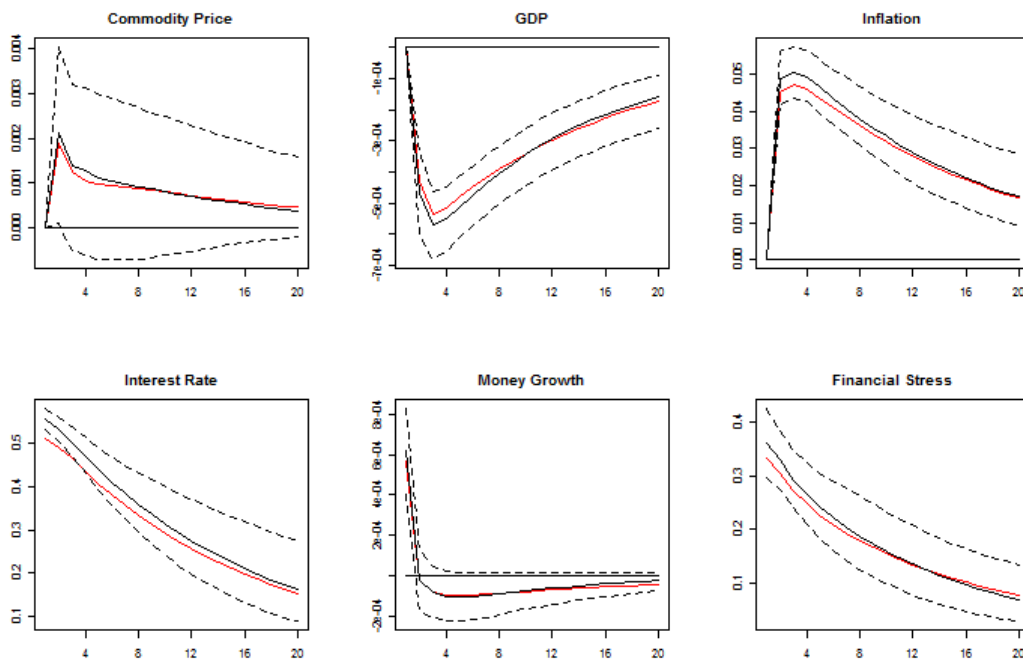
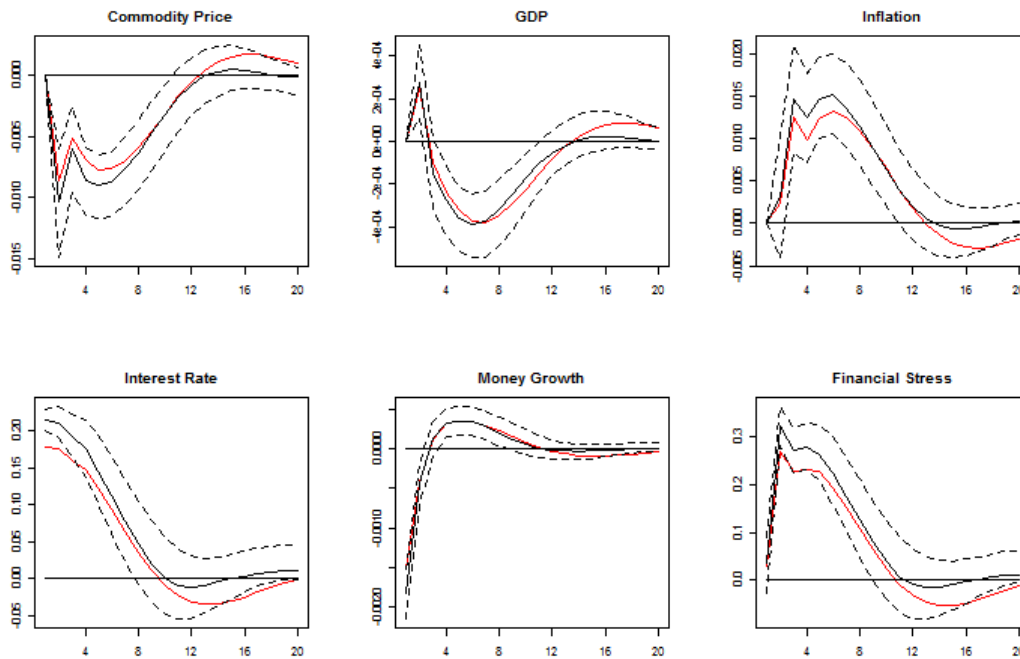


Figure 16 - Impulse-response functions using a B-SVAR framework:
monetary policy shock, 1999:1-2007:4.



