Core inflation in selected European Union countries

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Introduction

The issue of how to measure inflation and, in particular, its underlying trend has attracted increasing attention in recent years. A major reason for this renewed interest is that a number of central banks, both inside and outside the European Union, have committed themselves to explicit quantitative inflation targets.[1] The assessment of deviations of current and expected inflation from the target requires taking volatile and temporary price influences into account. The issue of distinguishing transitory from persistent price movements is also relevant for countries aiming for price stability in other monetary policy frameworks than inflation targeting. Alternative inflation indicators, especially those of underlying inflation, may cast light on the sustainability of a country's inflation performance.

An important limitation of commonly used inflation measures such as the Consumer Price Index (CPI) is their susceptibility to specific disturbances which are unrelated to the "pure" (or core) inflationary process. As a result, measured inflation may give a misleading picture of underlying price trends relevant for monetary policy.

The purpose of this study is to provide information on underlying price movements relevant for the single monetary policy of the ECB. For comparative reasons, we use a model-based approach to calculate core inflation indicators for selected European countries. The core inflation process is identified by means of a VAR (vector autoregression) technique that was first suggested by Quah and Vahey (1995). We use a modification of the original model along the lines specified by Blix (1995) and Dewachter and Lustig (1997) in order to split measured inflation into core and non-core components. The underlying inflation process is that component of measured price movements which is governed by demand shocks.

In view of the central role price stability plays for the single monetary policy of the ECB alternative inflation indicators, especially those of core or underlying inflation, will play an important role as monetary policy indicators, independent of the specific choice of the monetary policy strategy by the ECB. Although this topic has been treated in some studies, Austria has never been included so far.

[1] For a comprehensive survey see, for example, Leiderman and Svensson (1995), and Haldane (1995). More recent contributions include Debelle (1997) and Masson et al. (1997).

1. The concept and measurement of underlying inflation

Although the concept of underlying inflation is widely used in monetary policy analysis,[2] views differ about its precise definition.

Most papers[3] refer to Eckstein's (1981) definition of underlying or core inflation as the rate of price increases that would occur along the economy's long-term growth path. The core inflation rate is thus a steady-state concept and equivalent to the *trend increase of the price of aggregate supply*. Alternatively, Parkin (1984) assumes that in the long-run equilibrium, factor prices for labour and capital fully reflect inflation expectations. In that case, core inflation is identical to *expected inflation*. As deviations of actual from core inflation result from demand fluctuations and random supply (and other) disturbances, his results are consistent with the existence of a short-run expectations-augmented supply (or Phillips) curve reflecting such factors.

As there is no single concept of what is understood by core inflation it is not surprising that views on how to measure it differ.

The standard approach has been to remove, in some ad hoc manner, the "unwanted" component, such as transitory noise, which has its sources in changing seasonal patterns, resource shocks, exchange rate changes, indirect tax changes or asynchronous price adjustments, or other distorting influences like weighting differences, quality changes, new goods or the substitution bias. The remainder is seen as a reliable estimate of the underlying inflation process.[4] Removing distorting, temporary or particularly volatile influences can be done either on a case-by-case basis or in a more structured way. The first group of procedures includes the zero-weighting technique and its variants. The structural methods of calculating specific underlying inflation indicators include simple as well as more sophisticated smoothing techniques (trimmed mean method; Hodrick-Prescott filter, Kalman filter) and the VAR models based on the paper by Quah and Vahey (1995). Model-based calculation of core inflation allows an economic interpretation of the resulting indicator. In contrast, in the case of ad hoc procedures such as zero-weighting and smoothing techniques, an interpretation based on economic theory is not straightforward.

We decided to use a VAR approach similar to Quah and Vahey's for two reasons:

1. Fluch and Gartner (1997) suggest that mechanical procedures such as the zero-weighting approach have certain drawbacks for cross-country analysis. Their empirical results show that the trend of and deviations from headline inflation heavily depend on the definition used. In spite of harmonisation efforts initiated by the European Monetary Institute, concepts of calculating core inflation still differ markedly.

2. We are interested in a forward-looking assessment of inflation performance. Forecasting is not possible with the zero-weighting procedure and possible only with certain restrictions using the smoothing technique, whereas a model-based approach enables to project historical structures into the future.

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[2] The interest in Austria in alternative inflation indicators is relatively new. As is well known, the Oesterreichische Nationalbank (OeNB) follows an exchange rate target and thus gears its monetary policy to that of the anchor currency (among others, see Gartner (1995), and Hochreiter and Winckler (1995)). The effectiveness of the monetary strategy is measured in terms of the degree of inflation convergence with Germany. Up to now measures of underlying inflation played only a limited role. As far as the OeNB is concerned it focused its attention on the headline inflation rate, the CPI changes being the inflation indicator, making additive adjustments for the contribution of specific indirect tax changes or seasonal food prices whenever relevant.

[3] Among others, see EMI (1995).

[4] This approach has been used, inter alia, in Sweden, the United Kingdom and Finland, and was also suggested by the EMI.

2. Identifying core inflation

The two approaches mentioned above (zero weighting and smoothing) remove, in some *ad hoc* manner, the "unwanted" components ("noise") of measured inflation. What remains ought to be a reliable estimate of the underlying inflation process. In their paper, Quah and Vahey (1995) argue that the conceptual mismatch between current methods for calculating inflation and economic theory is more than just a measurement error. Price indices such as the CPI measure the costs of particular goods and services, while the economic notion of inflation is that of sustained increases in the general price level. As economic theory does not suggest a particular functional form of inflation, there is no justification for believing that core inflation is the result of some arbitrary smoothing procedure.

Consequently Quah and Vahey (1995) suggest an alternative technique that is based on an explicit economic hypothesis. They define core inflation as that component of measured inflation that has no medium to long-run impact on real output. This definition is consistent with a vertical long-run Phillips curve interpretation of the co-movements in output and inflation. They then implement this definition as a restriction on a bivariate SVAR (structural vector autoregressive) model and use it to extract a measure of core inflation. Our identification scheme differs only slightly as we identify effects on prices instead of price changes, thus referring to, from a theoretical viewpoint, a standard aggregate demand/aggregate supply framework.[5]

2.1 Methodology

The identification scheme of Quah and Vahey's model is very similar to that of Blanchard and Quah (1989) and Shapiro and Watson (1988).

It follows the VAR tradition in methodology, employing impulse response analysis and variance decompositions. The identification of the shocks is based on a Choleski decomposition of a long-run parameter matrix and is therefore different from the short-run identification schemes of Bernanke (1986) and others.

The structural model of real GDP, y, and CPI, p, has the long-run solution form:

$$y = f(\varepsilon^s) \text{ and} \tag{1}$$

$$p = f(\varepsilon^s, \varepsilon^d) \tag{2}$$

We assume that the economy is hit by innovations given in the vector $\varepsilon = (\varepsilon^s, \varepsilon^d)$, which consists of a supply shock ε^s and a demand shock ε^d. While supply shocks[6] may have permanent effects on both prices and output, demand shocks are defined to have no long-run effect on output, i.e. they are transitory with respect to real variables. We identify the core inflation process as that part of the increases in the CPI that has no long-run effects on output, i.e. price movements that are determined solely by shifts in the aggregate demand curve ("demand pull" inflation).[7] We compute core inflation by simulations imposing paths of structural shocks as described in Section 2.3.

We impose two kinds of restrictions on structural innovations. First, both of the structural disturbances are assumed to be uncorrelated at all leads and lags and have unit variance. Second, demand shocks cannot have long-run effects on output. The long-run effects of demand disturbances

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[5] From an empirical viewpoint we refer to the fact that most price changes can be considered as (trend-)stationary. See also the data section below on this issue.

[6] Typical supply shocks are productivity changes, energy shocks, taxes and price controls.

[7] The simple framework applied here could be extended in order to capture also, for example, "cost-push" inflation effects by including other variables such as wages and other specific prices.

on CPI are unconstrained. These restrictions are sufficient to uniquely identify both of the underlying disturbances as will be shown below.

2.2 Identifying restrictions and identification of the model

Assume that a vector Δx of (differenced) macroeconomic variables follows a covariance stationary process of the form:

$$\Delta x_t = C(L)u_t \tag{3}$$

In our case $\Delta x = [\Delta y, \Delta p]'$, with y the log of domestic output and p the log of prices (CPI), respectively. $C(L)$ is a lag polynomial where the C's are coefficient matrices at the respective lags of the serially uncorrelated errors u, where $E(u\ u') = \Sigma$. The first coefficient matrix of the polynomial, C_0, is normalised to the identity matrix I.

A reduced form and normalised moving average representation of the same process is given by:

$$\Delta x_t = E(L)e_t \tag{4}$$

with $E(e\ e') = I$ and the shocks uncorrelated across time and across variables.

Only the u's can be directly estimated from the VAR, the e's have to be calculated based on its moving average representation (3). As we have assumed $C_0 = I$ and we have a linear relation between $C(L)$ and $E(L)$ we can write:

$$u_t = E_0 e_t \tag{5}$$

The problem is then to find E_0 imposing $k \times k$ restrictions, where k is the number of variables in the model and thus $k \times k$ is the dimension of E_0.

From $ee' = I$ and $uu' = \Sigma$ we have with (5):

$$\Sigma = E_0 E_0' \tag{6}$$

This factorisation yields $\frac{1}{2}k(k+1)$ non-linear restrictions, for the rest of $\frac{1}{2}k(k-1)$ restrictions we impose long-term neutrality properties for certain errors driving the respective variables. If we evaluate the polynomial matrices at $L = 1$, where a matrix $E(1) = E_0 + E_1 + E_2 + E_3...$, we get the long-run impacts of errors on the variable vector Δx, and, specifically,

$$\Delta^* x = \begin{bmatrix} \Delta^* y \\ \Delta^* p \end{bmatrix} = \begin{bmatrix} E_{11}(1) & 0 \\ E_{21}(1) & E_{22}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_s \\ \varepsilon_d \end{bmatrix} \tag{7}$$

where $\Delta^* x = \lim_{t \to \infty} x_t - x_{t^*}$

As E(1) is assumed to be lower triangular, we can use this fact to recover E_0 in the following way. Equating (3) and (4) at their long-run values we have

$$C(1)u_t = E(1)e_t. \tag{8}$$

With $ee' = I$ and $uu' = \Sigma$, the matrix E(1) can be derived from a Choleski decomposition of

$$C(1)\Sigma C(1)' = E(1)E(1)' \tag{9}$$

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From the values for C(1), which can be derived from the estimated VAR-parameters, and the variance-covariance matrix Σ we compute the Choleski factor E(1) and can then recover E_0 as:

$$E_0 = C(1)^{-1} E(1) \tag{10}$$

The matrix E_0 can then be used in $u_t = E_0 e_t$ to compute the impact of structural shocks on the elements of Δx_t (orthogonal impulse responses).

With this background, we proceed as follows for the empirical analysis. First we estimate a vector-autoregressive (VAR) model of the form:

$$A(L)\Delta x_t = u_t \tag{11}$$

From $A(L)$ we compute (accumulate for) the long-run entries of $A(1)$. Inverting, yields $A(1)^{-1} = C(1)$. Consequently we get E_0 from (9) and (10), which we use to compute the respective impulse responses and the variance decomposition of the structural shocks given in (4).

2.3 Computing core inflation: simulations using structural shocks

We calculate core inflation by imposing certain paths of structural shocks. The structural shocks e_t are recovered from the estimated errors u_t through the relation $e_t = E_0^{-1} u_t$. Having found e_t two alternative forecast simulations can be computed by dropping certain elements of the shock vector: the variables' path "due to" specific, single shocks and "absent" specific shocks.

The first class of simulations can be done by setting $e_t^S = \left[e_{S,t}, 0 \right]$ for the simulations "due to supply" and $e_t^D = \left[0, e_{D,t} \right]$ for the simulations "due to demand", where the errors u_t^X ($X=S,D$) to be used for the forecasts with the estimated VAR models will be recovered from $u_t^X = E_0 e_t^X$.

The alternative simulations pursued here set $e_t^{S'} = \left[0, e_{D,t} \right]$ for the simulations "absent supply" and $e_t^{D'} = \left[e_{S,t}, 0 \right]$ for the simulations "absent demand", where, as before, the errors $u_t^{X'}$ ($X' = S', D'$) to be used for the forecasts with the estimated VAR models will be recovered through $u_t^{X'} = E_0 e_t^{X'}$.

As the originally estimated variables are differences, we also perform accumulations (eventually including a mean that had been subtracted before estimation) in order to see how the simulated levels of the variables would evolve under the different assumptions.

Core inflation π^c is defined as that component of inflation which has no permanent effect on output. In our specification that would correspond to the "absent supply" or the "due to demand"[8] simulation path for Δp.

2.4 Interpretation

The first important assumption underlying this technique concerns the number of structural innovations. Quah and Vahey (1995) assume that there are only two types of shocks affecting inflation and output. In reality, the economy is hit by a large number of heterogeneous shocks, and each of them may have different effects on measured inflation and output. In line with the

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[8] This is only true for the bivariate SVAR system, of course.

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work of Blix (1995) and Dewachter and Lustig (1997), we explicitly address this potential misspecification problem by extending the SVAR and checking the robustness of the results. In the extension we distinguish between monetary and real aggregate demand shifts, since these may affect inflation and output differently.

