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Money and monetary policy transmission in the euro area: evidence from FAVAR- and VAR approaches

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Abstract:

This paper investigates the transmission of monetary policy in the euro area based on the factor augmented vector autoregressive approach of Bernanke, Boivin and Eliasz (2005) as well as on a standard VAR model. We focus on the reaction of monetary aggregates to a one-off monetary policy shock. We find that – as theory suggests – money growth is dampened by a restrictive monetary policy stance in the longer term. In the short-run, however, M3 growth may increase due to portfolio shifts caused by the rise in the short-term interest rate. This has consequences for the interpretation of money growth as an input for monetary policy decisions.

Keywords: Monetary policy transmission, FAVAR, VAR, money stock, euro area.

JEL-Classification: C32, E40, E52.

Non technical summary

Recent years witnessed a strong trend growth in euro area nominal money stock M3. Despite a series of increases in the monetary policy interest rates which started in December 2005, the annual growth rate of the monetary aggregate M3 was still at about 9% in the summer months of 2008, which is far above of what is deemed in line with price stability by the Eurosystem. The assessment of these developments from a monetary policy perspective requires a comprehensive knowledge of the monetary transmission process.

According to traditional transmission channels, restrictive monetary policy dampens money growth because it impacts negatively on credit growth. In principle, however, one could also think of a situation in which monetary growth is fostered by the rise in short-term interest rates: If the tightening of monetary policy results in a flatter yield curve, it renders investments in short-term financial assets (which are part of money) more attractive relative to investments in longer-term exposures (which are not part of monetary aggregates). A positive correlation between money growth and short-term interest rates could also mean a reverse causation in the sense that strong money growth indicates inflationary risks which prompt the monetary authorities to tighten monetary policy accordingly. Hence, any empirical approach that intends to capture the monetary transmission process has to take this "reverse causation" relationship explicitly into account. This calls for a vector autoregressive (VAR) framework which has become a standard toolbox for estimating the effects of monetary policy shocks without, *a priori*, dismissing any of the potential correlations and causal relationships among the variables included in a model. However, the number of variables generally used in traditional VAR models is relatively small, in order to save degrees of freedom. This limitation is at odds with the decision-making process at central banks, which have, in fact, much more information at their disposal than can be included in traditional VAR models. Therefore, our analysis builds on the factor augmented vector autoregressive (FAVAR) approach suggested by Bernanke, Boivin and Eliasz (2005). This approach uses factor extracting techniques to summarise the relevant information from a large set of time series. Thus, the advantage of the FAVAR approach is that all potentially relevant information for policymakers can be taken into consideration. As a cross check, we compare the results of our FAVAR model with those of a standard VAR model.

Our findings are largely in line with prevailing expectations regarding the qualitative effects of monetary policy. Concerning the monetary dynamics, the empirical results from either FAVAR and standard VAR models indicate that nominal M3 initially rises in response to a one-off positive shock in the short-term interest rate and shows the expected falling pattern after about the fifth quarter with convergence towards the zero line in the long run.

Nicht-technische Zusammenfassung

In den letzten Jahren nahm die Wachstumsrate der nominalen Geldmenge M3 im Euro-Raum unter leichten Schwankungen trendmäßig immer weiter zu. Trotz der schrittweisen Erhöhung der Notenbankzinsen ab Dezember 2005 betrug die jährliche Wachstumsrate des Geldmengenaggregats M3 noch im Sommer 2008 rund 9% und lag damit weit über dem Wert, der vom Eurosystem als preisstabilitätskonform angesehen wird. Die geldpolitische Bewertung dieser monetären Entwicklung setzt ein umfassendes Verständnis des geldpolitischen Transmissionsmechanismus im Euro-Raum voraus.

Gemäß der traditionellen Transmissionskanäle führt eine restriktive Geldpolitik über die Abschwächung der Kreditdynamik zur Dämpfung des Geldmengenwachstums. Andererseits ist es jedoch auch denkbar, dass das Geldmengenwachstum positiv auf die Notenbankzinserhöhungen reagiert: Wenn die restriktive Geldpolitik zu einer flacheren Zinsstrukturkurve führt, werden die in M3 enthaltenen kurzfristigen Anlagen zunächst attraktiver als die längerfristigen Anlagemöglichkeiten, was zu einer Erhöhung der Geldmenge führt. Eine positive Korrelation von Geldmengenwachstum und Zinssetzung kann aber auch auf eine umgekehrte Kausalität hindeuten, die die Reaktion der Geldpolitik auf die mit einem starken Geldmengenwachstum einhergehenden Inflationsrisiken beschreibt. Deshalb erfordert jede adäquate empirische Analyse des geldpolitischen Transmissionsprozesses die explizite Berücksichtigung auch dieser umgekehrten Kausalbeziehung. Dies ist im Rahmen eines vektorautoregressiven (VAR-) Models möglich. VAR-Modelle stellen einen empirischen Standardrahmen für die Analyse der Effekte von geldpolitischen Schocks auf die makroökonomischen Variablen dar. Die breite Anwendung dieser Modelle lässt sich insbesondere dadurch begründen, dass sie eine empirisch plausible Analyse der monetären Transmission ermöglichen, ohne dabei eine der denkbaren Korrelationen und Kausalbeziehungen zwischen den Modellvariablen von vornherein zu vernachlässigen. Die traditionellen VAR-Modelle können allerdings aufgrund der beschränkten Anzahl von Freiheitsgraden nur relativ sparsam spezifiziert werden. Diese Einschränkung widerspricht jedoch dem Entscheidungsfindungsprozess der Zentralbanken, die in der Realität über weit mehr Informationen verfügen, als in den traditionellen VAR-

Modellen berücksichtigt werden können. Deshalb führen wir unsere Analyse mit dem faktorerweiterten VAR- (FAVAR-) Modell von Bernanke, Boivin and Eliasz (2005) durch, bei dem anstelle einzelner Variablen sogenannte Faktoren berücksichtigt werden, die vorab mittels Faktoranalysetechniken aus einem großen Datensatz extrahiert werden. Der Vorteil des FAVAR-Modells liegt demnach in der Möglichkeit der Berücksichtigung aller für die Entscheidungsfindung der Zentralbanken potenziell relevanten Variablen. Anschließend vergleichen wir die Ergebnisse des FAVAR-Modells mit denjenigen eines Standard-VAR-Modells.

Unsere Ergebnisse stimmen weitgehend mit den vorherrschenden Erwartungen hinsichtlich der qualitativen Effekte der Geldpolitik überein. In Bezug auf die monetäre Dynamik zeigen die Ergebnisse aus beiden Modellen (FAVAR und Standard-VAR), dass die nominale Geldmenge nach einem einmaligen kontraktiven Zinsschock zunächst ansteigt, bevor sie etwa ab dem fünften Quartal den erwarteten fallenden und langfristig gegen Null konvergierenden Verlauf aufweist.

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1 Introduction

Recent years witnessed a strong trend growth in euro area nominal money stock M3. Despite a series of increases in the monetary policy interest rates which started in December 2005, the annual growth rate of the monetary aggregate M3 was still at about 9% in the summer months of 2008, which is far above of what is deemed in line with price stability by the Eurosystem. The assessment of these developments from a monetary policy perspective requires a comprehensive knowledge of the monetary transmission process. However, the available empirical evidence on the transmission process is fraught with uncertainty surrounding its details. Moreover, most empirical analyses of the monetary transmission process do not take into account developments of the money stock (see Christiano, Eichenbaum and Evans (1999) for a survey).

According to traditional transmission channels (e.g. interest rate channel, credit channels…), restrictive monetary policy dampens money growth because it impacts negatively on credit growth (either by reducing loan demand or loan supply).[1] In principle, however, one could also think of a situation in which monetary growth is fostered by a rise in short-term interest rates: If the monetary policy tightening results in a flatter yield curve, it renders investments in short-term financial assets (which are part of money) more attractive relative to investments in longer-term exposures (i.e. longer-term deposits or bank debt securities which are not part of monetary aggregates). Another possibility is that higher interest rates lead to an increased demand for external funds because firms are unable to quickly reduce their expenditures, but at the same time earn a lower cash flow (because their gross earnings decrease and/or they have to pay higher interest rates on their outstanding debt). If such "perverse" reactions of

* I would like to thank Jörg Breitung, Sandra Eickmeier, Christina Gerberding, Rafael Gerke, Felix Hammermann, Julian Reischle, Michael Scharnagl, Markus A. Schmidt and Andreas Worms for very helpful suggestions und fruitful discussions. All errors are my own.