Figures 17 and 18 display the impulse-response functions to a financial stress shock over the two sub-sample periods. While there is no apparent difference in the magnitude of the response of GDP to the shock which falls in both sub-samples, the reaction of the interest rate should be emphasized. In fact, before the introduction of the Euro, there is no significant response of the interest rate to the financial stress shock. In contrast, the monetary authority seems to react both significantly and more quickly to the shock in the post-Euro period: the interest rate falls after the shock in financial stress and the trough (of almost 15 basis points) is reached after 4 quarters, suggesting that episodes of financial stress demand a stronger response by the monetary authority.

Figure 17 - Impulse-response functions using a B-SVAR framework:
financial stress shock, 1981:1-1998:4.

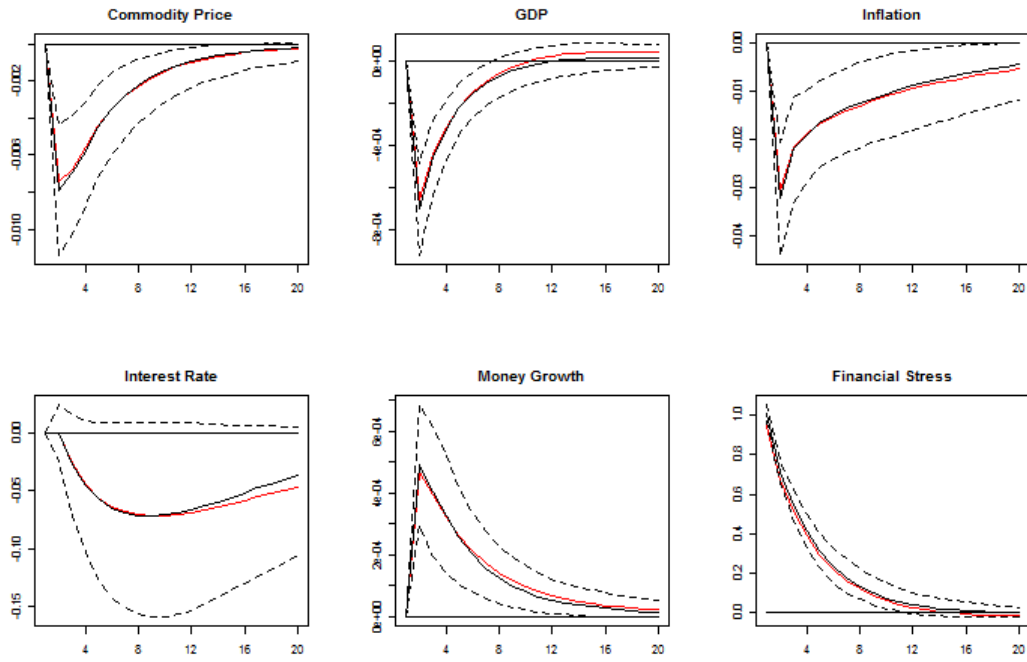
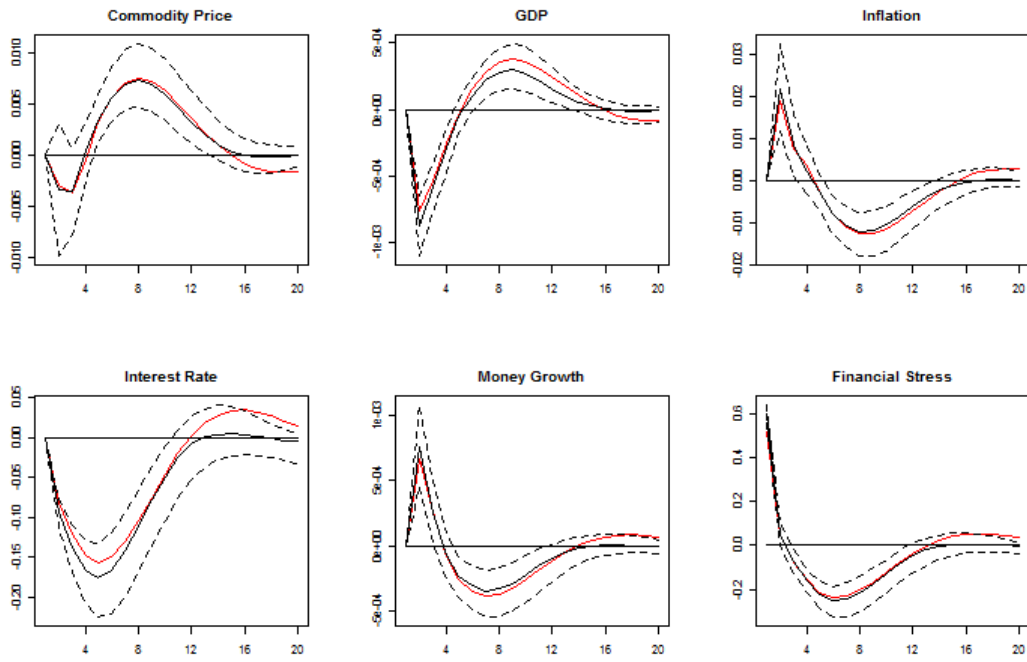