The second debatable assumption is the orthogonality restriction on the structural innovations. Following the Quah and Vahey (1995) methodology we assume core and non-core innovations to be uncorrelated at all leads and lags. Nevertheless, some policy shifts in response to core shocks (for instance a restrictive or loose fiscal policy in response to a price hike) may have a permanent effect on output. As a result, non-core innovations may be caused by core innovations. The model, however, excludes the possibility of actual correlation.

The identifying restrictions do not constrain the structural multipliers determining the response of measured inflation to non-core innovations. This long-run effect is entirely determined by the estimations. If these non-core innovations explain a sizeable part of the long-run variability in measured inflation, the Quah and Vahey (1995) identification procedure has to be re-examined. This would mean that the non-core innovations drive the underlying inflationary process.

2.5   Extension: including monetary policy

To assess the restrictiveness of the two-shock approach outlined above, we extend the bivariate SVAR by introducing a monetary variable. This has been done before: Blix (1995) introduced monetary aggregates as a third variable. Dewachter and Lustig (1997), who are mainly interested in empirical results for the ERM-countries, include a short-term nominal interest rate in the model. As our (future) interest is in common trends in underlying inflation, we proceed along the lines of Dewachter and Lustig (1997) and also include short-term interest rates as the monetary policy variable. We implicitly assume that monetary aggregates are endogenous, which appears to be a fair assumption for most European countries.

We assume that a small open economy with a fixed exchange rate regime is hit by three structural innovations: a supply shock, a monetary shock and a demand shock, the latter two of which are core innovations. Hence, the structural model in real output, y, short-term interest rates, i, and CPI, p, in its long-run representation has the following form:

$$y = f(\varepsilon^s), \tag{12}$$

$$i = f(\varepsilon^s, \varepsilon^m), \text{ and} \tag{13}$$

$$p = f(\varepsilon^s, \varepsilon^m, \varepsilon^d) \tag{14}$$

The non-core innovations ε^s are interpreted as supply disturbances (e.g. technology shocks),[9] which generate relative price shifts. These supply shocks are assumed to have a permanent effect on output. As before core inflation is defined as that component of measured inflation which is not affected by supply innovations.

The first type of core innovations ε^m captures the effects of a monetary disturbance. These LM-innovations do not affect real output permanently, but they are supposed to exert a lasting influence on short-term nominal interest rates and on inflation. Given the validity of interest parity, $i = i^* + \dot{e}$,[10] in the long run, the ε^m innovation can also be interpreted as an EU-wide (ERM-wide, see

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[9]   Cf. footnote 6.

[10] Where i denotes the domestic interest rate, i^* the foreign interest rate or that of the anchor currency country and $\dot{e}$ is the expected change in the nominal exchange rate over time.

below) monetary policy shock. As for countries pursuing a fixed exchange rate regime it holds that $\dot{e} \cong 0$ in the long run, an exogenous shift in the level of i^* has to be accommodated by a permanent shift in i. In the short run, due to lower credibility of the peg, i can deviate from i^* to the extent of devaluation expectations.

Two major effects of nominal interest rate innovations can then be distinguished among countries of the European Monetary System (EMS): for (smaller) countries with a credible and tight exchange-rate peg (within the Exchange Rate Mechanism, ERM) an interest rate increase will arise mainly due to an accommodation of an increased ERM-wide interest rate level, and even short-run output and price effects should be very small. For countries allowing (or having allowed) for more flexibility in the exchange-rate peg (e.g., not having permanently participated in the ERM) a nominal interest-rate shock can, given the validity of the interest parity, also be interpreted as following an autonomous expansionary monetary disturbance, giving rise to devaluation expectations $\dot{e}$, increasing output at least temporarily (long-run effects are restricted to be zero) and prices even at longer time horizons.[11]

The second type of core innovations consists of a real demand shock. This AD- or IS-shift affects the rate of inflation in the short run and the price level in the long run, but leaves output and the interest rate level (i) unchanged at an infinite horizon.

Consider a vector Δz which now includes changes in the short-term nominal interest rate, Δi. This vector Δz is a covariance-stationary process not constrained by a cointegrating relation. This in turn means that it has an invertible moving average representation which, in its long-run (accumulated) form, is given by:

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\Delta^* z = \begin{bmatrix} \Delta^* y \\ \Delta^* i \\ \Delta^* p \end{bmatrix} = \begin{bmatrix} E_{11}(1) & 0 & 0 \\ E_{21}(1) & E_{22}(1) & 0 \\ E_{31}(1) & E_{32}(1) & E_{33}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_S \\ \varepsilon_M \\ \varepsilon_D \end{bmatrix} \tag{15}
$$

where $\Delta^* z = \lim_{t \to \infty} z_t - z_{t^*}$

ε_S denotes the supply shock (i.e. non-core innovation), ε_M represents the monetary shock and ε_D is a real demand disturbance. Note that the matrix of the structural multipliers in (15) is invertible. This system is fully identified. Core innovations are distinguished from non-core innovations by imposing that the latter cannot affect output in the long run. Money demand shocks are distinguished from real demand innovations by assuming that the latter have no lasting impact on interest rates.

2.6   Computing core inflation in the extended model

As in Section 2.3 we again use the method of imposing long-run paths on structural shocks to compute core inflation π^c. Having recovered e_t from the estimated errors u_t through the relation $e_t = E_0^{-1} u_t$, two alternative forecast simulations are computed by dropping certain elements of the shock vector: the variables' path "due to" specific, single shocks and "absent" specific shocks.

In the trivariate case, the first class of simulations can be done by setting $e_t^S = [e_{S,t}, 0, 0]$ for the simulations "due to supply", $e_t^{LM} = [0, e_{LM,t}, 0]$ for the simulations "due to

[11] In fact, as shown below, we find such behaviour of variables in Belgium, Finland, France, Italy, Sweden and the United Kingdom.

LM" and $e_t^D = [0,0,e_{D,t}]$ for the simulations "due to demand ", where the errors u_t^Z ($Z = S, LM, D$) to be used for the forecasts with the estimated VAR models are recovered from $u_t^Z = E_0 e_t^Z$.

The alternative simulations pursued here set $e_t^{S'} = [0, e_{LM,t}, e_{D,t}]$ for the simulations "absent supply", $e_t^{LM'} = [e_{S,t}, 0, e_{D,t}]$ for the simulations "absent LM", and $e_t^{D'} = [e_{S,t}, e_{LM,t}, 0]$ for the simulations "absent demand", where, as before, the errors $u_t^{Z'}$ ($Z' = S', LM', D'$) to be used for the forecasts with the estimated VAR models are recovered through $u_t^{Z'} = E_0 e_t^{Z'}$.

As the originally estimated variables are differences, we perform accumulations as in the bivariate case.

Again, core inflation π^c is defined as that component of inflation which has no permanent effect on output. In the trivariate SVAR model this would correspond to the "absent supply" simulation path for Δp, as core inflation is only that component of measured inflation which is driven by core (real demand and monetary) shocks.

3. Estimation

In this section we apply the identification technique outlined above to assess the performance of the CPI as a measure of "true" inflation. This is done simply by tracing the difference between measured inflation (using CPI) and (computed) core inflation using bivariate and trivariate SVAR models. We estimate bi- and trivariate VAR systems in GDP growth, changes in prices and short-term nominal interest rates for Austria, Belgium, Germany, Finland, France, Italy, the Netherlands, Sweden and the United Kingdom. The estimation period is 1971:1 to 1996:4. Values for 1997 and 1998 are forecasts from the estimated VAR model.

3.1 Data

We use quarterly, non-seasonally-adjusted data for the CPI (or a comparable price index such as cost of living or Retail Price Index – RPI) provided by OECD Main Economic Indicators. Quarterly GDP data and short term interest rates (3-months) are taken from the BIS data base. We subject the log levels of the data to a couple of tests such as the Hylleberg test,[12] the Augmented Dickey-Fuller[13] (ADF) as well as the Phillips-Perron[14] tests. The Hylleberg test results suggest to take the fourth lag differences of the data, ADF and Phillips-Perron tests are then applied to these differences. The results are broadly consistent with output, prices and interest rates being integrated of order one (hence, there is at least one shock for each variable affecting it permanently). Therefore, GDP, prices and interest rates enter the VAR system as year-on-year growth rates. Before entering the VAR, we deduct the respective means from changes in GDP and interest rates (i.e. the level series contain a trend). As the test results suggest year-on-year inflation rates to be trend-stationary, we adjust inflation rates for a trend variable, which could capture the impact of a "secular" downward

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[12] Hylleberg et al. (1990) suggest a test for seasonal roots, as implied by our annual differencing of the data.

[13] See Dickey and Fuller (1979,1981).

[14] See Perron (1988) and Pillips and Perron (1988).

trend in inflation which is observed in most countries.[15] Such a behaviour of inflation seems plausible, given the increase in competitive pressures, the ongoing deregulation and integration of markets; at least, test results in general do not suggest cointegrating restrictions or error correction terms.[16]

3.2 Bivariate SVAR

As a first step bivariate VAR systems in GDP growth and changes in prices are estimated over the period 1971:4 to 1996:4 for all countries. We include three lags, supported by various information criteria.[17] Estimation results are reported in Figures 1 to 9.[18] Both inflation measures (CPI and core inflation) are calculated as the log change in the price level with respect to the corresponding quarter of the previous year. Core inflation is estimated as specified in Section 2.3.

3.2.1 Core versus CPI inflation

Figure 1 displays the results for *Austria*. Overall CPI inflation seems to track the underlying rate of inflation reasonably well. The peaks and troughs of both measures coincide more or less. Yet the deviations tend to be very persistent. From 1971 to 1975 the underlying inflationary process was stronger than the conventional inflation measure would have suggested. After 1975 the opposite was true. Beginning with the late 1970s up to 1987 CPI inflation was considerably higher than our measure of core inflation resulting mainly from the absence of positive supply shocks (productivity slowdown). In the late 1980s, the Austrian economy was hit by a number of positive demand (core) shocks which led to an underlying inflation process considerably stronger than CPI inflation.

Estimation results for *Belgium* are shown in Figure 2. Again, core inflation tracks actual inflation quite well. We found a core inflation process that is in some periods considerable weaker than actual inflation. Especially, in the years around the first (1974) and the second oil price shock (1981) inflation was overestimated by the conventional inflation statistics. Also in the 1990s core inflation is lower than actual inflation. After 1993, deviations of core from actual inflation diminish gradually due the absence of positive supply shocks. At the end of 1993, the "plan global" was implemented which included tax increases and programmes of wage moderation. Consequently, core shocks gained relative importance explaining the inflation process.

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[15] Many price series can be considered borderline cases between being I(1) and I(2) (integrated of order one or two, respectively). As we found I(1) evidence in many cases we treated even the borderline cases as such in order to provide a single framework for our analysis.

[16] Applying the Engle and Granger (1987) tests we could not find cointegrating relationships between the variables; applying Johansens (1991) procedure some of the cases look more ambiguous. However, adding error correction terms to the VAR then did not seem to alter the results significantly. Therefore and in order to keep the framework simple but still applicable to all countries we did not estimate the model in its vector-error correction form.

[17] Three information criteria were used to determine the lag length for the respective VAR estimation: the Akaike Information Criterion (AIC; Akaike (1973), the Schwarz Information Criterion (SC; Schwarz (1978); for both cf., e.g., Judge et al. (1988), p. 870ff), and the Hannan and Quinn Information Criterion (HQ; Hannan and Quinn (1979)), using, respectively, the simple formulae

$$AIC = \log|\Sigma| + \frac{2k}{T}, \quad SC = \log|\Sigma| + \frac{k \log T}{T}, \quad HQ = \log|\Sigma| + \frac{2k \log(\log T)}{T},$$

where $|\Sigma|$ is the determinant of the variance-covariance matrix of the VAR residuals, k is the number of parameters in the model and T is the number of observations.

[18] All graphs can be found in Appendix B.

Estimation results for *Finland* can be seen in Figure 3. According to our calculations the Finnish case represents an exception. Very much like the British RPI, the Finnish CPI inflation seems hardly to be influenced by core innovations. Supply shocks tend to have had a massive impact on the Finnish inflation statistics. Deviations of the underlying inflation measure from the CPI inflation process are substantial. Massive positive deviations can be observed for the years around the first and the second oil price shocks. More recently the opening up of Eastern Europe had significant consequences for the Finnish economy. Negative supply shocks lead to an underlying inflation rate considerably lower than actual inflation. The danger of imported inflation due to a sharp depreciation of the markka was mitigated by incomes policy. In more recent years the core inflation indicator overestimated actual inflation (which could be a sign of an overheating economy).

The inflation experience in *France* is illustrated in Figure 4. We find an underestimation of the underlying inflation by the conventional inflation statistics in the first part of the 1980s, whereas in the second half of the decade inflation was underestimated by the CPI measure. For the 1990s, we get a core inflation measure that is lying substantially below measured inflation. One explanation could be that the French economy, in the process of budget consolidation, was hit by a couple of supply shocks that are not captured by the core inflation measure.

Figure 5 considers the case in *Germany*. As in the Austrian case, the calculated core inflation tracks the CPI inflation well, i.e. the turning points coincide. The deviations of core inflation from CPI are not very large; with the exception of 1991 (German unification) they remain within the 1.5% band over the whole sample.