[1] The negative correlation between monetary policy rates and money growth plays a central role in conventional views of the monetary transmission mechanism and is termed in the literature as a liquidity effect. Nevertheless, yet to day the empirical evidence for this effect remains very mixed (see Bernanke and Mihov (1998) for a review and discussion).

money growth to monetary policy were quantitatively important, they would have to be accounted for when interpreting money growth as an input for monetary policy decisions.

Historically, the strong monetary dynamics of the recent period of rising interest rates shows some similarity with the development in Germany during the period of rising interest rates from mid-1988 to mid-1992: Like in the period from end-2005 to end-2007 in the euro area, this episode was characterized by strong growth in M3 and central bank rate hikes. However, the fact that periods of rising policy rates need not necessarily be accompanied by higher monetary growth is evident from the period end-1999 to end-2000 when short-term interest rates rose and monetary growth weakened. Clearly, the key question here is about the causal relationship between money growth and monetary policy rates: A positive correlation between money growth and short-term interest should not *per se* be interpreted as indicating that money growth reacts "perversely" to monetary policy; instead, it could also mean a reverse causation in the sense that strong money growth indicates inflationary risks which prompted the monetary authorities to tighten monetary policy accordingly. Hence, any empirical approach that intends to capture the monetary transmission process has to take this "reverse causation" (that is, policy reaction function) relationship explicitly into account.

This calls for a vector autoregressive (VAR) framework which has become a standard toolbox for estimating the effects of monetary policy innovations on macroeconomic variables without requiring a complete structural model of the economy and hence, *a priori*, dismissing any of the potential correlations and causal relationships among the variables included in a model. The number of variables generally used in traditional VAR models, however, is relatively small, in order to save degrees of freedom. This limitation is at odds with the decision-making process in central banks, which have, in fact, much more information at their disposal than can be included in traditional VAR models. In the recent debate on the monetary transmission process, it has increasingly been noted that omitting information relevant for central banks' decision-making process may result in a biased estimate of the non-systematic component of monetary policy, potentially calling into question the inference of traditional VAR models (Bernanke et al. (2005), Giannone, Reichlin and Sala (2002)).

In addition, it has been argued that representing the underlying dynamics of some fundamental macroeconomic variables (e.g. inflation) by using just a single indicator (e.g. CPI) may be insufficient since their meaningfulness could be impaired by measurement errors or other statistical problems (Boivin and Giannoni (2006)). Therefore, the empirical analysis presented here builds on the factor augmented vector autoregressive (FAVAR) approach suggested by Bernanke, Boivin and Eliasz (2005). This approach uses factor extracting techniques to obtain a relatively small set of factors which summarises the relevant information from a large set of time series to a sufficient degree.[2] Thus, an important advantage of FAVAR models is that all potentially relevant information for policymakers can be taken into consideration. In addition, it is possible to calculate impulse response functions for numerous variables in order to get a comprehensive picture of the effects of monetary policy shocks on the economy.

Most studies applying a FAVAR approach to analyse monetary transmission are related to the USA (see e.g. Bernanke et al. (2005), Stock and Watson (2005), Favero, Marcellino and Neglia (2005), Belviso and Milani (2006), Boivin, Giannoni and Mihov (2007), Boivin and Giannoni (2008)), whereas – to our knowledge – up to now only few studies have been conducted for the euro area. One is Eickmeier (2008) who analyses the importance of common monetary policy shocks for variations of economic activity and inflation in individual EMU countries. Her analysis is based on the structural dynamic factor model of Forni and Reichlin (1998) and covers the period from 1981 to 2003. McCallum and Smets (2007) use the FAVAR model of Bernanke et al. (2005) to analyse the effects of monetary policy shocks on real wages and employment in individual euro area countries as well as the euro area as a whole over the period from 1986 to 2005. Boivin, Giannoni and Mojon (2008) focus on potential differences in the transmission process of individual euro area countries and over time. They also use the FAVAR approach by Bernanke et al. (2005) and their sample covers the period from 1980 to 2007.

This paper departs from the existing literature in its focus on the investigation of the effects of interest rate shocks on broad measures of monetary aggregates. Our

[2] There are two main approaches for factor extraction: See Stock and Watson (2002, 2005) for factor extraction by static principal components and Forni et al. (2000, 2003) for factor extraction using dynamic principal components, respectively.

findings are largely in line with expectations regarding the qualitative effects of monetary policy (see for "stylised facts" e.g. Christiano et al. (1999)). Concerning the monetary dynamics, the empirical results indicate that nominal M3 initially rises in response to a one-off positive shock in the short-term interest rate and then shows the expected falling pattern after about the fifth quarter with convergence towards zero in the long run. In a second step, we follow Bernanke et al. (2005) and investigate whether different data environments (rich versus small) within the FAVAR and the standard VAR models affect the identification of monetary policy shocks and the empirical plausibility of estimated impulse response functions. Our results suggest that the two methods produce overall qualitatively similar results. Still, the FAVAR model is the more attractive approach as it permits us to provide a broader characterisation of the monetary policy effects on the economy.

The remainder of this paper is organised as follows: Section 2 describes the econometric framework. Section 3 provides information of the data used in the study. Section 4 presents the estimation results. The final Section 5 summarises the findings and concludes.

2 FAVAR Model

2.1 Model Framework

This paper follows the approach of Bernanke et al. (2005). The basic idea of a FAVAR model rests on merging the large amount of macroeconomic data into a sufficiently small number of factors which is subsequently used for the estimation of a VAR model.

We assume that a $(N \times 1)$ vector of macroeconomic time series X_t can be represented as a linear combination of the $(K \times 1)$ vector of unobservable factors F_t $(K$ is relatively small, $K << N)$ and an observable factor R_t, which represents the short-term interest rate variable, such that:

$$X_t = \Lambda^f F_t + \Lambda^r R_t + e_t, \tag{1}$$

where Λ^f, Λ^r are the $(N \times K)$ matrix of factor loadings and the $(N \times 1)$ vector of factor loadings, respectively, and e_t is the $(N \times 1)$ vector of error terms with mean zero and assumed to be serially and mutually weakly correlated. Equation (1) implies that the dynamics of each individual time series in the vector X_t are driven by the common factors (F_t, R_t) and an idiosyncratic component e_t which may also contain measurement errors. Furthermore, we assume that the joint dynamics of F_t and R_t are given as follows:

$$\Phi(L)\begin{bmatrix} F_t \\ R_t \end{bmatrix} = \upsilon_t, \qquad (2)$$

where $\Phi(L) = I - \Phi_1 L - ... - \Phi_d L^d$ is the matrix of lag polynomials of order d, the error term υ_t is mean zero with covariance matrix Σ_υ. Equation (2) represents the factor augmented VAR model in (F_t, R_t).

The estimation of the FAVAR model is carried out in two-steps. First, we estimate the factors by using the Stock and Watson (2002) principal component method. In the second step, we estimate the model in (2) by replacing the unobservable factors F_t with their estimates from the first step. The monetary policy shock is identified using a Cholesky identification scheme assuming that the monetary policy variable, that is, the short-term interest rate R_t, has only a lagged impact on the unobservable factors F_t.

2.2 Empirical Implementation

In the first step of the analysis, common static factors $\hat{C}(F_t, R_t)$ are estimated using the first $(K+1)$ principal components of all time series in vector X_t.[3] Since each linear combination, which underlies $\hat{C}(F_t, R_t)$, also contains the observable factor R_t, it is not possible to estimate the VAR model in $\hat{C}(F_t, R_t)$ and R_t, and to identify the monetary policy shock recursively. Therefore, the estimated principal components $\hat{C}(F_t, R_t)$ have to be corrected for the direct influence of the observable factor R_t. To this end, a distinction is made between the variables that do not react in the current period t to the monetary policy shock – slow moving series – and those variables that are highly sensitive to the contemporaneous monetary policy shock – fast moving series. A new

[3] Note, that the term static factor refers to a static relationship between $\hat{C}(F_t, R_t)$ and X_t, but $\hat{C}(F_t, R_t)$ itself can be a dynamic process (see Bai and Ng (2007)).

vector $\hat{F}_t^S$ of the principal components is subsequently extracted from the former category. Since these factors are, by definition, not contemporaneously correlated with the observable factor R_t, the influence of R_t can be calculated on the basis of the following multiple regression:

$$\hat{C}(F_t, R_t) = \beta_S \hat{F}_t^S + \beta_R R_t + \varepsilon_t, \qquad (3)$$

where β_S is the coefficient matrix of estimated factors $\hat{F}_t^S$, β_R is the coefficient vector of the observable factor R_t and ε_t is a vector of random variables with zero mean and covariance matrix Σ_ε. The unobservable factors $\hat{F}_t$ can now be calculated by subtracting $\hat{\beta}_R R_t$ from $\hat{C}(F_t, R_t)$ or, in other words, by removing the direct dependence of $\hat{C}(F_t, R_t)$ on R_t.

