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Monetary Analysis: a **Vector Autoregressive (VAR)** Perspective

The ultimately monetary nature of inflation, that is the fact that prolonged periods of high inflation are associated with high monetary growth, is essentially undisputed in academic and central banking circles. While other factors (such as variations in aggregate demand or technological changes) can influence price developments at shorter horizons, this does not negate the underlying long-term relationship between prices and the money stock. As a consequence, this key relationship has also led called for the assignment of a prominent role for money in the ECB's monetary policy strategy.

Separating Risk from Noise

In addressing the challenge of separating medium- to longer-term risks from shorter-term "noise", a number of tools have been used. Besides a regular analysis of excess liquidity measures and the analysis of monetary variables in conjunction with variables from the real side of the economy, a thorough investigation of the components and counterparts of M3 is carried out on a regular basis by the ECB.

In fact, the relationship between interest rates, money, its components and counterparts, real income and and ultimately prices forms an integral part of the transmission mechanism and, therefore, stands at the heart of monetary analysis policy. The dynamics, strength and timing of the effects of changes in policy interest rates on these variables are key questions for any central bank. When trying to quantify these effects, various econometric methods have been used, including Vector Autoregressive (VAR) models, small structural models and large macro-econometric models. This article focuses on presenting quantitative evidence on the interplay between interest rates, money, its components and counterparts, real GDP and prices in the euro area by making use of such VAR models. More specifically, the purpose is to trace out the historical relationships that have prevailed in the last two and a half decades in euro area data.

VAR models and monetary policy

VAR models have become very popular in empirical economics and also in the analysis of monetary policy effects.[1)] The general representation of such a model is as follows:

$$1) \qquad Y_t = A + BY_{t-1} + C(L)X_t + \varepsilon_t$$

where Y_t is a vector of several (euro area) variables measured over the same sample period $(t = 1, .., T)$, A is a vector of absolute terms, B is a vector of autoregressive coefficients, C is a vector of exogenous variables and ε_t is a vector of error terms. The vector X is included to allow for a contemporaneous influence of exogenous variables such as, for instance, oil prices. The specification implicitly assumes that there is no feedback from the euro area to the exogenous variables. In line with these considerations, a standard VAR widely used in the literature would read as follows:

$$2) \qquad Y_t = A + BY_{t-1} + C(L)X_t + \varepsilon_t$$

$$3) \qquad Y'_t = [s_t \; yr_t \; p_t]$$

$$4) \qquad Y'_t = [oilp_t]$$

where s stands for a short-term interest rate, p, yr and $oilp$ stand for a consumer price index, real GDP and the oil price, respectively. The small letters – with the exception of the interest rate – would denote logarithms. In such a framework, monetary policy effects have often been described in terms of reactions of the other variables in the system to a unexpected rise (a "shock") in short-term interest rates. Given that the VAR system attempts to mirror the historical behavior of the date, a contractionary monetary policy shock is then defined as a positive deviation of the interest rate from the average reaction function of the central bank for the sample period.

The dynamic response pattern of the reactions of the other variables to a shock are then often illustrated in terms of the so-