The results for *Italy* are summarised in Figure 6. The Italian CPI seems to perform very well in measuring inflation. The differences between the two inflation measures are minor. There is also evidence that supply shocks have had only a very restricted impact on the CPI inflation measure. As a result the calculated underlying inflation process perfectly fits the CPI inflation.

Figure 7 shows the estimated core and CPI inflation for the *Netherlands*. The assessment of our results for the Dutch inflation experience is very much the same as for Italy. Supply shocks seem to have only a minor impact on the inflationary process. The deviations of actual inflation from core inflation remain well within the 1% band. As for Italy, we have no clear-cut explanations for these empirical findings.

As can be seen from Figure 8, our calculations for the underlying inflation rate follow the CPI measure considerably well also in *Sweden*. At the beginning of the sample, the underlying inflation indicator ignores the ups and downs of the rather volatile CPI inflation rate. So we cannot give a clear statement whether the underlying inflation rate was definitely over- or underestimated in the first part of the 1970s. In the second part of the 1970s core inflation is overestimated by CPI inflation. The picture changes at the beginning of the 1980s: Deviations of actual inflation from core inflation tend to be comparatively small in the 1980s due to the absence of positive supply shocks. Negative supply shocks and a strong depreciation of the krona led to an actual inflation rate that substantially overestimated the underlying inflation rate. Beginning with 1994 price stability could be restored. In the following years the Swedish economy displayed low inflation rates, hence it is not surprising that the calculated core inflation indictor is well above the measured CPI inflation.[19]

The results for the *United Kingdom* are reported in Figure 9. The calculated core inflation measure for the United Kingdom tends to be relatively smooth as compared to the actual inflation. This means that supply innovations seem to have an important impact on the measured inflation rate. As the United Kingdom is one of the major oil producing OECD countries (apart from Norway), oil price shocks constitute an important (and positive) part of supply shocks leading to downward shifts of the price level. Consequently, actual inflation overestimates the underlying

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[19] The results for this period are completely opposed to the observations by Blix (1995). He found a strong overestimation of the core inflation by the CPI measure. Thereafter the core inflation calculated by Blix shows a smoother development as is the case with our calculations.

inflation trend for the respective periods. In the 1980s the absence of positive supply shocks brings about an underlying inflation that lies considerably above the measured inflation rate (which could also be due to the influence of low oil prices, a non-core element of the inflation process). At the beginning of the 1990s the calculated core inflation rate is very low and turns out to be negative for a few periods. Negative productivity shocks may have pushed RPI above core inflation. Towards the end of the sample, positive productivity shocks (increased flexibility of the labour market) may have put downward pressure on inflation by increasing the output potential and thus resulting in an underlying inflation lower than the usual inflation measure.[20]

We compared our findings with those of Bjørnland (1997), Blix (1995), Dewachter and Lustig (1997), Fase and Folkertsma (1997), Quah and Vahey (1995) and Jacquinot (1998), who used similar concepts. It is not surprising that their results sometimes differ markedly. We want to name only three possible reasons for these differences, which seem to be the most influencing factors. First, in contrast to other empirical studies on this topic, we did not use industrial output data as a proxy for overall output of the economy, but we applied real GDP.[21] Due to data availability, the second difference is a consequence of the first: we used quarterly instead of monthly data. The third source for the deviation clearly comes from the specification of the model. As we assumed the inflation rate to be (trend-)stationary, the change of prices instead of the change of the inflation rate enters the VAR system. The results are very sensitive to such differences in specification.

3.2.2 Impulse response functions and variance decompositions

Figures 10, 14, 18, 22, 26, 30, 34, 38 and 42 report the estimated dynamic responses of measured inflation and output to a one percentage point (ppt.) supply (core) and demand (non-core) shock, for all countries and for the bivariate case. For our purposes the upper and lower right graphs of each figure are relevant.

The dynamic response of CPI inflation to supply disturbances differs substantially from its response to demand disturbances. The results for the impulse response functions very much coincide with what we would expect from theory. Let us consider a simple AS–AD (aggregate supply–aggregate demand) model. A positive productivity shock would shift the AS curve to the right. As a consequence, prices would decrease. This is exactly what we can see in the shape of the impulse response function of CPI on a one period one ppt. increase in aggregate supply. An initial downward jump in prices is followed by step-by-step decreases of prices until the inflation rate converges to zero and the new price level is found.

A positive demand shock shifts the AD curve to the right. In the absence of price rigidities, we would observe immediate price increases. In any case, prices adjust until the new equilibrium is reached. The adjustment process of prices gives us the shape of the impulse response function of CPI to a one ppt. increase in aggregate demand. Immediately after the demand shock an increase in the price level can be observed. After that inflation rates decrease step-by-step until the inflationary impact of the shock disappears and the new equilibrium price level is set.

In view of the theory, we find the shape of the estimated impulse response functions very convincing. The short- and long-run impacts, of course, differ across countries due to structural differences. A demand disturbance increases prices permanently, although the initial effect is much larger than the long run effect. Core shocks also increase output initially, but the effect dies out and the impulse response is close to zero, reflecting the imposed output-neutrality assumption.

The variance decomposition results are reported in Figures 11, 15, 19, 23, 27, 31, 35, 39 and 43. According to the definition of core inflation, its fluctuations are mainly explained by the core

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[20] By visual inspection, we find that the core inflation process is very much the same as the one reported by Blix (1995). Deviations of CPI inflation are substantial. Periods of under- and overestimation can be distinguished easily.

[21] We consider the GDP measure to be the more general proxy.

(demand) innovation for all countries. This observation is most accentuated for Italy (Figure 31) and the Netherlands (Figure 35). It is less pronounced for Austria (Figure 11), Germany (Figure 27), Belgium (Figure 15), France (Figure 23) and Sweden (Figure 39). Finland (Figure 19) and the United Kingdom (Figure 43) constitute exceptions, because core and non-core innovations explain more or less equal parts of CPI inflation forecast variance.

3.3 Trivariate SVAR

In a second step we differentiate monetary or LM shocks from real demand shocks. Both of these shocks were restricted not to have long-lasting effects on the level of output. This implies that both are core innovations, driving the underlying inflation process. The objective of the model extension is to investigate whether real aggregate demand and monetary innovations have similar effects on measured inflation. We also expect that the estimates for the inflation measures could be improved by the extension. We estimate a trivariate VAR system in GDP growth, Δy_t, the change in nominal interest rates, Δi_t, and in quarterly CPI inflation rates, Δp_t. The estimation results for all countries are summarised in Figures 1 to 9. The growth rates are calculated on a year-on-year basis. Again, the estimation period is 1970:1 to 1996:12. The values for 1997 and 1998 are forecasts. The system includes 3 lags, which is supported by various information criteria applied.[22] As previously indicated, this specification is consistent with y_t, i_t and p_t being I(1) (integrated of order one). Cointegration tests do not give evidence of cointegrating vectors.[23]

3.3.1 Core inflation versus CPI inflation

The estimation results for all countries are summarised again in Figures 1 to 9. Even though the Core CPI differentials differ somewhat from those obtained in the bivariate approach, the pattern of deviations closely matches the one of the previous results. In almost every case, the cyclical pattern of over- and underestimations is remarkably similar across both specifications.

For Austria, Belgium and Germany, the difference between the bivariate and the trivariate approach is negligible. For Finland, the Netherlands, Sweden and United Kingdom the deviations are minor. For France and Italy differences in the results are more important.

3.3.2 Impulse response functions and variance decompositions

The impulse response estimates for the trivariate VAR systems displayed in Figures 12, 16, 20, 24, 28, 32, 36, 40 and 44 reveal significant differences in the effects of real and monetary demand shocks on measured inflation. According to the theoretical background outlined above,[24] we expect the monetary policy or LM innovations to have negligible output and price effects for countries credibly pegging their exchange rate, and positive effects for countries with lesser credibility of the peg. Such "credibility effects" can only be found for Austria (Figure 12), Germany (Figure 28) and the Netherlands (Figure 36). As we observe negative price effects in the latter case, we might interpret this interest rate increase in the traditional manner as resulting from autonomous restrictive monetary measures. In all other countries monetary innovations increase output temporarily and prices even in the long-run.[25]

As in the bivariate case, we estimated variance decompositions for each country. The results are shown in Figure 13 (Austria), 17 (Belgium), 21 (Finland), 25 (France), 29 (Germany),

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[22] See footnote 17.

[23] See footnote 16.

[24] See also footnote 11.

[25] Due to our identifying restrictions, we do not allow for long-run output effects of a nominal interest rate shock.

33 (Italy), 37 (Netherlands), 41 (Sweden) and 45 (United Kingdom). We can not fully confirm the findings by Dewachter and Lustig (1997). We have already touched upon the problem of differences in results when describing the impulse response functions for the trivariate case: Interpreting their variance decompositions, Dewachter and Lustig (1997) discovered that the inflationary process is mainly driven by monetary shocks, rather than real (core) shocks. In the long run, 75% to 95% of the variability in measured inflation are accounted for by monetary innovations. Referring to the respective figures, they conclude that inflation is really a monetary phenomenon. According to our estimates, we can share their opinion on inflation being essentially demand driven, but we cannot support the judgement of inflation being a purely monetary phenomenon.

4. Does monetary policy co-ordination enhance inflation convergence? A correlation analysis

In Section 3 we calculated indicators for the underlying inflation process. These core inflation indicators are considered to be more relevant assessing the sustainability of a country's inflation performance than the conventional CPI inflation measure. For the assessment of the ECB's single monetary policy, it is important to know whether there are common trends or common cycles in inflation performance of EU member states. We will address this issue stepwise.

First, we start by a cross correlation analysis involving the CPI inflation and core inflation indicators of the selected countries, whereby we seek to answer the following questions:

Hypothesis 1: We expect that the correlation coefficient between inflation indicators is higher if the country belongs to the "core group" (Austria, Belgium, France, Germany and the Netherlands) rather than to the "periphery group" (Finland, Italy, Sweden and the United Kingdom).[26]

Hypothesis 2: We also expect that the correlation coefficient between the CPI inflation measures is lower than that between the core inflation measures.

Hypothesis 3: We expect that the correlation coefficients are higher in the 1990s due to enhanced monetary policy co-ordination and economic integration than the figures calculated for the 1970s and 1980s, respectively.

As far as the first hypothesis is concerned, we find weak evidence that the inflation performance correlation among ERM countries is closer than among the "periphery group" (see Table 1 in Appendix B). The results are distorted due to the rather "ad hoc" definition of the groups (e.g. relatively high correlation coefficients of France/Italy and rather low coefficients of Austria/France).

Similar results were obtained for the second hypothesis (see Table 1). In most of the cases it seems that especially the correlation coefficient for the core inflation indicators calculated by the bivariate decomposition, "Core Infl. (2)", is slightly higher than between actual inflation rates; the differences are not significant, though.

As to the third hypothesis, the results do not allow us to give a clear answer (cf. Table 1).

Further analysis is required. Cointegration analysis of core inflation series could cast some more light on the existence of common inflation trends in the EU.

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[26] We define "core countries" as the ones that have (at least during most of the estimation period) been tying their currency explicitly to the Deutsche mark, and Germany itself.

Conclusions

We calculated core inflation indicators for Austria, Belgium, Finland, France, Germany, Italy, the Netherlands, Sweden and the United Kingdom in a structural VAR framework applying long-run identification schemes similar to the ones proposed by Quah and Vahey (1995). As also suggested by their work we included a third variable in the VAR system, short-term nominal interest rates, which we assumed to capture the effects of monetary disturbances in the system. Contrasting the results (when applicable) to those of Blix (1995) and Dewachter and Lustig (1997), they differ in many respects for obvious reasons: First of all, we used quarterly instead of monthly data, because we included GDP instead of industrial production data in our analysis. Secondly, especially in the trivariate case, we used a different identification scheme (e.g., both Blix (1995) and Dewachter and Lustig (1997) included cointegrating restrictions motivated by economic theory). Specifically, we use changes of prices instead of changes in inflation in our estimations and impose respective long-term restrictions in this context. The analysis bears on an IS–LM/AS–AD framework for small open economies and/or countries with fixed exchange rate regimes.

Dewachter and Lustig (1997) find that the inflation process is mainly driven by monetary shocks, rather than demand shocks. Hence, they conclude that inflation is a monetary phenomenon. According to our estimates, we find that inflation is essentially demand-driven, but our results at this stage do not support their view that inflation is a purely monetary phenomenon.

A cross correlation analysis completes the paper, this exercise being a first attempt to address the question about the existence of common inflation trends in EU countries. Future research should aim for an in-depth analysis of common trends and cycles among EU inflation measures.