In the second step of the analysis, the factor augmented VAR model in equation (2) is estimated by replacing the true unobservable factors F_t with their estimates from the first step:

$$\Phi(L)\begin{bmatrix} \hat{F}_t \\ R_t \end{bmatrix} = \upsilon_t, \qquad (2')$$

where $\hat{F}_t' = \left(\hat{F}_{1t}\ \hat{F}_{2t} \ldots \hat{F}_{ft}\right)$ with f as the number of unobservable factors. The lag length of two is selected on the basis of lag order selection statistics. According to Stock and Watson (2002), the number of factors is determined on the basis of model's goodness of fit characteristics (inter alia information criteria).[4] Thus, in the preferred specification, seven unobservable factors are extracted which jointly explain almost 80% of total variance in the data base.

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[4] Bai and Ng (2002) developed criteria to determine the optimal number of factors. However, these criteria work well only if $N, T \to \infty$. Since our dataset has a much smaller dimension ($N = 65$ and $T = 81$), we do not apply these criteria. Bernanke et al. (2005) stress, in addition, that the factor selecting criteria suggested by Bai and Ng (2002) do not necessarily address the question of how many factors should be included in the VAR model. Many studies determine the number of factors, therefore, simply in an *ad hoc* fashion (see e.g. Bernanke et al. (2005), Shibamoto (2007), McCallum and Smets (2007)).

The impulse response functions of $\hat{F}_t$ and R_t are given by:

$$\begin{bmatrix} \hat{F}_t \\ R_t \end{bmatrix} = \sum_{j=0}^{\infty} \Psi_j L^j \upsilon_t = \sum_{j=0}^{\infty} \Psi_j \upsilon_{t-j}, \tag{4}$$

where $\sum_{j=0}^{\infty} \Psi_j L^j = [\Phi(L)]^{-1}$. Finally, the impulse response functions of each variable i in X_t can be calculated according to the equations (1) and (3) by the following transformation:

$$X_{it}^{IRF} = \begin{bmatrix} \hat{\Lambda}_i^f & \hat{\Lambda}_i^r \end{bmatrix} \begin{bmatrix} \hat{F}_t \\ R_t \end{bmatrix} = \begin{bmatrix} \hat{\Lambda}_i^f & \hat{\Lambda}_i^r \end{bmatrix} \left(\sum_{j=0}^{\infty} \Psi_j \upsilon_{t-j} \right), \tag{5}$$

where $\hat{\Lambda}_i^f \left(f = 1, 2, .., 7 \right)$ and $\hat{\Lambda}_i^r$ are factor loadings estimated for series i according to the equation (1).

3 Data

The data set consists of 65 quarterly macroeconomic time series for the euro area from 1986:Q4 to 2006:Q4.[5] The series are mostly taken from the Area Wide Model (AWM) data set, which reflects a broad range of economic activity in the euro area, a number of global variables (e.g. World GDP, World GDP-Deflator, World monetary aggregate), as well as foreign variables (US GDP, US Federal Funds Rate, US long-term interest rate).[6] The latter are integrated as proxies for external real and monetary influences. Given the motivation for this analysis, a few euro area monetary variables (nominal M1, nominal M2, nominal M3, nominal M3 corrected for portfolio shifts, monetary capital, MFI loans) have been added to the data set.[7]

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5 Our sample starts in 1986:Q4 due to the findings in the literature that some key macroeconomic time series underwent a structural break in the mid-1980s, see e.g. Altissimo, Ehrmann and Smets (2006), McCallum and Smets (2007). We end in 2006Q4 because of data availability.

6 The AWM data set covers a wide range of quarterly euro area macroeconomic time series and has become a standard reference for empirical studies on the euro area economy. For a detailed description of AWM data see Fagan, Henry and Mestre (2001).

7 The number of time series included in this study is relatively small compared to other studies. As a check, national series have also been added in order to broaden the data set. We find, however, that this cause a noticeable deterioration in the Kaiser-Mayer-Olkin (KMO) and Measure of Sampling Adequacy (MSA) values, each of which measures the sampling adequacy for the factor analysis. The addition of national time series apparently lead to impairments in factor extraction. Bernanke et al. (2005), Boivin and Ng (2006) point out in this context that the size of the data set is not crucial for

All variables - with the exception of interest rates - are transformed in logs and, if necessary, differentiated to get stationary time series. These transformations were carried out on the basis of unit root tests. Since the different scales of the time series could impair factor extraction, all series were standardised to have a zero mean and a variance of one. Appendix 2 describes the series as well as their sources and transformations in more detail. In order to give an idea about the goodness of fit properties of estimated factors, Table 1 reports the *adjusted* R^2 of some variables, that is, the fraction of the variance explained by the common factors $\hat{F}_t, R_t$.

Table 1: Explanatory power of factors for some macroeconomic variables

Description	Adjusted R2
Short-term interest rate (nominal)	1.000
HCPI (index)	0.995
Wealth (real)	0.992
GDP-deflator (index)	0.991
Private Consumption (real)	0.984
Wage per head (real)	0.946
Long-term interest rate (nominal)	0.945
GDP (real)	0.867
Nominal M2	0.844
Nominal M3	0.827
Nominal M3 adjusted	0.795
Gross real investment	0.781
Unemployment rate (as a percentage of labour force)	0.701
Nominal M1	0.661
Stocks	0.647
Monetary capital	0.492
Real effective exchange rate	0.488
Exports of goods and services (real)	0.448
MFI-loans	0.446
Household’s savings/GDP	0.342
Household housing wealth (real)	0.112

factor extraction. Based on simulation analysis Boivin and Ng (2006) find that factors extracted from as few as 40 series yield satisfactory or even better results than using all (in their study there were 147) series.

The adjusted R^2 values are obtained by regressing the respective series on the common factors $\hat{F}_t, R_t$. There is considerable correlation between almost all of the listed variables and the common factors, indicating that the estimated factors summarise the information contained in these series quite well. However, there are also a few series that cannot be satisfactorily explained by the common factors. For instance, the growth rate of the households' savings ratio with adjusted R^2 of 34% and the changes in growth rate of real household housing wealth with adjusted R^2 of 11% display much less correlation with the common factors. This implies that we should have less confidence in impulse response estimates for these variables. Nevertheless, the common factors explain nearly 80% of the total variance in the entire data set with sufficiently high R^2 statistics for key macroeconomic variables (e.g. real GDP growth, Gross real investments, HICP inflation) as well as for monetary aggregates (growth rates of monetary aggregates M1, M2, M3 and M3 adjusted).[8]

4 Estimation Results

In this section, we first present the estimated impulse responses of the FAVAR model specified in section 2. Further, we follow Bernanke et al. (2005) and compare the FAVAR results with those obtained in a small-scale standard VAR model. In doing so, we specify our VAR model in six endogenous variables (real GDP, GDP deflator, short-term interest rate, long-term interest rate, nominal M3, real household housing wealth) as well as two exogenous variables (US federal funds rate, commodity price index).[9] Details of the VAR model specification can be found in Appendix 1. In both models, we define the monetary policy shock as a 50 basis points innovation in the short-term interest rate.

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8 The large proportion (30%) of the variation in the data is explained by the first factor. The second factor accounts for 13%, the third factor for 9%, and the fourth to eighth factors elucidate remaining fraction (roundly 28%) of explained overall variance of the data.