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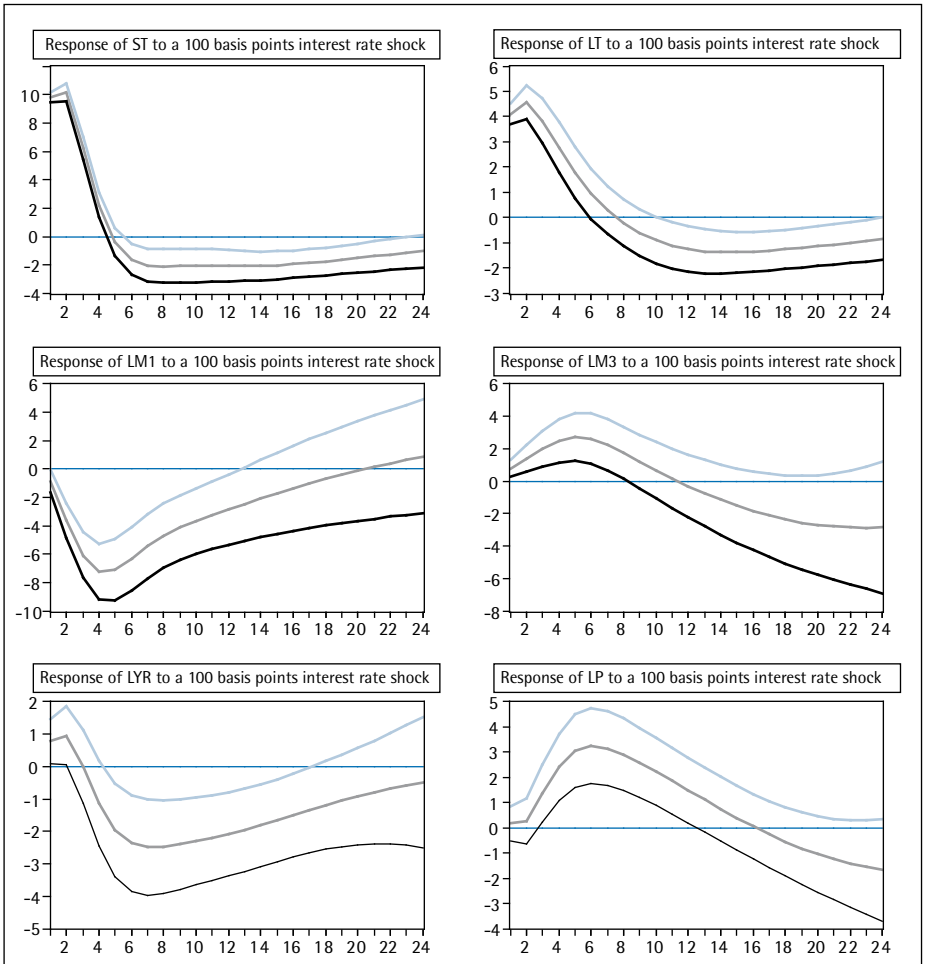
Die Aufgabe der monetären Analyse besteht aus Sicht der Autoren in der Unterscheidung kurzfristiger Störungen des Geld/Preis-Verhältnisses von mittel- bis langfristigen Signalen. In der Praxis, so halten sie fest, liegt die Herausforderung darin, die zugrunde liegenden monetären Entwicklungen in Echtzeit zu identifizieren um sich abzeichnende Trends schnellstmöglich erkennen zu können. In ihrer Arbeit untersuchen sie die dynamischen Beziehungen einiger Eurogebiet-Schlüsselgrößen im Rahmen von Vektor-Autoregressionsmodellen (VAR) und simulieren deren Ergebnisse im Rahmen geldpolitischer „Schocks". Insgesamt kommen sie zu dem Ergebnis, dass mit recht einfachen Modellen plausible geldpolitische Reaktionen bestimmbar sind. Konkret zeigen sie unter anderem, dass ein positiver Schock bei den nominalen Zinsraten von einem Rückgang des Realeinkommens sowie einem negativen und beständigen Effekt auf Preisniveaus und die nominale Geldmenge M3 begleitet wird, während die reale M3 weitestgehend unverändert bleibt. (Red.)

Chart 1: Impulse response functions following a transitory increase in the short term interest rate by 100 basis points



Note: Sample period first quarter 1995 to fourth quarter 2007

called "impulse response functions". The basic reason why the impulse response analysis of the effects of monetary policy focuses on the impact of the unsystematic shock to short-term interest rates is that this approach addresses the so-called "identification problem". In essence, the transmission mechanism describes how a change in monetary policy affects other macroeconomic variables (in particular, prices), other things equal.

If monetary policy changes because of a shock to output or prices (as emphasized, for instance, in Taylor rules), it is often not possible to separate the impact of monetary policy on other variables from the impact of the initial shock. Only the unsystematic part of monetary policy is (by definition) identified separately from developments in other variables and thus allows the transmission mechanism itself to be traced out.

As a first step, we try to closer investigate the behaviour of the components of M3. The corresponding system thus includes as key variables the euro area HICP, real GDP, nominal M3, nominal M1, a long-term and a short-term nominal interest rate. In addition a linear trend[2], a commodity price index[2)3)] and an oil price index were used as exogenous explanatory variables.

Analysis of components

The linear trend allows trend long-term growth and the prolonged disinflation over the sample to be controlled for. Since the focus of this box is on the long-run relationships between the variables, a VAR in levels is estimated and solved for its dynamic responses.[4)] As is quite common in the literature, the three-month interest rate is chosen as the policy variable. The chart below then illustrates the reaction of all variables in response to a transitory (one-off) shock in the interest rate by 100 basis points and the respective 65 percent confidence interval.[5)] The reactions of the variables included in the system are then shown for a time horizon of 24 quarters.