Appendix A: Confidence bands of impulse response functions

In order to report two-standard error bands in the graphs of the impulse response functions as shown below we apply a Monte-Carlo approach. Although there is a common procedure for the "traditional" VARs that use short-term restrictions to identify the structural shocks, the calculation of the error bands for VARs using long-run restrictions are, as of now, not common knowledge among model builders. So far, also an analytical approach – which is given by Lütkepohl (1993, p. 313ff) for "traditional" VARs – has not been finally designed in the context of long-run identifying restrictions.[27] Here we use a slightly modified version of a technique expounded in, e.g., Mélitz and Weber (1996).[28]

If we write the VAR as:

$$y_t = (I \otimes x_t)\beta + u_t$$

where $\otimes$ is the Kronecker product, x_t is the vector of lagged y_{it}'s ($i = 1,2,...m$), β is a vector containing the stacked version of the structural VAR lag polynomial matrices, $A(L)$, and u_t is i.i.d. with distribution $N(0,\Sigma)$. The OLS estimates of β and Σ are denoted by b and Z. Assuming that the prior distribution of β is $f(\beta,\Sigma) \propto |\Sigma|^{-(n+1)/2}$, the posterior distribution of β, conditional on Σ, is $N(b, \Sigma \otimes (x'x)^{-1})$ and the distribution of Σ^{-1} is $Wishart((TZ)^{-1}, T)$ with T as sample size.

First and second moments for the impulse responses (the moving average representation) can be computed by drawing q times[29] from the above distribution for β and Σ, inverting the VAR, calculating each time[30] the innovation-orthogonalising matrix E_0^{-1} (as shown in the text) and conditional on that calculating the mean and the variance impulse responses (moving average parameters).

In order to derive standard errors for the accumulated impulse responses as shown in the graphs (for "level series"), we accumulate the impulses of each of the q draws for every impulse step period p, calculate their variance over the q draws and then adjust this variance in each impulse step, multiplying it by p^{-1}. The standard errors are then given by the square root of the resulting adjusted variances. We perform this adjustment referring to the fact that the identifying restrictions are imposed on the long-run moving average parameters, i.e. the accumulations of the moving average parameters derived from the estimated model with differenced series, and any variance of the accumulated parameters at step p has to be treated as sample variance of the parameters up to step p.

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[27] But see the suggestion by Vlaar (1997).

[28] For the calculations we modify a RATS program procedure given in Doan (1992, p.10-5).

[29] We used $q = 300$ for our calculations.

[30] Here we differ from the approach as given in Melitz and Weber (1996); they perform the calculations conditional on E_0^{-1} as derived from the initial estimation.

Appendix B: Tables and graphs

Table 1

Cross correlations of inflation series between countries

|		Belgium	Finland	France	Germany	Italy	Netherlands	Sweden	U. Kingdom
Austria	Actual Infl.	0.88	0.83	0.76	0.82	0.72	0.94	0.57	0.73
1971:1-96:4	Core Infl. (2)	0.92	0.82	0.72	0.84	0.73	0.96	0.61	0.68
	Core Infl. (3)	0.81	0.74	0.76	0.82	0.85	0.92	0.71	0.36
	Actual-Core (2)	0.56	0.32	0.59	0.42	0.12	0.57	0.04	0.50
	Actual-Core (3)	0.14	0.11	0.58	0.40	0.07	0.36	0.34	0.29
1971:1-80:4	Actual Infl.	0.85	0.73	0.35	0.73	0.33	0.92	0.10	0.44
	Core Infl. (2)	0.85	0.65	0.14	0.81	0.36	0.92	-0.08	0.32
	Core Infl. (3)	0.59	0.66	0.87	-0.12	0.94	0.93	0.51	-0.24
	Actual-Core (2)	0.64	0.33	0.74	0.60	0.35	0.69	-0.07	0.67
	Actual-Core (3)	-0.51	0.95	0.67	-0.01	-0.88	0.84	0.97	0.39
1981:1-90:4	Actual Infl.	0.82	0.81	0.86	0.84	0.83	0.93	0.74	0.62
	Core Infl. (2)	0.86	0.88	0.84	0.90	0.86	0.96	0.92	0.07
	Core Infl. (3)	0.85	0.85	0.81	0.89	0.86	0.95	0.83	0.00
	Actual-Core (2)	0.49	0.27	0.70	0.35	-0.14	0.49	-0.25	0.37
	Actual-Core (3)	0.24	0.23	0.76	0.34	-0.19	0.34	-0.04	0.20
1990:1-96:4	Actual Infl.	0.65	0.57	0.37	0.80	0.36	0.65	0.42	0.22
	Core Infl. (2)	0.69	0.06	0.61	0.86	0.39	0.73	0.54	-0.02
	Core Infl. (3)	0.64	0.56	0.64	0.84	0.24	0.69	0.44	0.11
	Actual-Core (2)	0.45	0.43	0.45	0.46	0.21	0.71	0.53	0.23
	Actual-Core (3)	0.07	-0.16	0.46	0.52	0.22	0.31	0.69	0.29
Belgium	Actual Infl.	1.00	0.89	0.84	0.68	0.82	0.85	0.63	0.75
1971:1-96:4	Core Infl. (2)	1.00	0.90	0.82	0.72	0.79	0.89	0.67	0.79
	Core Infl. (3)	1.00	0.84	0.88	0.75	0.83	0.76	0.74	0.43
	Actual-Core (2)	1.00	0.10	0.67	0.30	-0.11	0.34	0.01	0.31
	Actual-Core (3)	1.00	-0.68	0.41	0.08	-0.25	-0.36	-0.31	-0.09
1971:1-80:4	Actual Infl.	1.00	0.89	0.56	0.48	0.51	0.82	0.24	0.64
	Core Infl. (2)	1.00	0.90	0.38	0.52	0.57	0.85	0.09	0.56
	Core Infl. (3)	1.00	0.89	0.48	0.27	0.82	0.74	0.67	-0.61
	Actual-Core (2)	1.00	0.50	0.84	0.60	0.39	0.51	0.07	0.80
	Actual-Core (3)	1.00	-0.61	-0.96	0.39	0.61	-0.49	-0.37	0.43
1981:1-90:4	Actual Infl.	1.00	0.81	0.90	0.83	0.92	0.85	0.66	0.41
	Core Infl. (2)	1.00	0.92	0.83	0.89	0.83	0.84	0.80	-0.08
	Core Infl. (3)	1.00	0.89	0.89	0.90	0.88	0.87	0.78	0.02
	Actual-Core (2)	1.00	-0.07	0.71	0.17	-0.28	0.42	-0.18	0.38
	Actual-Core (3)	1.00	-0.71	0.43	-0.02	-0.40	-0.28	-0.35	0.12
1990:1-96:4	Actual Infl.	1.00	0.81	0.75	0.38	0.42	0.56	0.75	0.61
	Core Infl. (2)	1.00	0.26	0.94	0.73	0.17	0.55	0.70	0.15
	Core Infl. (3)	1.00	0.47	0.90	0.78	-0.18	0.38	0.57	0.17
	Actual-Core (2)	1.00	-0.38	0.90	0.49	-0.44	0.22	0.04	-0.62
	Actual-Core (3)	1.00	-0.85	0.79	0.31	-0.61	-0.57	-0.34	-0.83
Finland	Actual Infl.		1.00	0.86	0.63	0.84	0.82	0.77	0.88
1971:1-96:4	Core Infl. (2)		1.00	0.91	0.58	0.83	0.80	0.77	0.89
	Core Infl. (3)		1.00	0.93	0.49	0.85	0.66	0.80	0.70
	Actual-Core (2)		1.00	0.23	0.31	0.05	0.31	0.44	0.60
	Actual-Core (3)		1.00	-0.22	-0.08	0.44	0.44	0.30	0.38
1971:1-80:4	Actual Infl.		1.00	0.58	0.40	0.58	0.73	0.43	0.77
	Core Infl. (2)		1.00	0.40	0.27	0.60	0.64	0.12	0.69
	Core Infl. (3)		1.00	0.36	-0.19	0.79	0.73	0.58	-0.85
	Actual-Core (2)		1.00	0.61	0.47	-0.31	0.19	0.29	0.66
	Actual-Core (3)		1.00	0.79	0.00	-0.82	0.70	0.95	0.33
1981:1-90:4	Actual Infl.		1.00	0.90	0.91	0.87	0.88	0.78	0.68
	Core Infl. (2)		1.00	0.95	0.89	0.95	0.92	0.83	0.09
	Core Infl. (3)		1.00	0.94	0.84	0.91	0.92	0.73	0.18
	Actual-Core (2)		1.00	0.38	0.62	0.61	0.50	0.55	0.21
	Actual-Core (3)		1.00	0.06	0.19	0.36	0.44	0.55	-0.01
1990:1-96:4	Actual Infl.		1.00	0.88	0.33	0.74	0.40	0.90	0.84
	Core Infl. (2)		1.00	0.44	-0.22	0.35	-0.13	0.68	0.96
	Core Infl. (3)		1.00	0.50	0.36	0.01	0.16	0.62	0.50
	Actual-Core (2)		1.00	-0.38	-0.09	0.49	0.50	0.58	0.86
	Actual-Core (3)		1.00	-0.71	-0.39	0.53	0.60	0.16	0.66

Table 2

Cross correlations of inflation series between countries (continued)

		Belgium	Finland	France	Germany	Italy	Netherlands	Sweden	U. Kingdom
France	Actual Infl.			1.00	0.63	0.95	0.75	0.75	0.77
1971:1-96:4	Core Infl. (2)			1.00	0.57	0.88	0.69	0.86	0.77
	Core Infl. (3)			1.00	0.56	0.91	0.70	0.84	0.73
	Actual-Core (2)			1.00	0.47	-0.16	0.48	-0.04	0.45
	Actual-Core (3)			1.00	0.44	-0.38	0.42	0.05	0.24
1971:1-80:4	Actual Infl.			1.00	0.14	0.89	0.15	0.58	0.66
	Core Infl. (2)			1.00	-0.25	0.88	-0.02	0.82	0.37
	Core Infl. (3)			1.00	0.20	0.85	0.89	0.61	0.17
	Actual-Core (2)			1.00	0.67	0.38	0.58	0.03	0.81
	Actual-Core (3)			1.00	-0.34	-0.73	0.53	0.57	-0.26
1981:1-90:4	Actual Infl.			1.00	0.86	0.96	0.92	0.65	0.52
	Core Infl. (2)			1.00	0.83	0.98	0.90	0.73	0.12
	Core Infl. (3)			1.00	0.83	0.96	0.90	0.69	0.19
	Actual-Core (2)			1.00	0.35	-0.10	0.60	-0.07	0.57
	Actual-Core (3)			1.00	0.33	-0.18	0.46	0.16	0.34
1990:1-96:4	Actual Infl.			1.00	0.24	0.82	0.31	0.86	0.84
	Core Infl. (2)			1.00	0.66	0.35	0.37	0.81	0.32
	Core Infl. (3)			1.00	0.74	0.15	0.31	0.81	0.48
	Actual-Core (2)			1.00	0.71	-0.54	0.27	-0.19	-0.67
	Actual-Core (3)			1.00	0.68	-0.58	-0.28	-0.18	-0.62
Germany	Actual Infl.				1.00	0.56	0.84	0.44	0.57
1971:1-96:4	Core Infl. (2)				1.00	0.56	0.85	0.52	0.37
	Core Infl. (3)				1.00	0.61	0.84	0.53	0.09
	Actual-Core (2)				1.00	0.18	0.51	-0.01	0.34
	Actual-Core (3)				1.00	0.04	0.21	0.32	0.22
1971:1-80:4	Actual Infl.				1.00	0.02	0.67	-0.12	0.23
	Core Infl. (2)				1.00	-0.10	0.80	-0.34	-0.03
	Core Infl. (3)				1.00	0.08	-0.01	0.02	0.44
	Actual-Core (2)				1.00	0.38	0.49	-0.16	0.77
	Actual-Core (3)				1.00	0.48	0.06	0.19	0.82
1981:1-90:4	Actual Infl.				1.00	0.85	0.93	0.78	0.79
	Core Infl. (2)				1.00	0.82	0.92	0.89	0.10
	Core Infl. (3)				1.00	0.79	0.92	0.85	0.15
	Actual-Core (2)				1.00	0.42	0.62	0.18	0.11
	Actual-Core (3)				1.00	0.30	0.26	0.34	0.00
1990:1-96:4	Actual Infl.				1.00	0.21	0.74	0.16	-0.07
	Core Infl. (2)				1.00	0.27	0.69	0.45	-0.29
	Core Infl. (3)				1.00	0.11	0.69	0.48	0.02
	Actual-Core (2)				1.00	-0.47	0.42	-0.12	-0.34
	Actual-Core (3)				1.00	-0.44	-0.04	0.18	-0.08
Italy	Actual Infl.					1.00	0.70	0.76	0.77
1971:1-96:4	Core Infl. (2)					1.00	0.72	0.80	0.70
	Core Infl. (3)					1.00	0.84	0.76	0.57
	Actual-Core (2)					1.00	0.24	0.17	0.21
	Actual-Core (3)					1.00	0.07	0.43	0.27
1971:1-80:4	Actual Infl.					1.00	0.15	0.64	0.66
	Core Infl. (2)					1.00	0.25	0.74	0.66
	Core Infl. (3)					1.00	0.97	0.66	-0.36
	Actual-Core (2)					1.00	0.31	-0.30	0.24
	Actual-Core (3)					1.00	-0.73	-0.76	0.05
1981:1-90:4	Actual Infl.					1.00	0.90	0.67	0.47
	Core Infl. (2)					1.00	0.90	0.78	0.05
	Core Infl. (3)					1.00	0.91	0.73	0.09
	Actual-Core (2)					1.00	0.22	0.77	0.03
	Actual-Core (3)					1.00	0.33	0.48	0.02
1990:1-96:4	Actual Infl.					1.00	0.20	0.82	0.78
	Core Infl. (2)					1.00	0.15	0.64	0.34
	Core Infl. (3)					1.00	-0.06	0.31	0.26
	Actual-Core (2)					1.00	0.19	0.65	0.71
	Actual-Core (3)					1.00	0.46	0.58	0.66