Figure 18 - Impulse-response functions using a B-SVAR framework:
financial stress shock, 1999:1-2007:4.



4.4. Should monetary policy prevent a credit bubble?

In this Section, we evaluate the credit channel by which monetary policy affects economic activity. In particular, we assess the conduct of monetary policy in terms of affecting the credit conditions and, similarly, whether it should prevent a rise in the credit-to-GDP ratio by means of avoiding potential credit bubbles. This approach focuses on evaluating the forecasting power of credit aggregates for real activity relative to the forecasting power of the money aggregate. This test for the credit channel suffers from the potentially incorrect assumption that credit aggregates are independent causal factors affecting the economy. In contrast, credit conditions and not the aggregate quantity of credit *per se* are an endogenous factor that help shaping the dynamic response of the economy to shifts in monetary policy. As a result, we replace the monetary growth by either the credit growth (Figure 19) or the loans-to-GDP ratio (Figure 20).

The results remain robust vis-a-vis the previous findings, therefore, suggesting that monetary policy shocks affect not only the liquidity conditions of the economy as a whole, but also the credit dynamics. More specifically, Figure 19 shows that, after a monetary contraction, loans grow for almost 4 quarters, before flipping into a situation where there is a negative growth. Similarly, Figure 20 highlights that a positive interest rate shock leads to an increase in the credit-to-GDP ratio for about 10 quarters, after which that ratio starts falling. These findings are in line with the idea that, although both monetary and credit aggregates are jointly determined by supply and demand, money demand tends to be procyclical, while credit demand seems to display an important countercyclical component. This, in turn, can be explained by the desire of households and firms to smooth the impact of cyclical variations in income on spending or production. For instance, consumers may borrow in the outcome of a fall in their

income. Similarly, firms may try to finance an inventory buildup following a monetary tightening, even though the external finance premium is rising. As a result, at the time the monetary policy shock occurs, credit growth and loans-to-GDP ratio continue rising.

Figure 19 - Impulse-response functions using a B-SVAR framework: the impact of a monetary policy shock on credit growth.