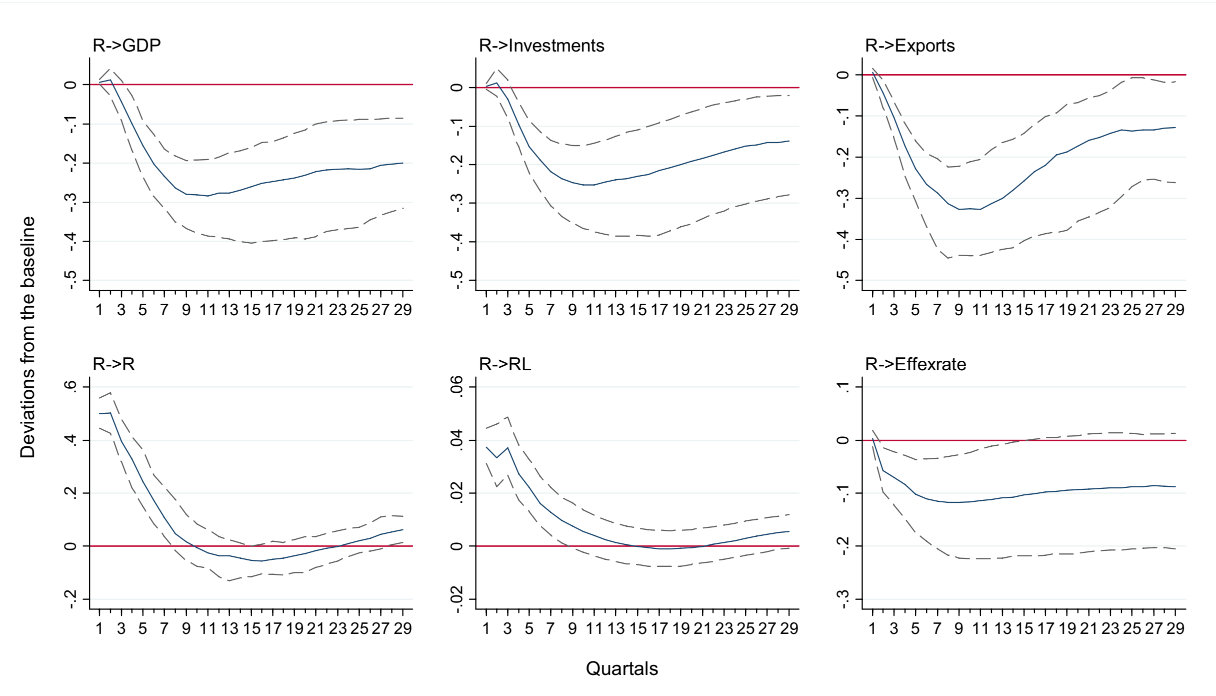
9 Other studies based on FAVAR model, such as Lagana and Mountford (2005) for UK and Shibamoto (2007) for Japan estimate their benchmark VAR model like Bernanke et al. (2005) in three variables. For the euro area, however, experience shows that more than three variables are necessary to describe the euro area macroeconomic dynamics properly.

4.1 Results of the FAVAR model

Figures 1 to 3 show the estimated impulse responses of a set of macroeconomic variables to an unexpected tightening in monetary policy. The corresponding 70-percent confidence intervals (dashed lines) are calculated using a standard bootstrap procedure with 1000 replications.[10]

As Figure 1 reveals, an unexpected tightening in monetary policy results in a gradual decrease in real GDP (*GDP)*, which reaches its maximum effect after around ten quarters before then reverting very slowly back to the baseline. Other measures of real activity, such as real investment (*Investments*) and real exports (*Exports*) react to an unexpected one-off increase in the short-term interest rate also in line with theoretical expectations: real investment initially falls because loans become more costly, while real exports decline because domestic goods become more expensive abroad. Both impulse responses converge back towards their starting level after around 26 quarters.

Figure 1: Impulse responses to a monetary tightening shock in the FAVAR model



Notes: Deviations from the baseline in percent, except for the short-term interest rate (*R*) as well as for the long-term interest rate (*RL*), for which the ordinates are in percentage points.

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[10] Note that it is quite common in the monetary transmission literature based on FAVAR model techniques to set the confidence bands at 70%, see e.g. Lagana and Mountford (2005), Belviso and Milani (2006), Boivin and Giannoni (2008).

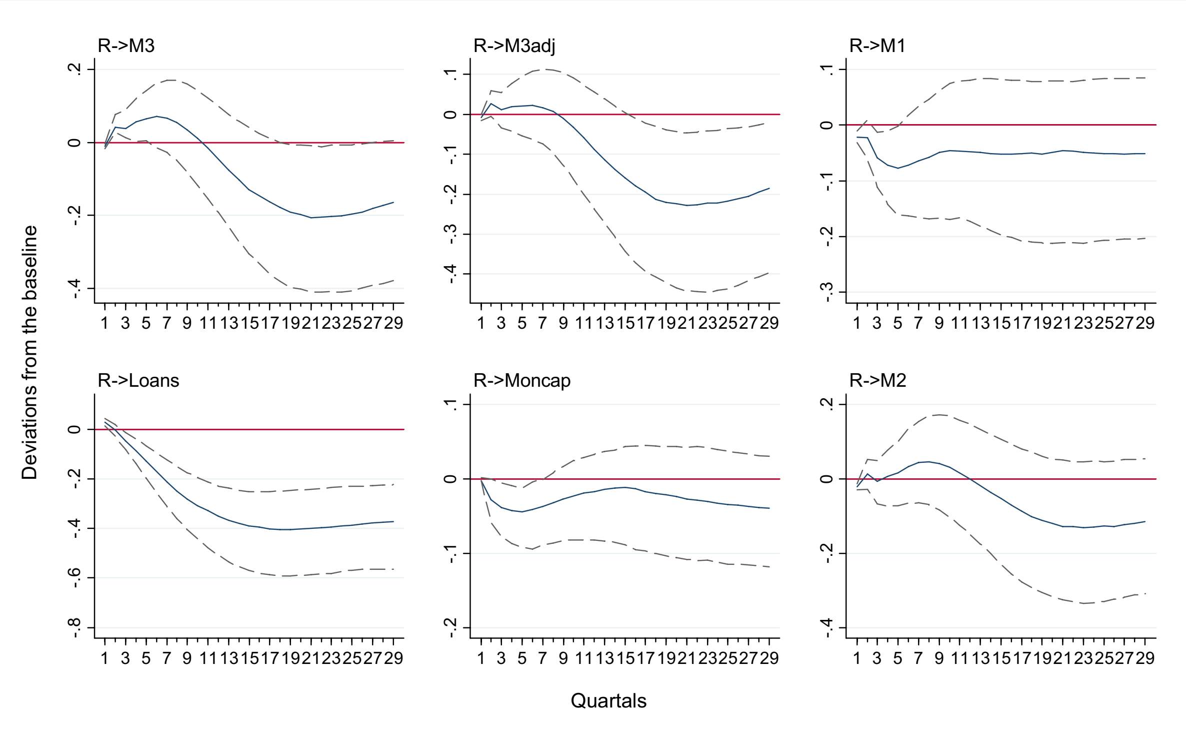
The impulse responses of interest rates are also consistent with theory. The short-term interest rate (*R*) initially reflects its own positive shock and falls continuously in the first six quarters. Afterwards, it stagnates at the benchmark level, i.e. the zero line. The long-term interest rate (*RL*) first rises significantly following monetary tightening, and shows the falling pattern after about two quarters before reaching the baseline by the eighth quarter. The initial rise in the long-term interest rate can be explained by the expectation hypothesis of the term structure, which indicates that the long-term interest rate reflects an average of expected future short-term interest rates. The observed subsequent decline can presumably be attributed to the dampening effect that the monetary tightening has on the economy.

The effective euro exchange rate (*Effexrate*) (in direct quotation) initially falls in response to an unexpected interest rate increase (higher capital inflows as a consequence of more attractive investment cause the euro to appreciate), reaching its maximum decline after around six quarters and reverting back to the starting level after ten quarters.

As the particular focus of this paper is on the effects of monetary policy shocks on the monetary aggregates, Figure 2 shows the estimated impulse responses of these variables. Following the one-off positive impulse to the short-term interest rate, nominal M3 (*M3*) initially rises (albeit with weak statistical significance) before showing the expected fall from roughly the fifth quarter and trending towards the zero line in the long run. The initially positive response of the nominal M3 to monetary tightening can be explained by temporary portfolio shifts: Higher short-term interest rates at first render the short-term assets contained in M3 more attractive than longer-term investments, leading to a temporary increase in money stock M3.[11] The medium-term decline in M3 then reflects, as generally expected, the decrease in demand for credit as reaction to the higher refinancing costs (cf. the impulse response for nominal loans to the private sector (*Loans*)) and the concomitant drop in money creation.