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Table 3

Cross correlations of inflation series between countries (continued)

		Belgium	Finland	France	Germany	Italy	Netherlands	Sweden	U. Kingdom
Netherlands	Actual Infl.						1.00	0.54	0.76
1971:1-96:4	Core Infl. (2)						1.00	0.57	0.67
	Core Infl. (3)						1.00	0.58	0.28
	Actual-Core (2)						1.00	0.23	0.46
	Actual-Core (3)						1.00	0.36	0.34
1971:1-80:4	Actual Infl.						1.00	0.02	0.44
	Core Infl. (2)						1.00	-0.18	0.32
	Core Infl. (3)						1.00	0.77	-0.28
	Actual-Core (2)						1.00	0.12	0.55
	Actual-Core (3)						1.00	0.78	0.29
1981:1-90:4	Actual Infl.						1.00	0.78	0.73
	Core Infl. (2)						1.00	0.88	0.18
	Core Infl. (3)						1.00	0.80	0.17
	Actual-Core (2)						1.00	0.22	0.28
	Actual-Core (3)						1.00	0.34	0.12
1990:1-96:4	Actual Infl.						1.00	0.26	0.12
	Core Infl. (2)						1.00	0.37	-0.08
	Core Infl. (3)						1.00	0.11	-0.11
	Actual-Core (2)						1.00	0.44	0.36
	Actual-Core (3)						1.00	0.43	0.61
Sweden	Actual Infl.							1.00	0.71
1971:1-96:4	Core Infl. (2)							1.00	0.66
	Core Infl. (3)							1.00	0.75
	Actual-Core (2)							1.00	0.18
	Actual-Core (3)							1.00	0.42
1971:1-80:4	Actual Infl.							1.00	0.53
	Core Infl. (2)							1.00	0.27
	Core Infl. (3)							1.00	-0.27
	Actual-Core (2)							1.00	0.07
	Actual-Core (3)							1.00	0.57
1981:1-90:4	Actual Infl.							1.00	0.72
	Core Infl. (2)							1.00	0.03
	Core Infl. (3)							1.00	0.07
	Actual-Core (2)							1.00	0.25
	Actual-Core (3)							1.00	0.29
1990:1-96:4	Actual Infl.							1.00	0.83
	Core Infl. (2)							1.00	0.65
	Core Infl. (3)							1.00	0.80
	Actual-Core (2)							1.00	0.56
	Actual-Core (3)							1.00	0.71

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.
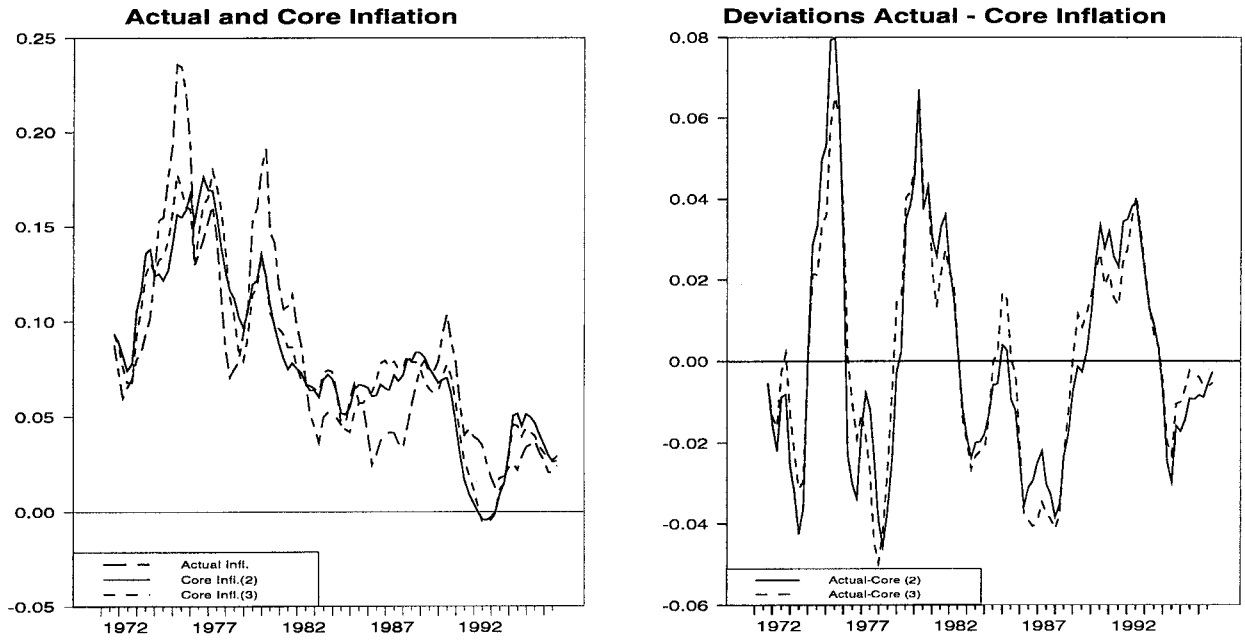
Figure 1

Inflation and core inflation in Austria
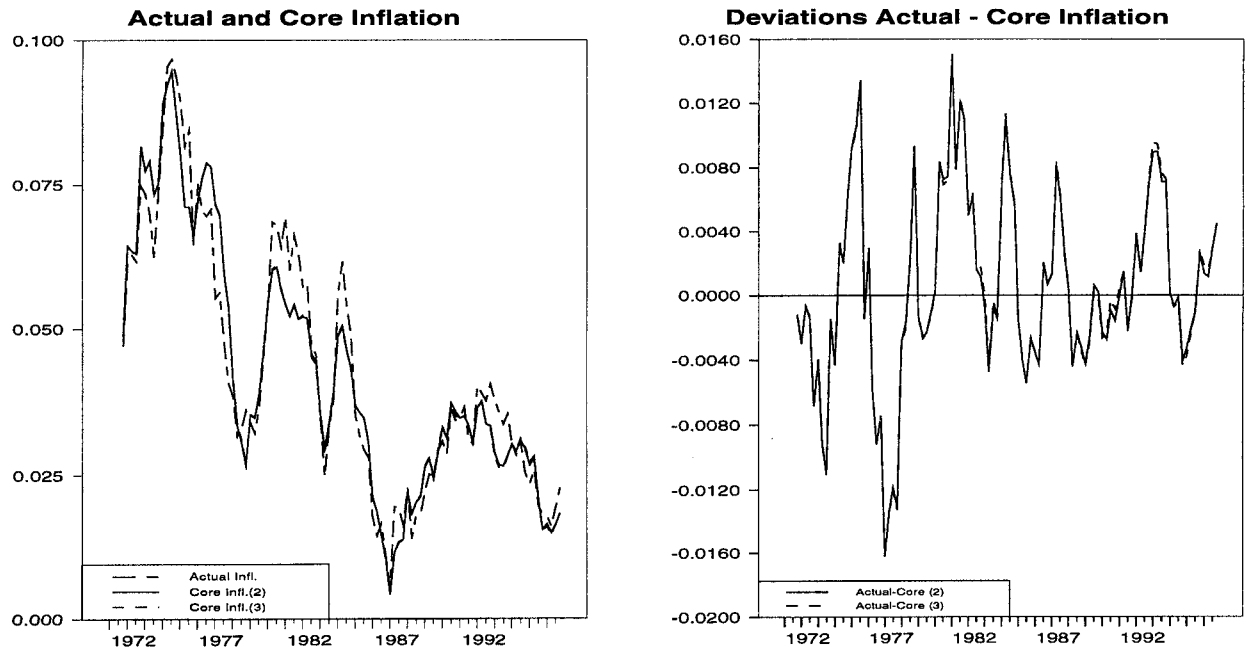
Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 2

Inflation and core inflation in Belgium
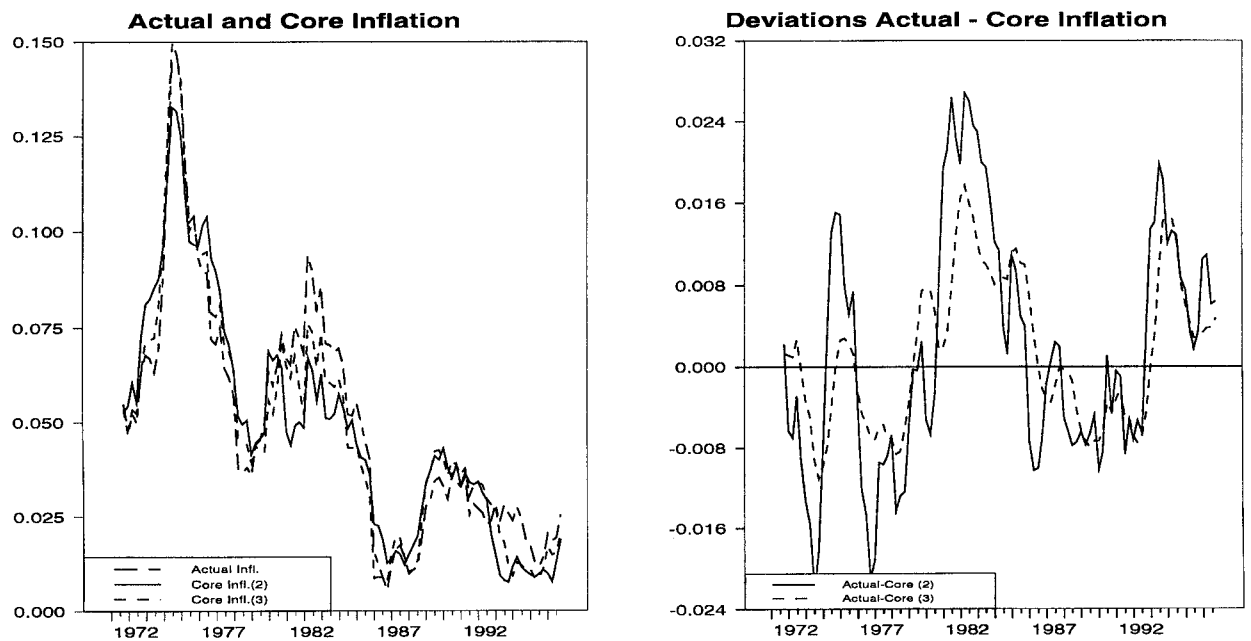
Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 3

Inflation and core inflation in Finland
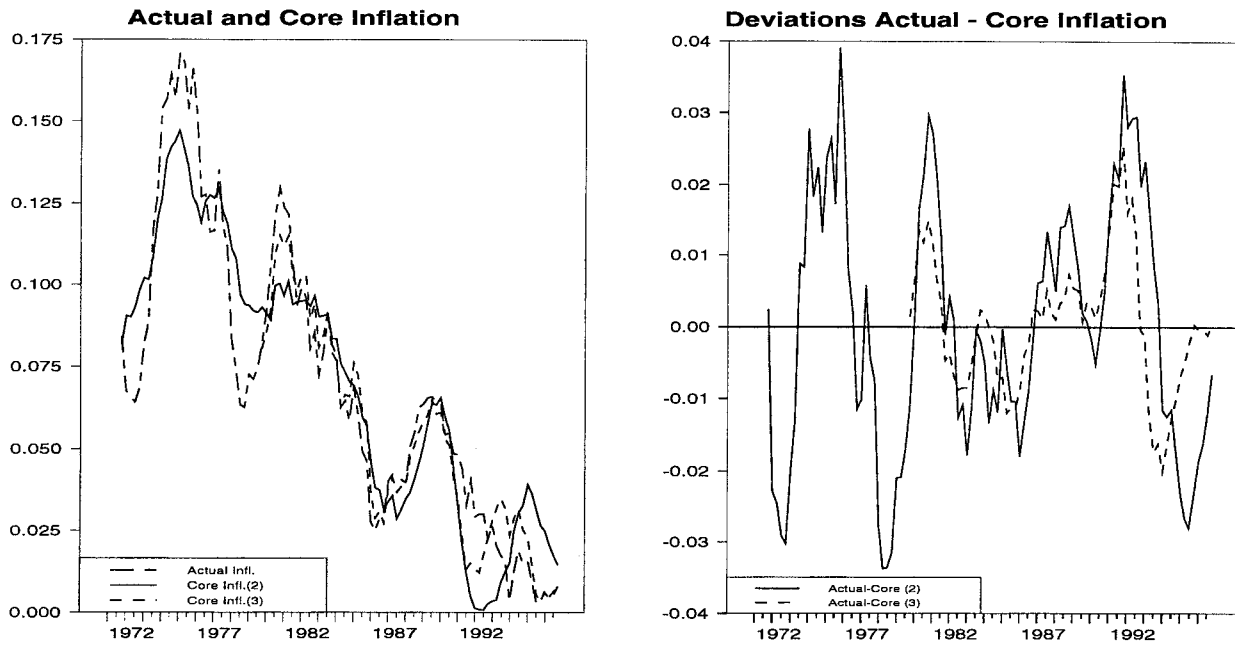
Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 4