Expressed in non-technical terms, the exercise described above will then cause an upward movement in the interest rate response by 1 percentage point (100 basis points) reflecting the exogenous shock. The subsequent movements in the selected variables are then endogenous, that is caused by the reactions of the variables in the system and the lagged values of the interest rate. By the same line of reasoning, all other variables start from the zero line, reflecting the fact that, in the first quarter, there are no deviations from the baseline since these variables are not shocked by definition.

Against this background, it is also worth mentioning that an earlier study of Peersman and Smets contains a number of interesting results.[6)] First and foremost, we concentrate deliberately on the monetary analyis aspects in our VAR. Second, we make use of generalised impulse responne functions which helps us to circumvent the issues related to the so-called "ordering problem". Third, but somewhat less important, we use a longer sample.

According to the results, the increase in the short rate by 100 basis points is accompanied by a similar, albeit smaller increase in the long-term rate (see Chart 1). This finding is clearly in line with the so-called "expectations hypothesis" of the term structure of the interest rates. Furthermore, a transitory rise in interest rates leads to an immediate decline in real income, reaching its trough after six quarters. After 24 quarters, however, the effect seems to have faded away, pointing towards long-run neutrality of money. Moreover, the rise in the short-term interest rate is followed by a significant decline in decline in the HICP and euro area M3 starting to materialize after around ten quarters. With respect to the latter finding, it is particularly noteworthy that both variables display an immediate rise, a phenomenon that is well-known in the literature as "price puzzle".

It is interesting to see, however, that, while M3 seems to react in a more sluggish way,

euro area M1 seems to react rather immediately and in a strongly negative way to the interest rate shock.

Quite obviously, the slow response of M3 is clearly due to the initial increase in the other components of M3. An interest rate tightening gives rise to substitution effects from monetary componentss that bear no or regulated interest to time deposits and money market funds that are included in the broad monetary aggregates. This finding is consistent with the literature on money demand.[7)]

In sum, the findings are in line with theoretical considerations stating that changes in money will have no long-run effects on real variables like real output, unemployment or real interest rates.

Analyis of counterparts

We next turn to a closer investigation of the counterparts of M3. The corresponding system includes as key variables the HICP, real GDP, nominal M3, nominal loans to the private sector, MFI longer-term financial liabilities, a long-term and a short-term nominal interest rate. As before, in addition, a linear trend, a commodity price index and an oil price index were used as exogenous explanatory variables.

The chart below then illustrates the responses of the variables in the system to a transitory (one-off) shock in the interest rate by 100 basis points and the respective 65 percent confidence interval.[4)] The reactions of the variables included in the system are again shown for a time horizon of 24 quarters.

Plausible reactions to changes in monetary policy

As in the case of the components' analysis, also the analysis of the counterparts seems to confirm the presence of a kind of "expectations hypothesis"-effect of the term structure of interest rates in the data. Moreover, a transitory decline in real income, and a permanent decline in euro area prices and M3. At the same time, loans to the private sector soon start to decline while MFI longer-term financial liabilities slowly start to increase after around six quarters, reaching a peak after roughly 16 quarters and then start to decline.

The purpose of the study is to investigate more closely the dynamic relationships between some key variables for the euro area. More specifically, two small models (one trying to capture the components' side of euro area M3 and one trying to capture the counterparts' side of euro area M3) are estimated by means of a VAR approach and simulated for their responses with respect to monetary policy shocks.[5)] The main result is that these rather simple models can provide plausible reactions to changes in monetary policy. In particular, a positive shock in the short-term nominal interest rate is followed by a transitory decline in real income and loans, a transitory increase in MFI longer-term financial liabilities as well as a negative and permanent effect on the price level and nominal M3, leaving real M3 broadly unchanged. Further work will need to focus on a further refinement of these results by imposing structural relationships and comparing them to the result reported here.