[11] While this interpretation seems to be contrary to the traditional expectation hypothesis (without risk premia), it is closer to reality, which is characterized by various frictions and risk premia. In addition, according to the term structure literature, changes of short term interest rates account for roughly 90 percent of variations in long-term rates. Consequently, the remaining 10 percent should be governed by other latent factors (e.g. inflation risk premia), which presumable are driving the above mentioned portfolio adjustments. See, for instance, Kim and Wright (2005), Cochrane and Piazzesi (2008) for decomposing yield curves into expectations of future interest rates and risk premia.

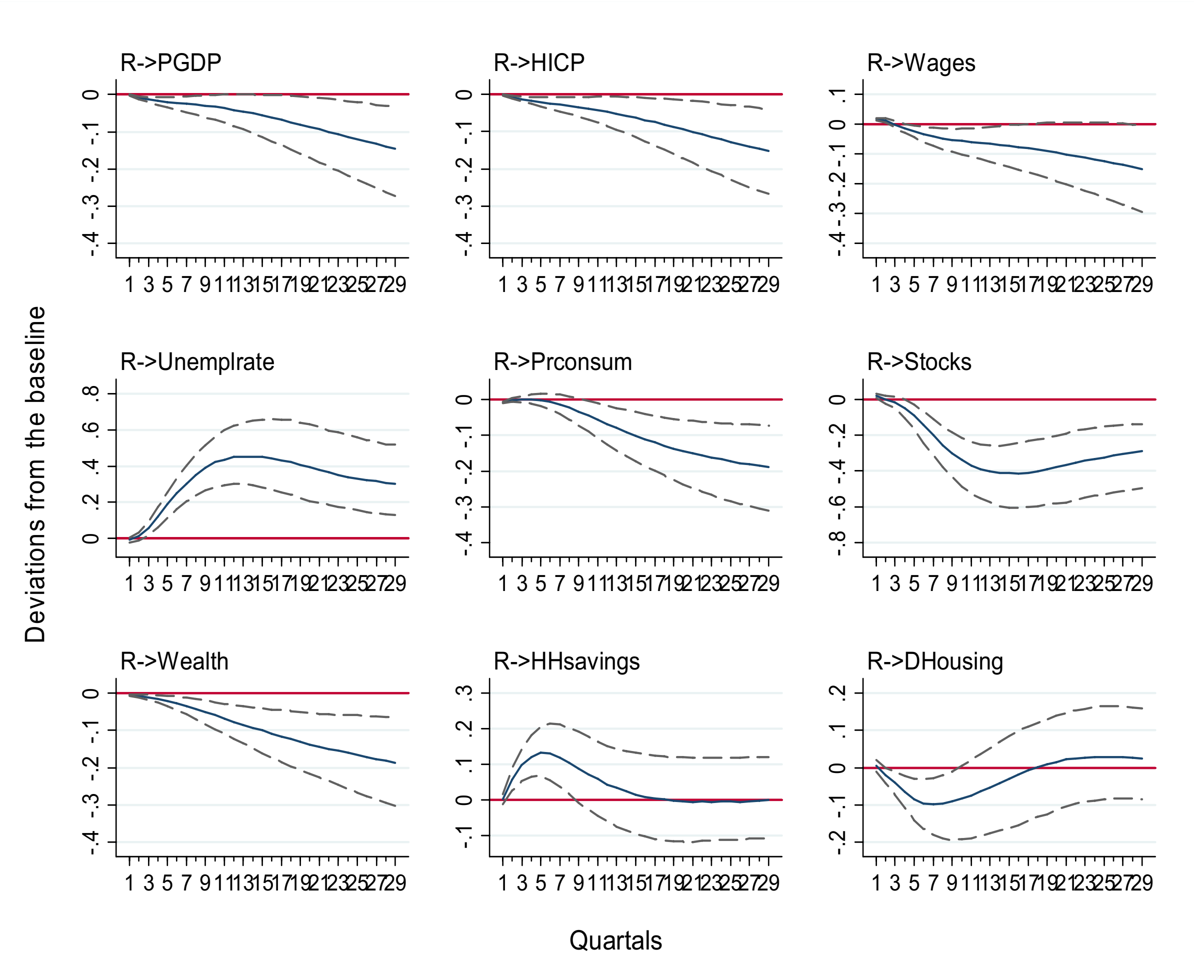
Figure 2: Impulse responses of monetary aggregates to a monetary tightening shock



Notes: Deviations from the baseline in percent.

Comparing the reaction of M3 with the impulse response of loans to the private sector which is shown to fall immediately after the contractionary monetary policy shock as well as of the M3 series corrected for portfolio shifts in the years 2001 to 2003 (*M3adj*) confirms the above mentioned intuition that the initial upward response of nominal M3 is largely due to portfolio reallocations. The impulse responses of nominal M1 (*M1*) and monetary capital (*Moncap*) provide further evidence for this conclusion: The liquid, non-interest-bearing (cash) or low-interest (overnight deposits) money assets contained in M1 initially react negatively to the monetary policy shock, resulting in higher opportunity costs of holding money, though the medium to long-term effect proves not to be different from zero. Monetary capital falls initially suggesting that longer maturity assets become unattractive relative to short-term assets comprised by M3. Nominal M2 (*M2*) shows no significant response to monetary tightening. Since the degree of uncertainty about the point estimates is quite large, the impulse response of M2 is not very informative.

Figure 3: Impulse responses to a monetary tightening shock in the FAVAR model



Notes: Deviations from the baseline in percent, except for growth rate of real household housing wealth (*DHousing*), for which the ordinate is in percentage points.

As shown in Figure 3, GDP deflator (*PGDP*) and harmonised index of consumer prices (*HICP*), both reported in levels, fall in response to the monetary tightening. However, this reaction is only weakly significant over the short to medium term. Interestingly, there is no "price puzzle", i.e. a counter-intuitive positive reaction of prices to a contractionary monetary policy shock often found in the VAR literature. This suggests that our factor augmented VAR model captures information about prices properly.

Following monetary tightening, real wages (*Wages*) fall with weak significance only in the short term, while over the medium- to longer-term the falling pattern of real wages is not different from zero. This result is widely consistent with the impulse response of the unemployment rate (*Unemplrate*), which is shown to increase before reverting very slowly back to the zero line. Firms appear to respond to an unfavourable economic development by rather adjusting their work force than by reducing wages. Our findings contrast somewhat with those observed in McCallum and Smets (2007), who find that real wages drop significantly following a positive monetary policy shock whereas the unemployment rate increases with weak statistical significance and less strongly.[12] Our results are, however, broadly in line with the comprehensive empirical evidence regarding the existence and implications of downward sticky wages. According to this literature, wages in most of the euro area countries are downwardly rigid and thus, at least from the firms' perspective, higher than desired resulting in overall elevated unemployment.[13]

After the restrictive monetary policy shock, private consumption (*Prconsum*) initially responds fairly sluggish und falls only after around eight quarters with visible persistence in the long run. The observed long-term persistence in the impulse response of consumption seems to be somewhat surprising at first glance. However, it is in fact largely compatible with theoretical considerations about consumption smoothing, suggesting that private consumption is less volatile than real income.

Stock prices (*Stocks*) – which serve as a proxy for financial asset prices - drop in reaction to an unexpected monetary tightening but converge toward the zero line in the long run, albeit at slow pace. Higher interest rates lead to a reduction in profit expectations since they increase financing costs. As stock prices represent the present value of all future profit expectations, they react to a positive interest rate shock by falling, too. The impulse response of stock prices reaches its minimum after about 14 quarters and converges then slowly towards the basis line. The somewhat higher persistence of long-term effects of stock prices is also reflected in the fall of total real wealth (*Wealth*).

The households' saving ratio (*HHsavings*) rises following to a one-off positive shock to short-term interest rate since saving is now more attractive. After around five quarters it then begins to revert quickly back to the zero line. Growth of real household housing wealth (*DHousing*) reacts to a contractionary monetary policy shock by falling

[12] In their study, McCallum and Smets (2007) explain the faster response of wages as a possible result of labour market or other structural reforms.

[13] See, for instance, Knoppik and Beissinger (2006), Dickens et al. (2007).

for about six quarters but then, after as few as eight quarters, already converges back towards the baseline. The impulse response of housing wealth is therefore widely consistent with both theoretical expectations (a higher short-term interest rate makes refinancing more expensive leading to sluggish housing demand and lower housing prices) and the existing empirical literature (cf. Greiber and Setzer (2007)). As already pointed out above, the household saving ratio and growth of real household housing wealth are variables for which the explanatory power of common factors is insufficiently low. Therefore, despite plausible impulse responses for these variables, they should be considered with cautions.