Inflation and core inflation in France
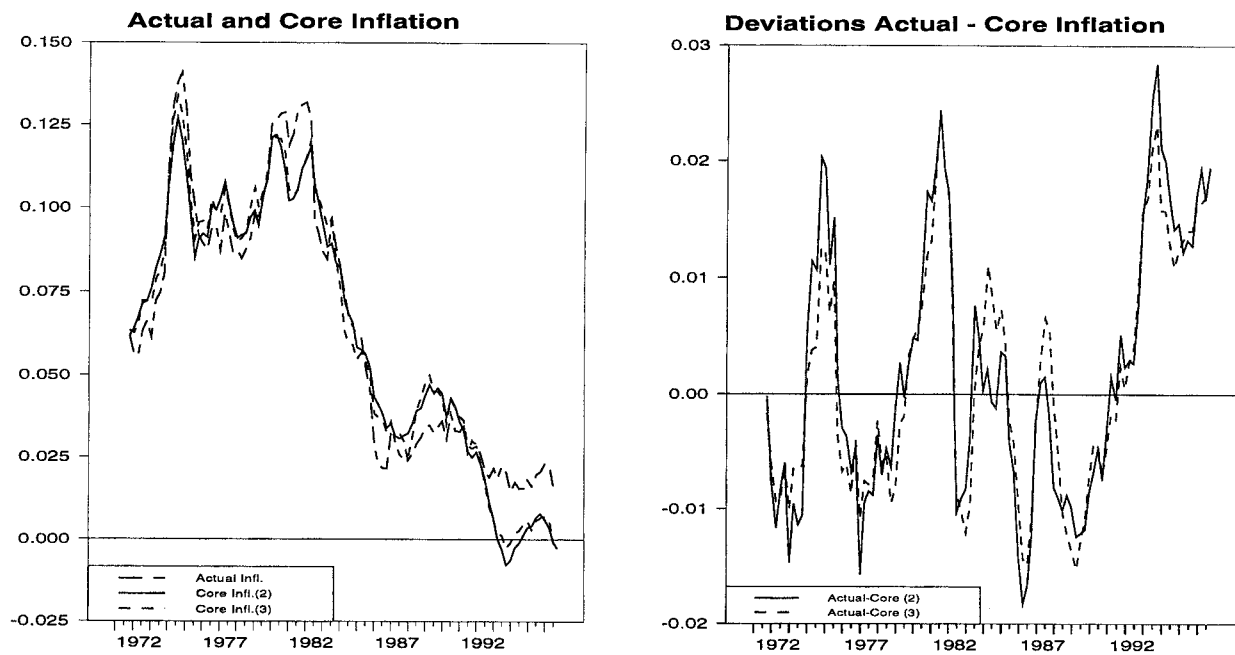
Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 5

Inflation and core inflation in Germany
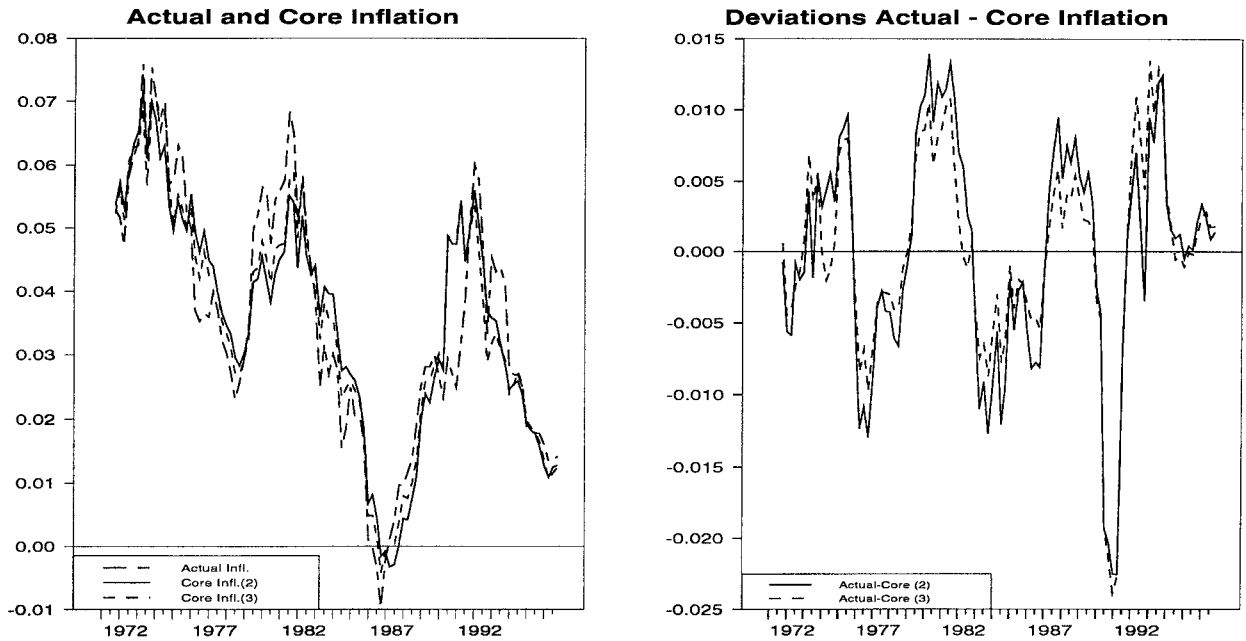
Actual and Core Inflation (left panel) — axis values 0.08, 0.07, 0.06, 0.05, 0.04, 0.03, 0.02, 0.01, 0.00, -0.01; years 1972, 1977, 1982, 1987, 1992. Legend: Actual Infl., Core Infl.(2), Core Infl.(3).

Deviations Actual - Core Inflation (right panel) — axis values 0.015, 0.010, 0.005, 0.000, -0.005, -0.010, -0.015, -0.020, -0.025; years 1972, 1977, 1982, 1987, 1992. Legend: Actual-Core (2), Actual-Core (3).

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 6

Inflation and core inflation in Italy
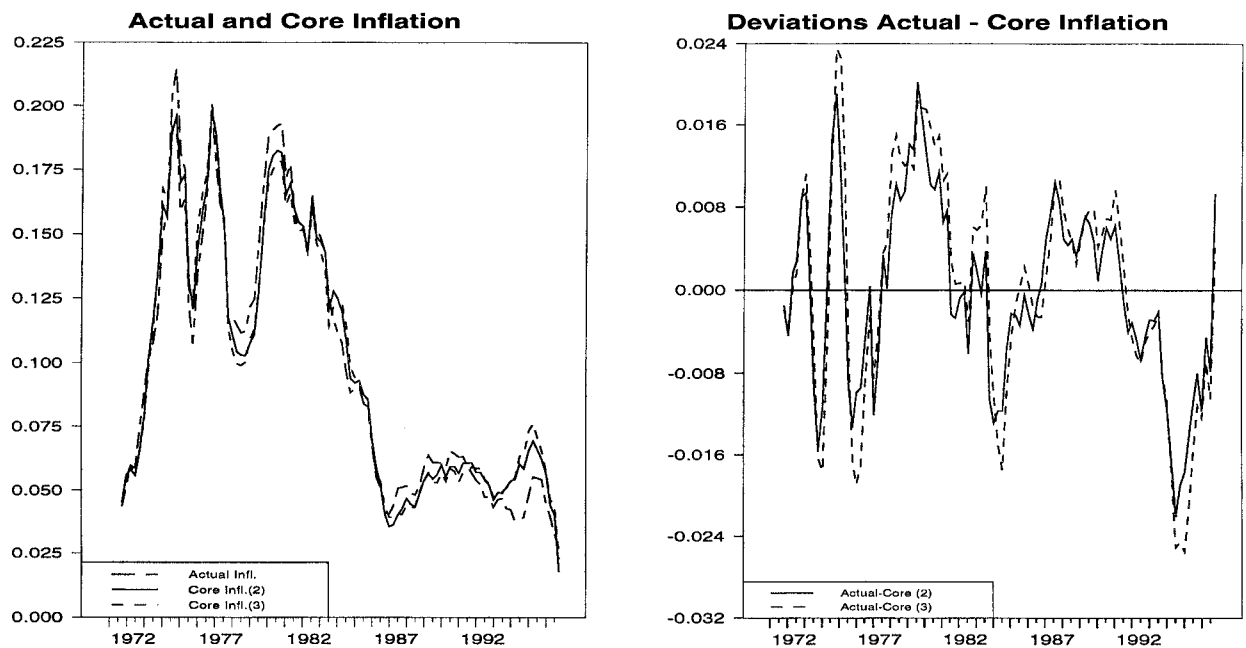
Actual and Core Inflation (left panel) — axis values 0.225, 0.200, 0.175, 0.150, 0.125, 0.100, 0.075, 0.050, 0.025, 0.000; years 1972, 1977, 1982, 1987, 1992. Legend: Actual Infl., Core Infl.(2), Core Infl.(3).

Deviations Actual - Core Inflation (right panel) — axis values 0.024, 0.016, 0.008, 0.000, -0.008, -0.016, -0.024, -0.032; years 1972, 1977, 1982, 1987, 1992. Legend: Actual-Core (2), Actual-Core (3).

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 7

Inflation and core inflation in the Netherlands
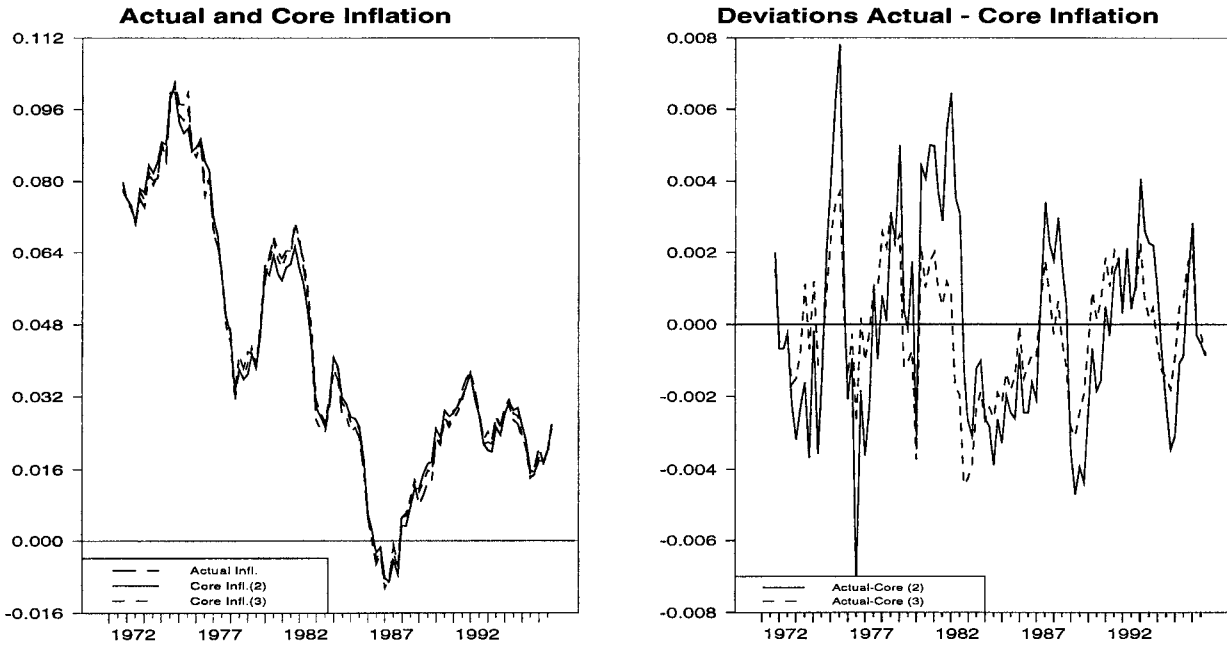
Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

Figure 8

Inflation and core inflation in Sweden
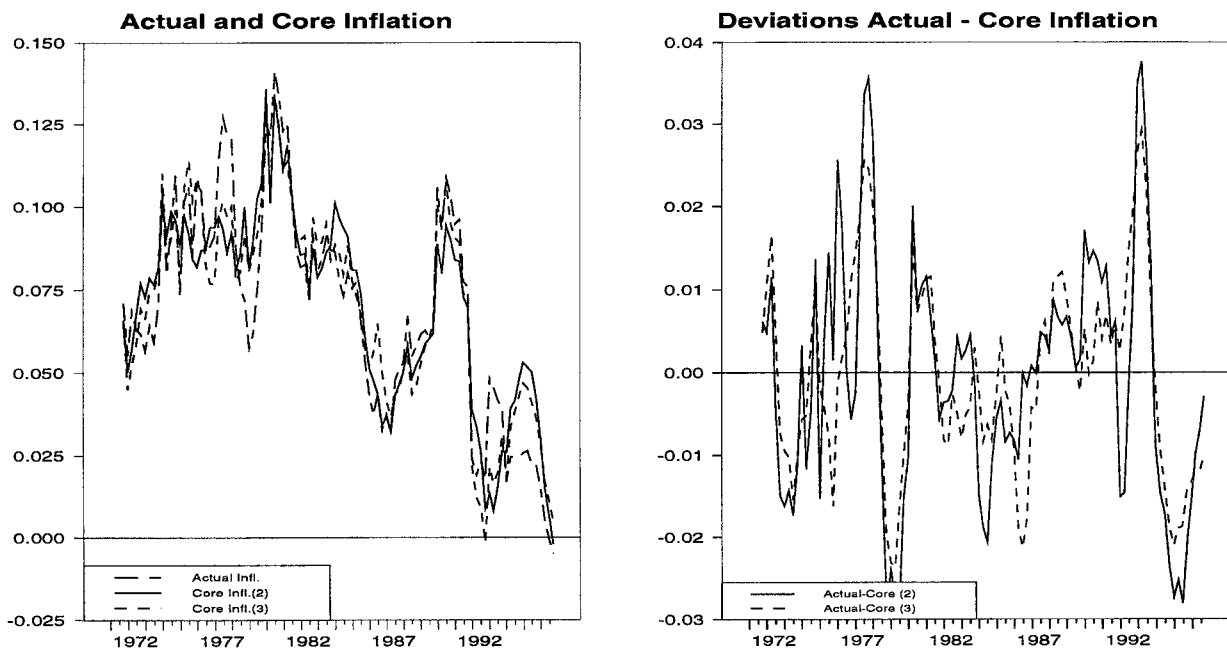
Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

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Figure 9

Inflation and core inflation in the United Kingdom

Actual and Core Inflation

Deviations Actual - Core Inflation

Note: The numbers in parentheses indicate the results of the bivariate (output, inflation) and trivariate (output, interest rate and inflation) model, respectively.