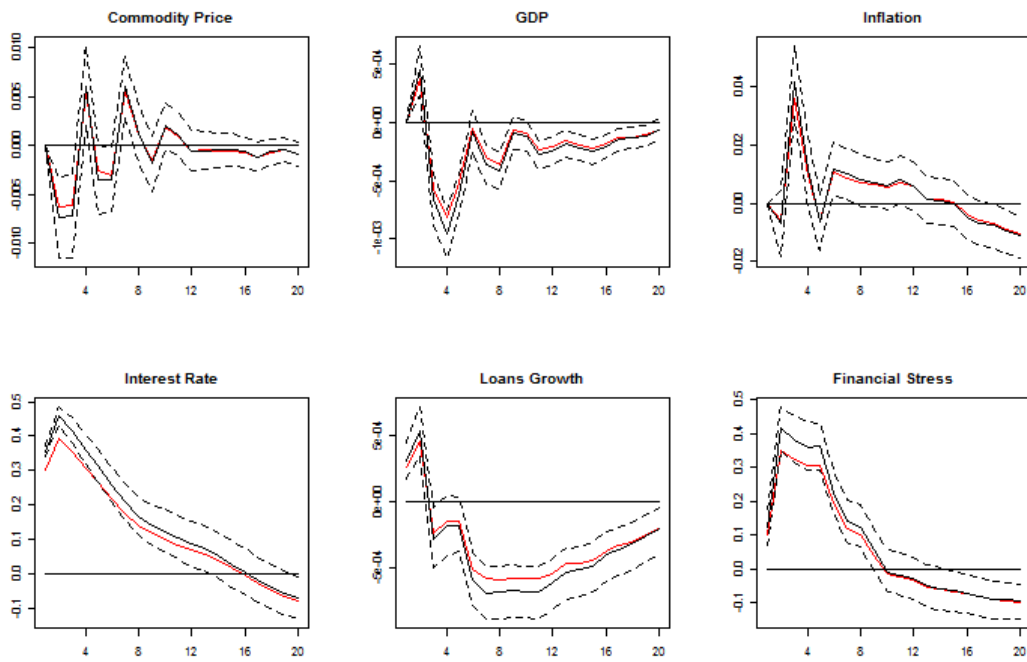
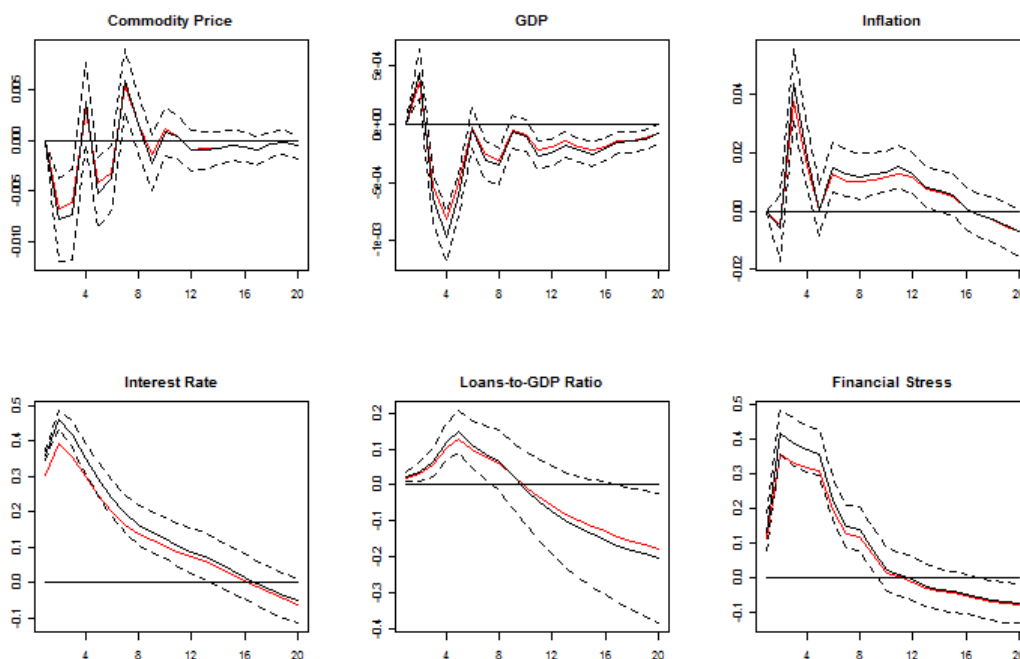


Figure 20 - Impulse-response functions using a B-SVAR framework:
the impact of a monetary policy shock on loans-to-GDP ratio.



It is also important to consider credit expansion in terms of the size of the economy in order to gauge the response of monetary policy. So we have included loan-to-GDP ratio in the VAR replacing money growth, as loan growth itself may not capture a possible credit bubble because it can be volatile from year to year. However, when the credit-to-GDP ratio is growing very fast, this is a clear indication of a credit bubble in mature economies. Given the recent crisis, it makes sense to identify a finance shock where a rise in credit-to-GDP ratio (CYR) generates GDP growth with signs of financial stress (see Table 2).

Table 2: Identifying Sign-Restrictions.