In summary, the results of the FAVAR model are largely in line with the prevalent expectations regarding the qualitative effects of monetary policy. Accordingly, they are widely consistent with the "stylised facts" of previous studies on monetary transmission in the euro area based on VAR models.

4.2 Results of the VAR model

In this subsection we follow Bernanke et al. (2005) and compare our results of the FAVAR model with a standard VAR model. In doing so, we examine, whether different data environments (rich versus small) within the factor augmented and standard VAR models affect the identification of monetary policy shocks and the empirical plausibility of the estimated impulse response functions, respectively. Figure 4 displays the resulting impulse response functions. The corresponding 90-percent confidence intervals are designed using a standard bootstrap procedure with 1000 replications. The sample period is 1986Q4 to 2007Q2. Details of the VAR model specification can be found in Appendix 1.

As Figure 4 shows, the estimated impulse responses are largely in line with the results of the FAVAR model outlined above. As with the FAVAR model, nominal M3 (*M3*) initially rises in response to unexpected increase of 50 basis points in short-term interest rate, before showing the expected fall after the fifth quarter and converging towards the zero line in the long run. Hence, like the FAVAR model, the standard VAR model shows that the effects of interest rate changes on money stock M3 are of alternating signs, suggesting that the monetary policy shock initially fosters monetary growth before exerting a dampening influence in the longer term.

The impulse response of GDP deflator (*PGDP*) is initially positive, i.e. we observe a temporary "price puzzle". According to Sims (1992), this may indicate an insufficient description of the central bank's information about future inflation. To obtain a more reasonable result, Sims (1992) suggests to account for additional variables such as an index of commodity prices in the VAR model.[14] In our study we follow Peersman and Smets (2003) by including a commodity price index as an exogenous variable in the VAR model. In doing so, we assume that there is no feedback from euro area endogenous variables to world commodity prices. While the inclusion of the commodity price index seems to improve the VAR model's properties (measured by information criteria), it cannot solve the "price puzzle". The impulse response of the GDP deflator remains widely unchanged. The comparison between the estimated impulse responses of the GDP deflator from the FAVAR and the standard VAR model suggests that the factor augmented model captures information about the price dynamics more properly since we did not obtain such a "price puzzle" in the FAVAR model. This result is largely consistent with the empirical literature based on the FAVAR model techniques, which shows that analysing monetary transmission in a data rich environment – that is by using several potential indicators of inflationary pressure simultaneously – helps resolving the "price puzzle".[15]

Real GDP (*GDP*) initially falls in response to an unexpected interest rate increase, reaching its maximum decline after around five quarters and reverting back to the benchmark level after ten quarters. Different to the FAVAR model, the impulse response of real GDP in the standard VAR model shows less long-term persistence and therefore stronger conformance with the hypothesis of the long-run monetary neutrality.

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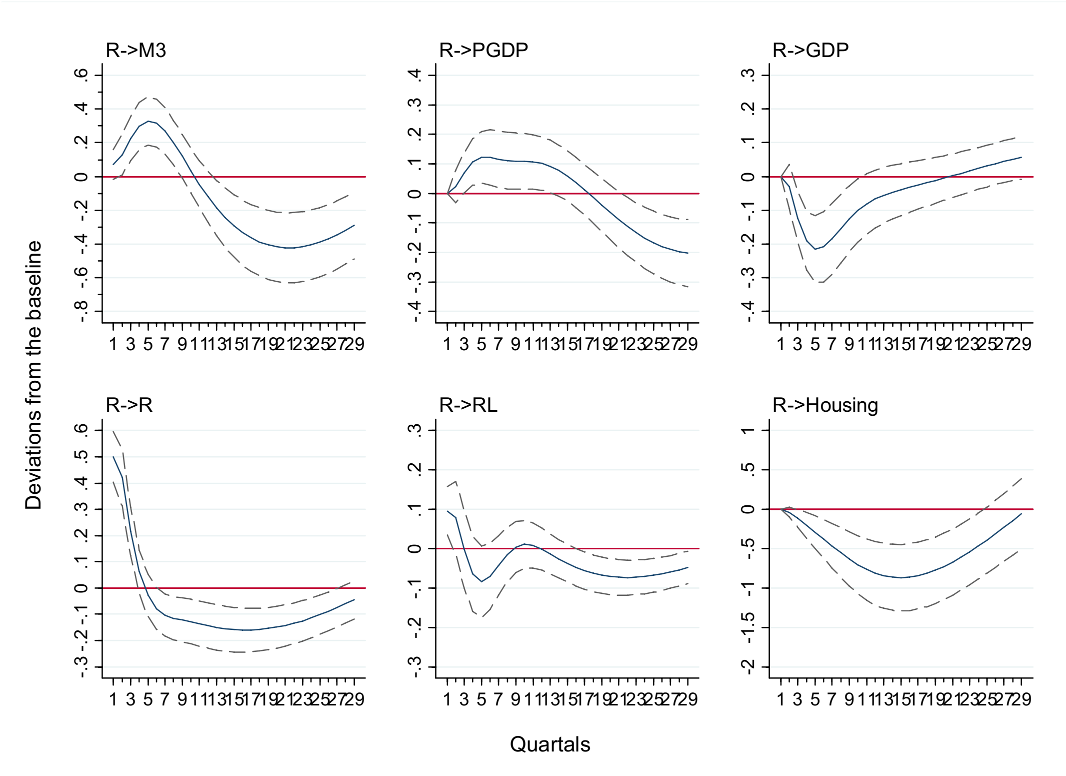
[14] This procedure has become standard practice in the VAR literature (e.g. Bernanke and Mihov (1995), Sims and Zha (1998), Christiano, Eichenbaum and Evans (2000) for the US, Peersman and Smets (2003) for the euro area). According to Sims (1992), commodity prices represent a key indicator of inflationary pressure, to which the central bank reacts by raising interest rates. If this indicator is left out of the model, the fact that commodity prices are positively correlated with both the rate of inflation and the short-term interest rate leads to the "price puzzle", i.e. a positive reaction of the price level to the (fuzzily identified) monetary policy shock.

[15] See, for example, Bernanke et al. (2005), Belviso and Milani (2006) for the US, Lagana and Mountford (2005) for UK, Shibamoto (2007) for Japan, McCallum and Smets (2007) for the euro area.

Figure 4: Impulse responses to a monetary tightening shock in the VAR model

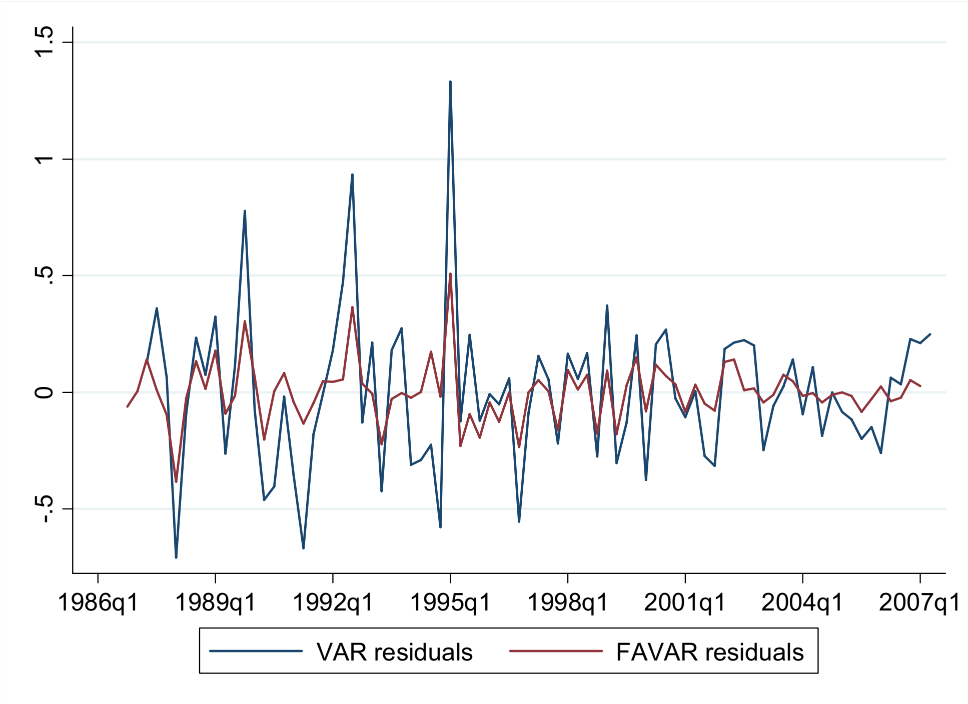


Notes: Deviations from the baseline in almost all cases in percent, except for short-term interest rate (*R*) as well as for long-term interest rate (*RL*), for which the ordinates are issued in percentage points.