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Figure 10

Impulse response functions (bivariate model) – Austria
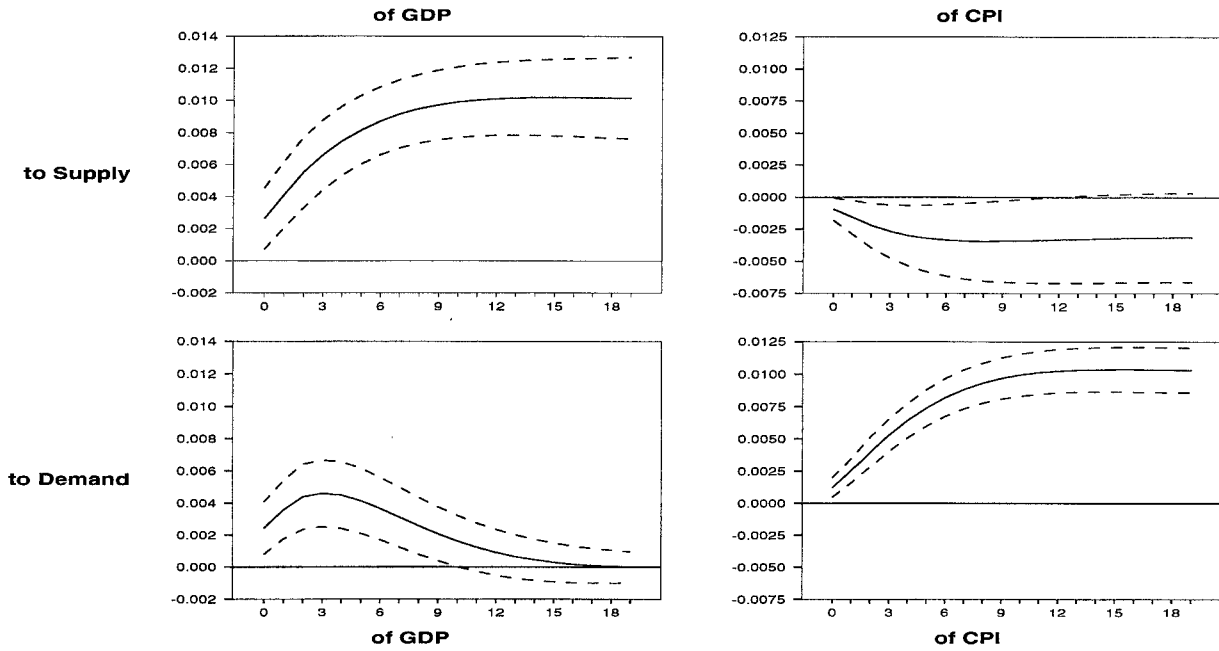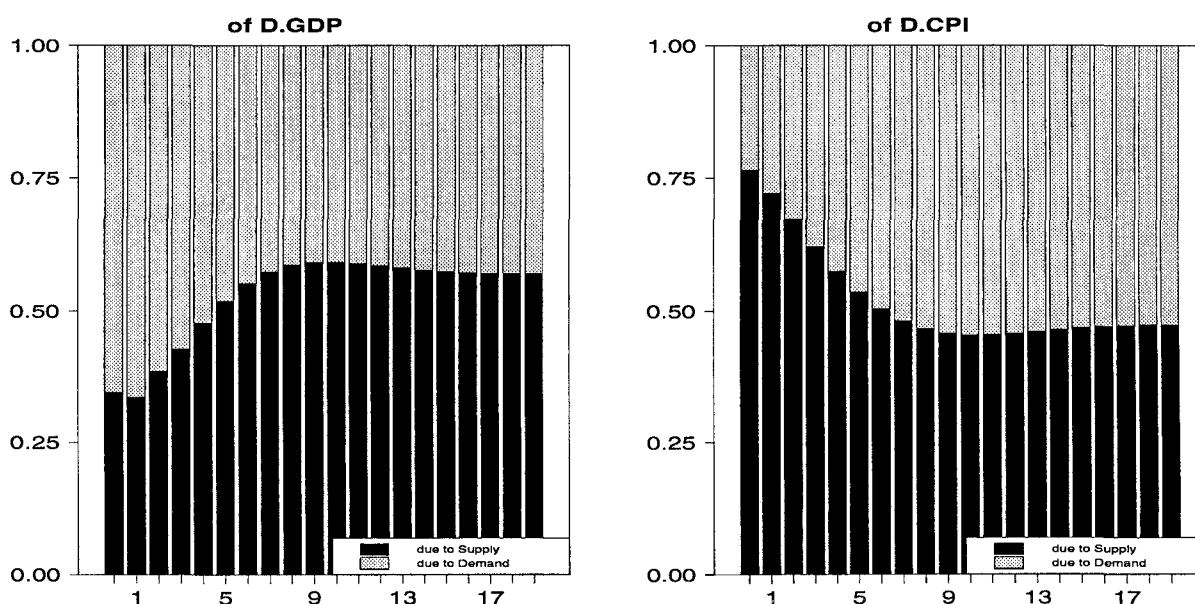
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 11

Variance decompositions (bivariate model) – Austria
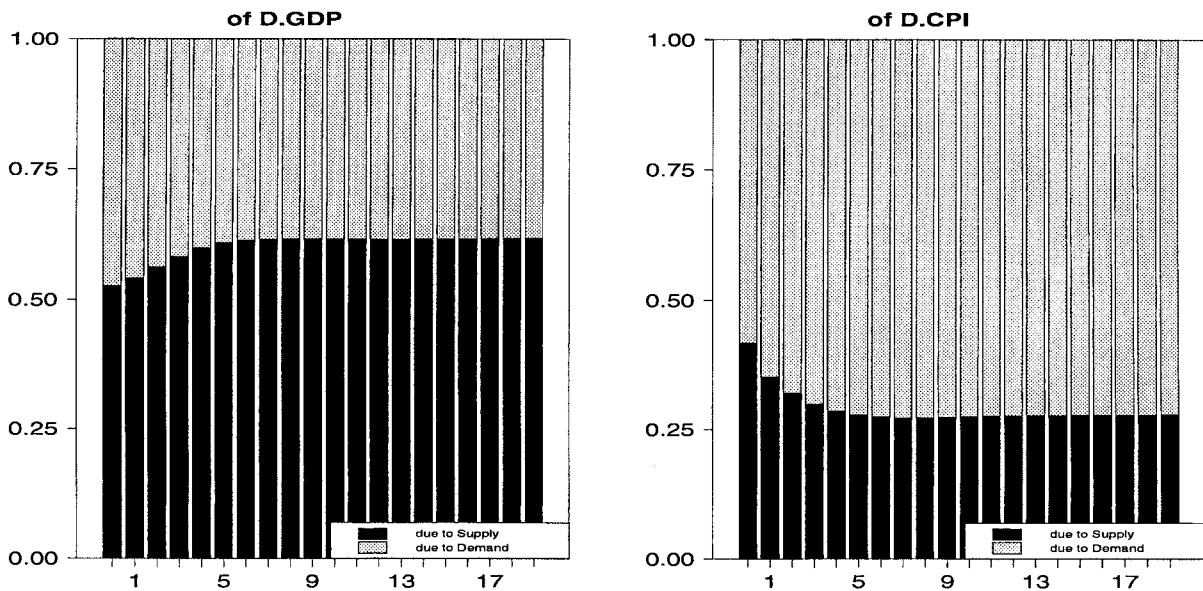
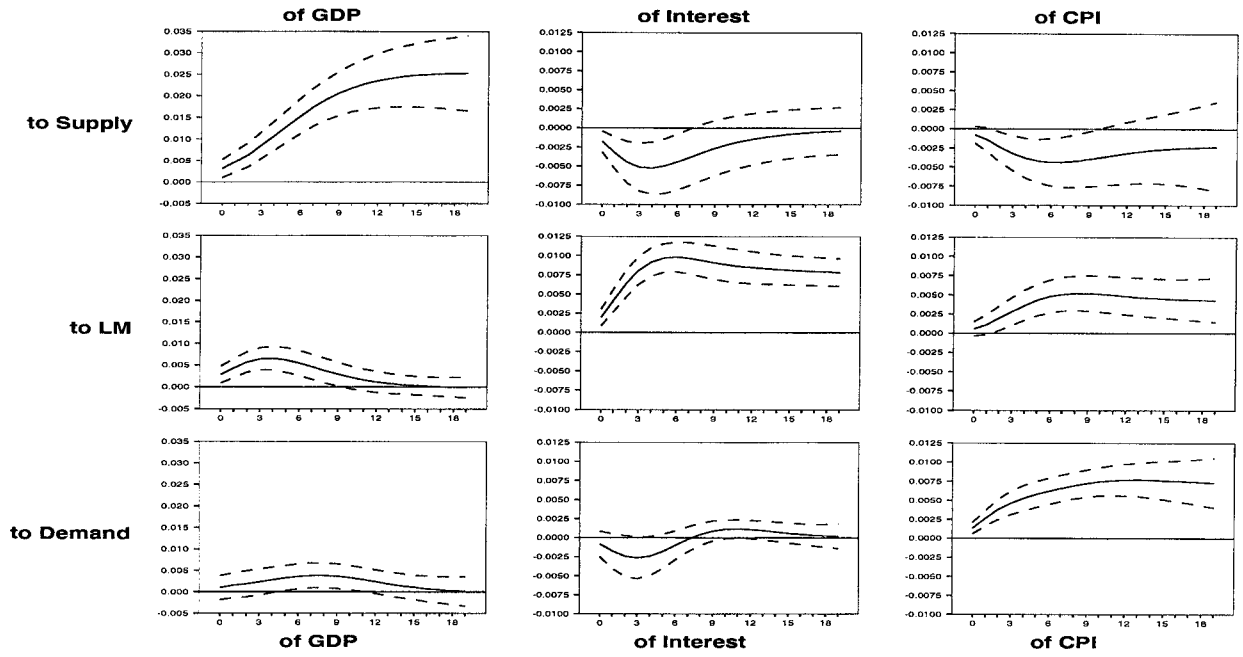*(VAR estim. with 3 lags, 1971:04 - 1996:04)*