		CMP	GDP	INF	INT	CYR	FIN
Monetary	Policy						
Shock (tightening)		?	?	-	+	-	?
Finance shock							
(Credit Bubble)		?	+	?	?	+	+

Figure 21 – Impulse-response functions using a Sign-Restrictions approach: monetary policy shock ($INT > 0$, $CYR < 0$, $INF < 0$), with monetary shock identified first and then financial shock (credit bubble and financial stress).

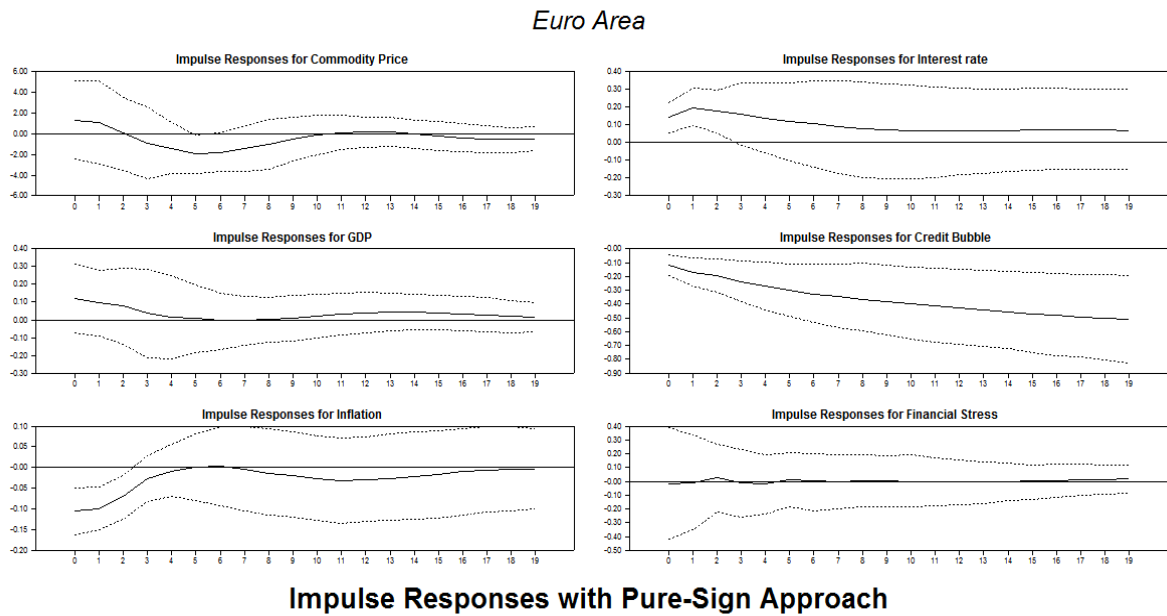
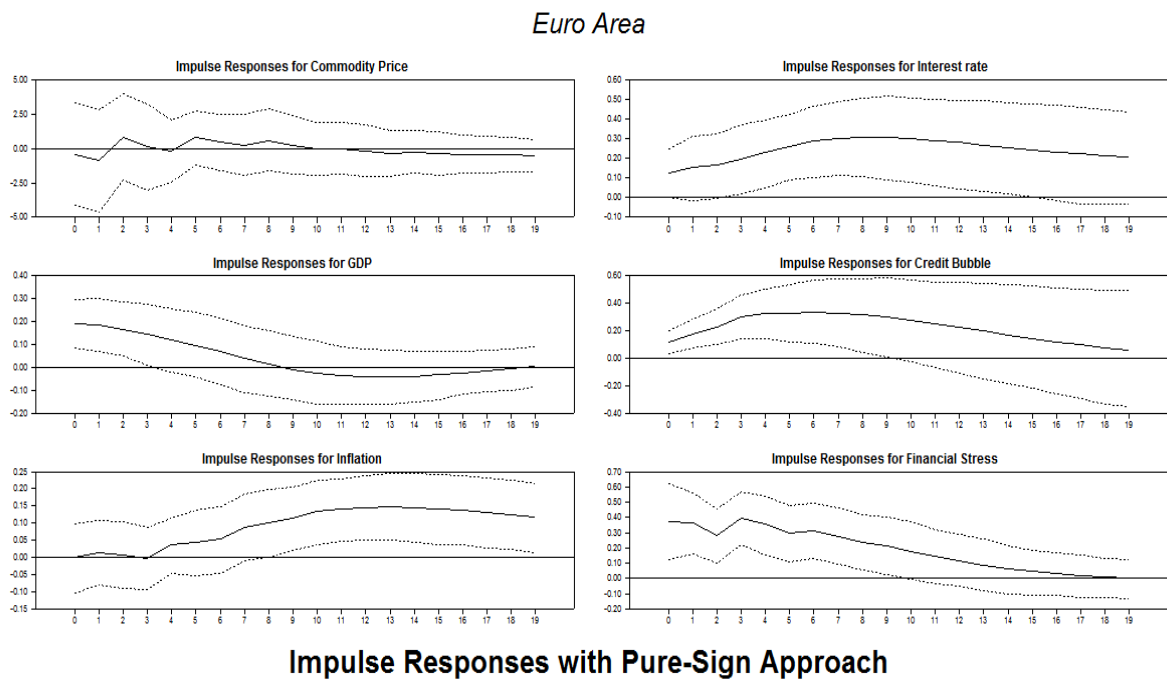