Real household housing wealth (*Housing*) is shown initially to fall in reaction to the unexpected monetary policy tightening with an overall "U"-shaped curve. The impulse response of the short-term interest rate (*R*) initially represents its own positive shock and falls continuously in the first six quarters. After that it remains for some quarters below the benchmark level before then slowly converging towards the zero line. The long-term interest (*RL*) initially rises, but then drops after approximately two quarters before reaching its maximum decline in the fifth quarter and moving back to the zero line in the long run.

Overall the qualitative effects of our standard VAR model are largely in line with those obtained from the FAVAR model outlined above. A comparison of the interest rate shocks of the two models fortify this conclusion: The shocks, measured as the error terms of the respective interest rate equations, are highly correlated with a correlation coefficient of almost 80 percent (Figure 5). The few differences observed between the two models, especially the temporary "price puzzle" in the standard VAR model and greater persistence of several impulse responses in the FAVAR model, can apparently be related to differences in the information content, which are, however, shown to be all in all of moderate extent.

Figure 5: Monetary policy shock in the VAR versus FAVAR model (in percentage points)



5 Conclusion

In this paper we have analysed the effects of monetary policy shocks in the euro area using the FAVAR approach of Bernanke et al. (2005). The model allows us to construct impulse response functions for the numerous variables in the data set in order to get a more comprehensive picture of the monetary policy transmission in the euro area. Our results are widely consistent with prevailing expectations regarding the qualitative effects of monetary policy. In terms of monetary dynamics, which are of particular interest in this study, the results suggest that a contractionary monetary policy shock fosters monetary growth prior to exerting dampening influence in the medium to long term. One important explanation for such dynamics in the reaction of money could be that broad monetary aggregates temporarily benefit from a flatter term structure before the negative effects of the policy tightening on banks' lending activity begin to prevail.

Therefore, the temporarily positive effect of an interest rate increase on the money stock should not be overrated.[16]

We have also examined whether different data environments within the factor augmented and the standard VAR model affect the identification of monetary policy shocks and the empirical plausibility of estimated impulse response functions, respectively. To this end, we have compared the relative performance of both models. Our investigation suggests that the two methods produce overall qualitatively similar results. However, if one is interested in analysing the effects of monetary policy shocks on more than a few variables, the FAVAR model constitutes the superior alternative.

[16] According to the Deutsche Bundesbank (2008), for example, the rate hikes carried out since December 2005 boosted monetary growth by no more than $1^1/_4$ percentage pints at their peak.

Appendix 1: Specification of the VAR model

To ensure an optimal comparability with the FAVAR model, we specify our standard VAR model by selecting the best specification on the basis of various specification tests. Thus, we estimate the standard VAR model with six endogenous variables: nominal M3, real GDP (*GDP*) as a measure of the real transaction volume in the good markets, GDP deflator (*PGDP*), which proxies the general price level in the economy as a whole, the nominal three-month interest rate (*R*) as a control variable for the own rate of return on M3, the nominal interest rate on ten-year euro-area government bonds (*RL*) as a measure of the opportunity costs of holding money, and the real household housing wealth (*Housing*), which – among other things – proxies the volume of transactions carried out by non-banks in asset markets. The latter variable is included based on the findings in Greiber and Setzer (2007), who identify a close relationship between housing wealth/prices and monetary developments over the past few years. Further, our VAR specification is extended to include two exogenous variables: the nominal US three-month rate for Treasury bills (*US_R*), which represents external monetary influences, and the commodity price index (*Pcm*) as an indicator of external inflationary pressure (see Sims (1992), Sims and Zha (1995)).

Following Sims, Stock and Watson (1990), all variables are modelled in levels. We determine the lag structure of two on the basis of lag order selection criteria. The identification of monetary policy shock is carried out via Cholesky decomposition assuming that the shocks to the GDP deflator, real housing household wealth, the short-term and long-term interest rate and nominal M3 do not affect real GDP contemporaneously. By contrast, M3 is allowed to respond to shocks in all other variables immediately. The impulse responses generated by our VAR model are robust to different orderings of the endogenous variables: Simulations of alternative recursive structures of the economic shocks have no net overall impact on the impulse responses. Thus the reduced form of our standard VAR model have the following representation:

$$Y_t = \alpha + t + \sum_{k=1}^{2} A_k Y_{t-k} + BX_t + e_t ,$$

where $Y_t^{'} = [GDP,\ PGDP,\ Housing,\ R,\ RL,\ M3]$ and $X_t^{'} = [US\_R,\ Pcm]$ denote the vectors of endogenous and exogenous variables, respectively. *A* and *B* are the respective parameters of the endogenous and exogenous variables, α is a vector with constant terms, *t* is a vector with a linear time trend and e_t is a vector of error terms, which follows a white noise process. The index k denotes the lag structure.

Appendix 2: Data Transformation

The database is comprised of 65 time series spanning the period from 1986:Q4 to 2006:Q4. The transformation codes are: 1 – no transformation; 2 – first difference; 3 – logarithm; 4 – first difference of logarithm; 5 – second difference of logarithm. The "Slow/Fast" column shows, whether the variable is assumed to be slow-moving (Slow) or fast-moving (Fast).

Table 2: Data transformation

#	Description	Transformation	Slow/Fast	Source
1	GDP-deflator	4	Slow	ECB
2	HICP	4	Slow	ECB: AWM
3	Commodity price index	4	Fast	HWWA(1)
4	Gross investment deflator	3	Slow	ECB: AWM
5	Government consumption deflator	3	Slow	ECB: AWM
6	Consumtion deflator	4	Slow	ECB: AWM
7	Oil price (EUR)	4	Fast	HWWA(1)
8	Exports of goods and services deflator	4	Slow	ECB: AWM
9	GDP at factor costs deflator	3	Slow	ECB: AWM
10	Imports of goods and services deflator	4	Slow	ECB: AWM
11	GDP at factor costs	4	Slow	ECB: AWM
12	GDP, income side	4	Slow	ECB: AWM
13	GDP (real)	4	Slow	ECB
14	Real effective exchange rate (EER12)	4	Fast	ECB: AWM
15	Exchange rate EUR/USD	4	Fast	ECB: AWM
16	Ratio public debt/GDP	4	Slow	ECB: AWM
17	Government expenditure/GDP	4	Slow	ECB: AWM

18	Ratio government net lending/GDP	2	Slow	ECB: AWM
19	Gross operating surplus (real)	4	Slow	ECB: AWM
20	Ratio government primary surplus/GDP	2	Slow	ECB: AWM
21	Ratio government revenue/GDP	4	Slow	ECB: AWM
22	Government savings/GDP	2	Slow	ECB: AWM
23	Private Consumtion (real)	3	Slow	ECB: AWM
24	Government Consumtion/GDP	3	Slow	ECB: AWM
25	Gross real investment	4	Slow	ECB: AWM
26	Whole-economy capital stock	5	Slow	ECB: AWM
27	Public investment/GDP	4	Slow	ECB: AWM
28	Exports of goods and services (real)	4	Slow	ECB: AWM
29	Imports of goods and services (real)	4	Slow	ECB: AWM
30	Government disposable income/GDP	4	Slow	ECB: AWM
31	Transfers to households/GDP	4	Slow	ECB: AWM
32	Government consumption (real)	4	Slow	ECB: AWM
33	Household`s savings/GDP	4	Slow	ECB: AWM
34	Social security contribution (ssc)	4	Slow	ECB: AWM
35	Direct taxes ex. social security contributions/GDP	4	Slow	ECB: AWM
36	Indirect taxes (net of subsidies)	5	Slow	ECB: AWM
37	Indirect taxes/GDP	4	Slow	ECB: AWM
38	Stocks	4	Slow	ECB: AWM
39	Total employment (persons)	5	Slow	ECB: AWM
40	Employees (persons)	4	Slow	ECB: AWM
41	Labour productivity	4	Slow	ECB: AWM
42	Unit labour costs	3	Slow	ECB: AWM
43	Number of employed	3	Slow	ECB: AWM
44	Unemployment rate (as a percentage of labour force)	4	Slow	ECB: AWM
45	Compensation to employees	4	Slow	ECB: AWM
46	Wage per head (real)	3	Slow	ECB: AWM
47	Wealth (real)	3	Slow	ECB: AWM
48	Houshould housing wealth (real)	5	Slow	ECB
49	M1 (nominal)	4	Fast	ECB
50	M2 (nominal)	4	Fast	ECB
51	M3 (nominal)	4	Fast	ECB