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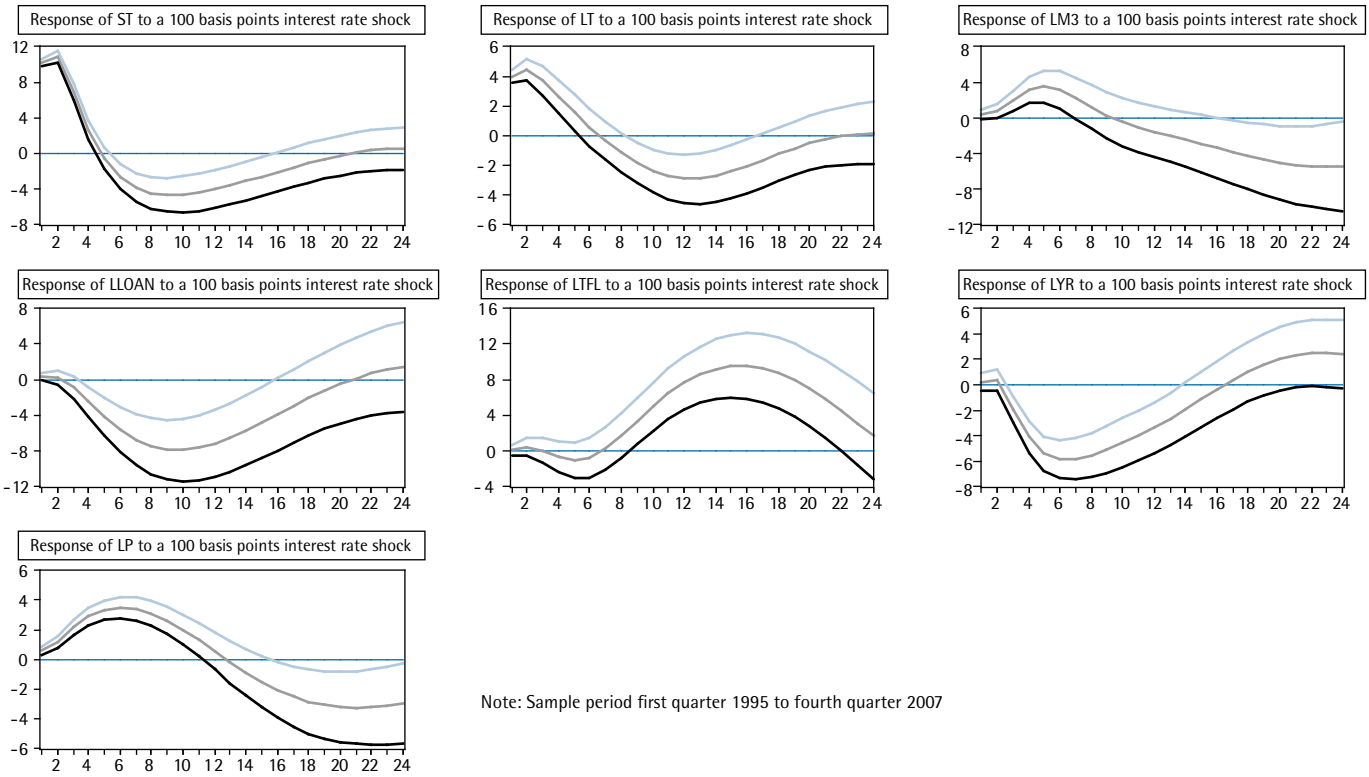
Chart 2: Impulse response functions following a transitory increase in the short term interest rate by 100 basis points



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Footnotes

[1] For a more detailed description, see Sims (1980).

[2] In n a technical sense, the reason for introducing the trend variable is the problem of „spurious correlation". This expression describes the fact that economic time series often tend to move in the same direction, reflecting an upward or downward trend. A simple regression of the variables may thus not reflect the true association: it may simply reflect the common trend present in them. One way of avoiding such „spurious correlation" is the introduction of a linear time trend into the model. Another way would be to explicitly „de-trend" the variables and run the regression on the de-trended variables.

[3] As emphasised by Sims for the case of the US, the use of a commodity price index as a leading indicator for domestic inflation in the policy reaction function eliminates the positive response of prices to a contractionary monetary policy shock. See Sims, C.A. (1992) for details.

[4] More specifically, the impulse response analysis is carried out using generalized impulse response functions. The purpose of generalized impulse response functions to circumvent the problem of the dependence of the orthogonalized impulse responses on the ordering of the variables in the VAR. See Pesaran and Shin (1998) for details.

[5] If the usual 95% confidence interval is used, the price reaction is not significant. This is not uncommon in the literature and can be attributed to the random walk behaviour of prices. Most authors react by choosing a narrower confidence interval. We follow Bagliano and Favero (1999) who also use one standard deviation (corresponding to 65% bands).

[6] See Peersman and Smets (2003).

[7] See Stracca, Coenen and Vega, Brand and Cassola, Calza; Gerdesmeier and Levy, Warne.