Figure 22 – Impulse-response functions using a Sign-Restrictions approach: Credit Bubble shock ($CYR > 0$, $FIN > 0$, $GDP > 0$), with monetary shock identified first and then financial shock (credit bubble and financial stress).



While the monetary policy shock in Figure 21 stabilises the price level by reducing inflation, the monetary policy response due to a credit bubble and subsequent

stress in other financial markets in Figure 22 suggests that the monetary authority must react by increasing the interest rate. So rapid expansions in credit in mature economies can raise concerns of possible financial imbalances and, thus, monetary authorities should aim at balancing the markets by tightening interest rates as shown in our responses in Figure 22. In contrast, a low-interest rate policy stance in such circumstances can create systemic risk elsewhere in the financial markets leading to a crisis. Over the years, the ECB pursued a monetary policy aimed at stabilising inflation around the objective target of 2%. However, in recent times, a period of very low nominal interest rates and even negative real interest rates gave rise to a credit bubble. Our results suggest that if interest rates had gone up to counter the bubble, a financial collapse might not have occurred.

5. Conclusion

This paper provides time-series evidence on the transmission of monetary policy and financial stress in the Eurozone. We use modern estimation techniques to identify the monetary policy and the financial stress shocks, namely, the Bayesian Structural Vector Auto-Regressive (B-SVAR) along with the more recent Sign-Restrictions approach.

The analysis is based on high-frequency (quarterly) data for the period 1980:1-2008:4, and the model includes 6 key variables: the interest rate (that is, the policy rate), a set of macroeconomic variables that adjust to the shock with a lag (real GDP, inflation rate, and commodity price), and a set of variables that react contemporaneously to the policy shock (the growth rate of the monetary aggregate, and the Financial Stress Index).

We show that a monetary policy contraction generates an important deterioration of financial stress conditions. This effect is magnified during recessions, as the period of

1991-1993, but also the recent financial turmoil reveal. We also find that a shock in financial stress conditions has a strong contractionary effect. Moreover, it requires an aggressive response by the monetary authority, namely, through the adoption of expansionary policies. As a result, our paper provides support for the need for keeping a close track of financial stress conditions, as well as the importance of implementing macro-prudential risk management.

The current paper is the first stage for further work. Specifically, a promising research avenue that we aim to explore refers to the estimation of a monetary policy rule that accounts for developments in the financial stress conditions. Indeed, it will provide the basis for forecasting future central bank's policy behaviour in those circumstances and, simultaneously, allow us to understand the major economic developments to which the monetary authority reacts in a systematic manner. In this context, Martin and Milas (2004) apply a nonlinear quadratic logistic smooth-transition (STR) model to the Bank of England's monetary policy. Interestingly, the authors show that the UK monetary authority tries to keep inflation within a range rather than pursuing a point target, and show that nonlinearity is important. Similarly, Surico (2007a, 2007b) and Castro (2010a) argue that central banks can have asymmetric preferences – for instance, they might assign different weights to negative and positive gaps in inflation, output or even in monetary variables included in their loss function. This, in turn, gives rise to the existence of a nonlinear monetary policy reaction function. We leave this line of investigation for the future.

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