52	M3 adjusted (nominal)	4	Fast	ECB
53	Loans to provate sector	4	Fast	ECB
54	Monetary Capital	4	Fast	ECB
55	Implicit public debt interest rate	1	Fast	ECB: AWM
56	Nominal three-month interest rate	1	Fast	ECB
57	Nominal interest rate on ten-year euro-area gov. bonds	1	Fast	ECB
58	US-GDP	4	Slow	St.Louis Fed
59	US federal funds rate	1	Slow	St.Louis Fed
60	US Long-term interest rate	1	Slow	St.Louis Fed
61	World monetary aggregate	4	Slow	BOS08(2)
62	World GDP-deflator	4	Slow	BOS08(2)
63	World GDP (real)	4	Slow	BOS08(2)
64	World Long-term interest rate	1	Fast	IMF
65	World short-term interest rate	1	Fast	IMF

(1) Source: HWWA, Hamburg Institute of International Economics.

(2) Source: BOS08, Belke, Orth and Setzer (2008).

References

Altissimo, F., M. Ehrmann and F. Smets (2006), Inflation persistence and price-setting behaviour in the euro area, ECB Occasional Paper 46.

Bai, J. and S. Ng (2002), Determining the Number of Factors in Approximate Factor Models, *Econometrica* 70 (1), 191-221.

Bai, J. and S. Ng (2007), Determining the Number of Primitive Shocks in Factor Models, *Journal of Business and Economic Statistics* 25 (1), 52-60.

Belke, A., W. Orth and R. Setzer (2008), Global Liquidity and House Prices: A VAR Anaylsis for OECD Countries, Research On Money in the Economy Discussion Paper 08-02.

Belviso, F. and F. Milani (2006), Structural Factor-Augmented VARs (SFAVARs) and the Effects of Monetary Policy, *Topics in Macroeconomics* 6 (3), Article 2.

Bernanke, B. S., J. Boivin and P. Eliasz (2005), Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach, *Quarterly Journal of Economics* 120 (1), 387-422.

Bernanke, B. S. and I. Mihov (1995), Measuring Monetary Policy, NBER Working Paper 5145.

Bernanke, B. S. and I. Mihov (1998), The Liquidity Effect and Long-Run Neutrality, NBER Working Paper 6608, National Bureau of Economic Research.

Boivin, J. and M. Giannoni (2006), DSGE Models in a Data-Rich Environment, NBER Working Paper 12772.

Boivin, J. and M. Giannoni (2008), Global Forces and Moneary Policy Effectiveness, NBER Working Paper 13736.

Boivin, J., M. Giannoni and B. Mojon (2008), Macroeconomic Dynamics in the Euro Area, for NBER Macroeconomics Annual 2008.

Boivin, J., M. P. Giannoni and I. Mihov (2007), Sticky Prices and Monetary Policy: Evidence from Disaggregated US Data, NBER Working Paper 12824.

Boivin, J. and S. Ng (2006), Are more data always better for factor analysis?, *Journal of Econometrics* 132, 169-194.

Christiano, L. J., M. Eichenbaum and C. L. Evans (1999), Monetary Policy Shocks: What Have We Learned and To What End?, in: Taylor, J. B. and M. Woodford (eds) *Handbook of Macroeconomics*, Elsevier, Amsterdam, 65-148.

Cochrane, J. H. and M. Piazzesi (2008), Decomposing the Yield Curve, Graduate School of Business, University of Chicago and NBER, http://faculty.chicagobooth.edu/john.cochrane/research/Papers/interest_rate_revised.pdf.

Deutsche Bundesbank (2008), Monetary growth and its determinants in recent years, Bundesbank Monthly Report September 2008, 41-56.

Dickens, W. T., L. Goette, E. L. Groshen, S. Holden, J. Messina, M. E. Schweitzer, J. Turunen and M. E. Ward (2007), How Wages Change: Micro Evidence from the International Wage Flexibility Project, *Journal of Economic Perspectives* 21 (2), 195-214.

Eickmeier, S. (2008), Comovements and heterogeneity in the euro area analyzed in a nonstationary dynamic factor model, *Journal of Applied Econometrics* (forthcoming).

Fagan, G., J. Henry and R. Mestre (2001), An Area-Wide Model (AWM) for the Euro Area, ECB Working Paper 42, European Central Bank.

Favero, C. A., M. Marcellino and F. Neglia (2005), Principal Components at Work: The Empirical Analysis of Monetary Policy with Large Datasets, *Journal of Applied Econometrics* 20 (5), 603-620.

Forni, M., M. Hallin, F. Lippi and L. Reichlin (2000), The Generalized Dynamic Factor Model: Identification and Estimation, *Review of Economics and Statistics* 82 (4), 540-554.

Forni, M., M. Hallin, F. Lippi and L. Reichlin (2003), Do Financial Variables Help Forecasting Inflation and Real Activity in the Euro Area, *Journal of Monetary Economics* 50(6), 1243–1255.

Forni, M. and L. Reichlin (1998), Let's get real: a factor analytic approach to disaggregated business cycle dynamics, *Review of Economic Studies* 65, 453-474.

Giannone, D., L. Reichlin and L. Sala (2002), Tracking Greenspan: systematic and unsystematic monetary policy revisited, CEPR Discussion Papers 3550, CEPR.

Greiber, C. and R. Setzer (2007), Money and Housing: Evidence for the Euro Area and the US, Deutsche Bundesbank Discussion Paper Series 1: Economic Studies 12/2007, Deutsche Bundesbank.

Kim, D. H. and J. H. Wright (2005), An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behavior of Long-Term Yields and Distant-Horizon Forward Rates, Finance and Economic Discussion Series, Federal Reserve Board, Washington, D.C.

Knoppik, C. and T. Beissinger (2006), Downward Nominal Wage Rigidity in Europe - An Analysis of European Micro Data from the ECHP 1994-2001, University of Hohenheim, Hohenheimer Diskussionsbeiträge 275.

Lagana, G. and A. Mountford (2005), Measuring Monetary Policy in the UK: A Factor-Augmented Vector Autoregression Model Approach, *Manchester School* 73 (S1), 77-98.

McCallum, A. and F. Smets (2007), Real wages and monetary transmission in the euro area, Kiel Working Paper 1360, Kiel Institute for the World Economy.

Peersman, G. and F. Smets (2003), The Monetary Transmission process in the Euro Area: Evidence from VAR Analysis, in: Angeloni, I., A. K. Kashyap and B. Mojon (eds) *Monetary Policy Transmission in the Euro Area*, Cambridge University Press, Cambridge, UK, 36-65.

Shibamoto, M. (2007), An Analysis of Monetary Policy Shocks in Japan: A Factor Augmented Vector Autoregressive Approach, *Japanese Economic Review* 58 (4), 484-503.

Sims, C. A. (1992), Interpreting the Macroeconomic Time Series Facts: The Effects of Monetary Policy, *European Economic Review* 36 (5), 975-1000.

Sims, C. A., J. H. Stock and M. W. Watson (1990), Inference in Linear Time Series Models with Some Unit Roots, *Econometrica* 58 (1), 113-144.

Sims, C. A. and T. Zha (1995), Does Monetary Policy Generate Recessions?, Mimeo, Yale University.

Sims, C. A. and T. Zha (1998), Does Monetary Policy Generate Recessions?, Federal Reserve Bank of Atlanta Working Paper 98-12, Federal Reserve Bank of Atlanta.

Stock, J. H. and M. W. Watson (2002), Macroeconomic Forecasting Using Diffusion Indexes, *Journal of Business and Economic Statistics* 20 (2), 147-162.

Stock, J. H. and M. W. Watson (2005), Implications of Dynamic Factor Models for VAR Analysis, NBER Working Paper 11467.

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