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 12

Impulse response functions (trivariate model) – Austria

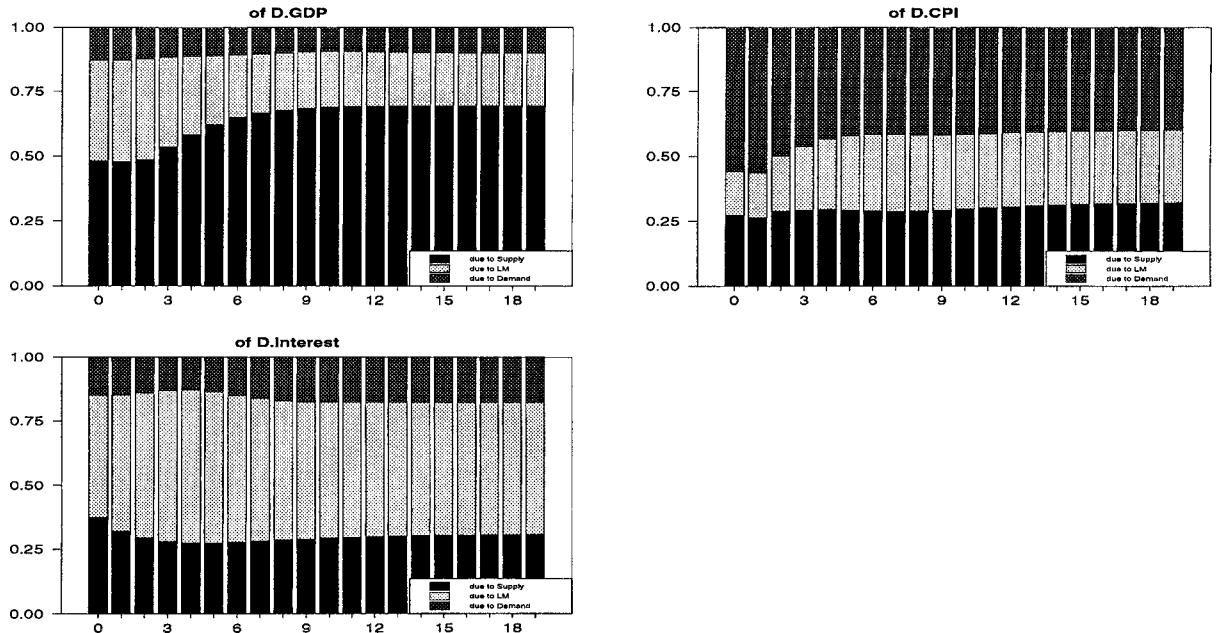*(VAR estim. with 3 lags, 1971:04 - 1996:04)*
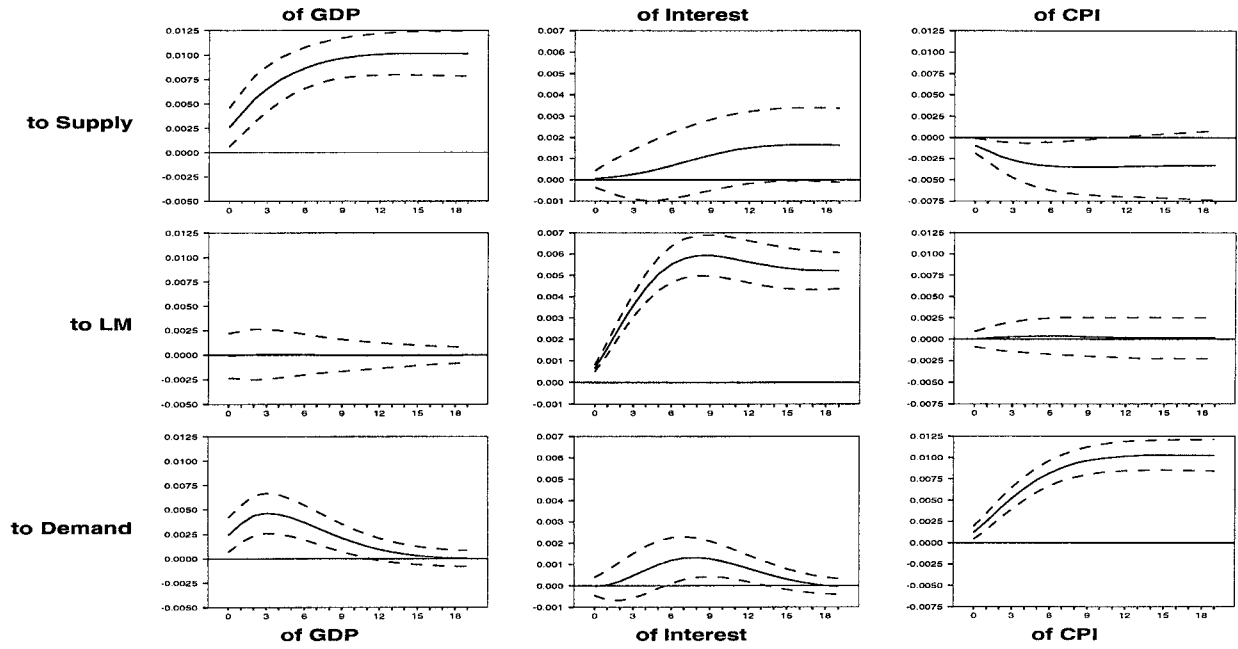
Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 13

Variance decompositions (trivariate model) – Austria
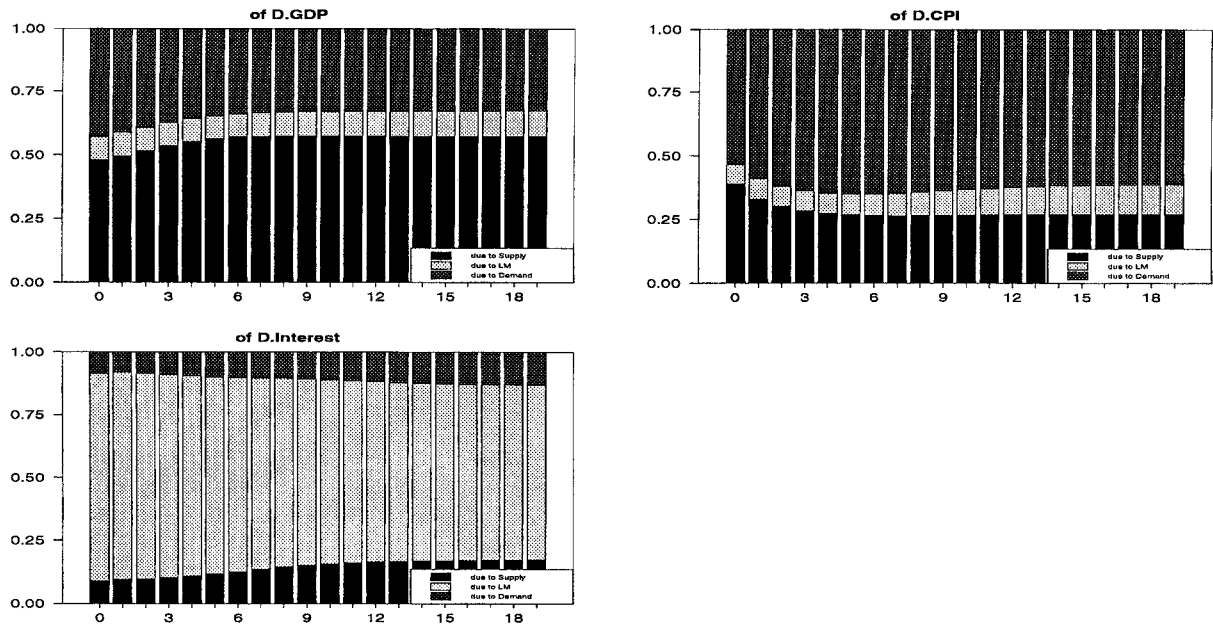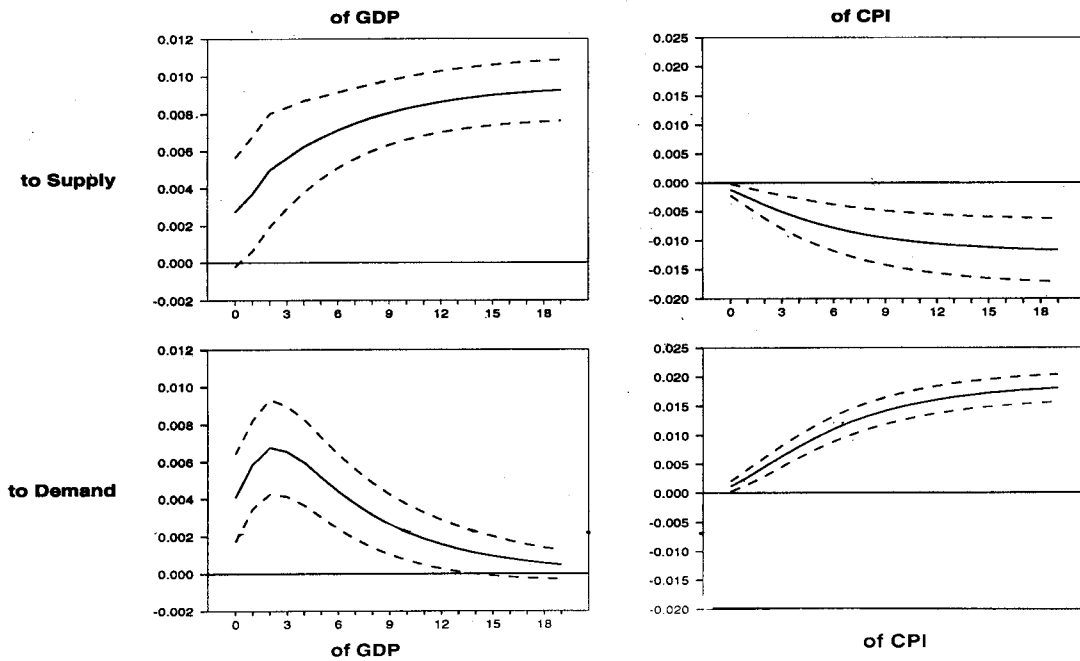
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 14

Impulse response functions (bivariate model) – Belgium
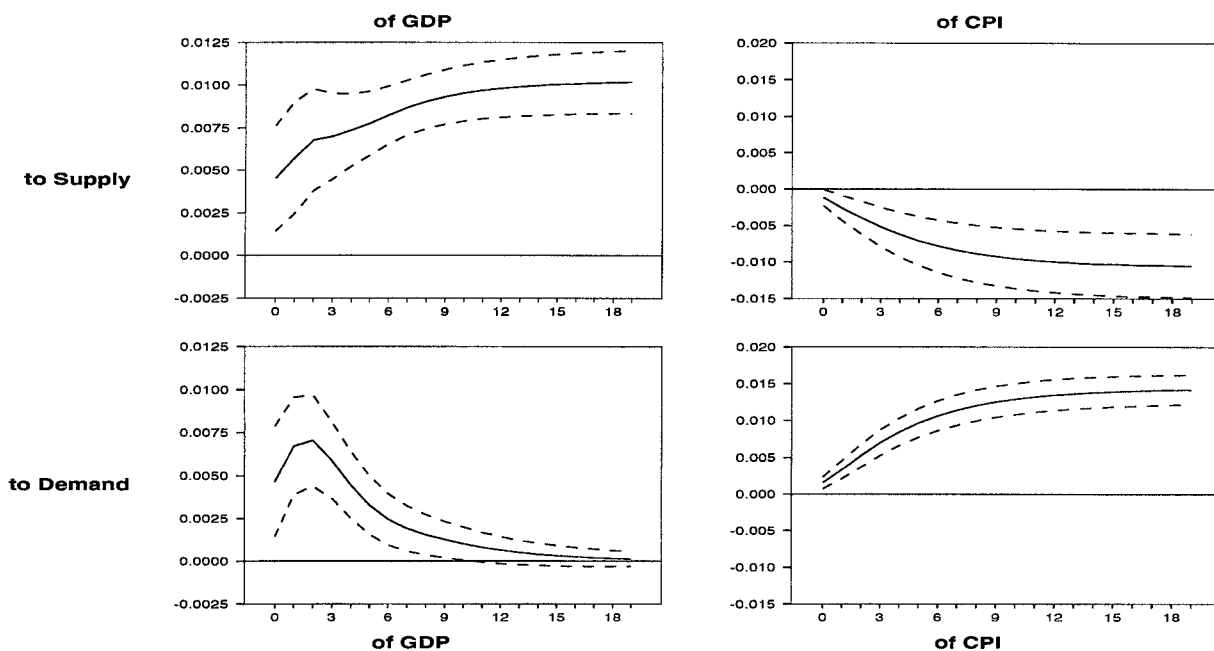
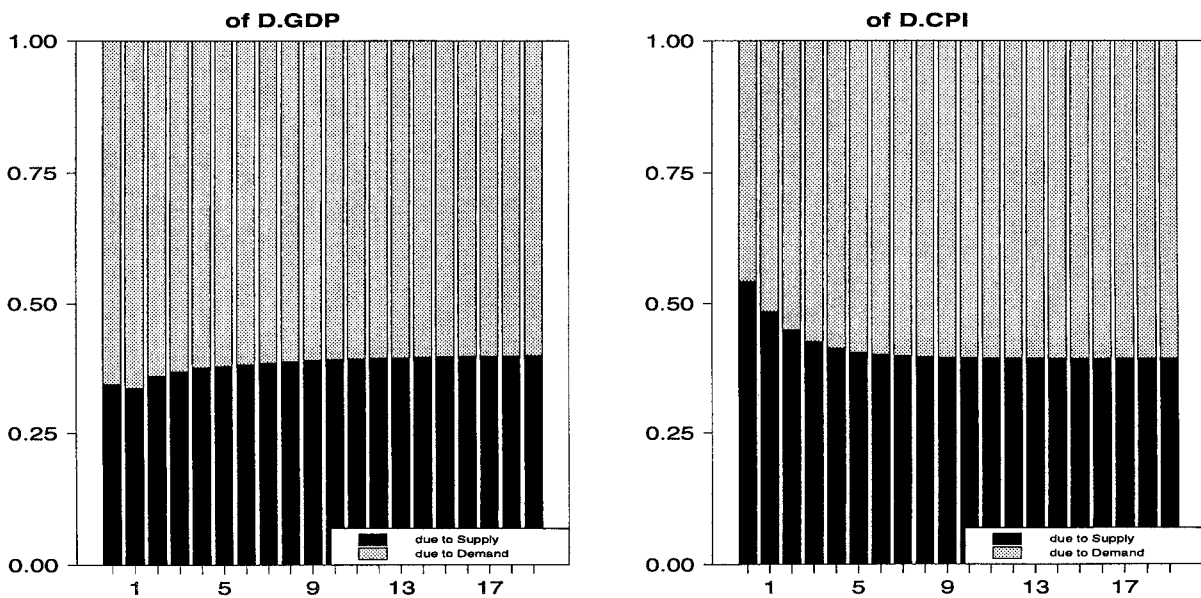*(VAR estim. with 3 lags, 1971:04 - 1996:04)*

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 15

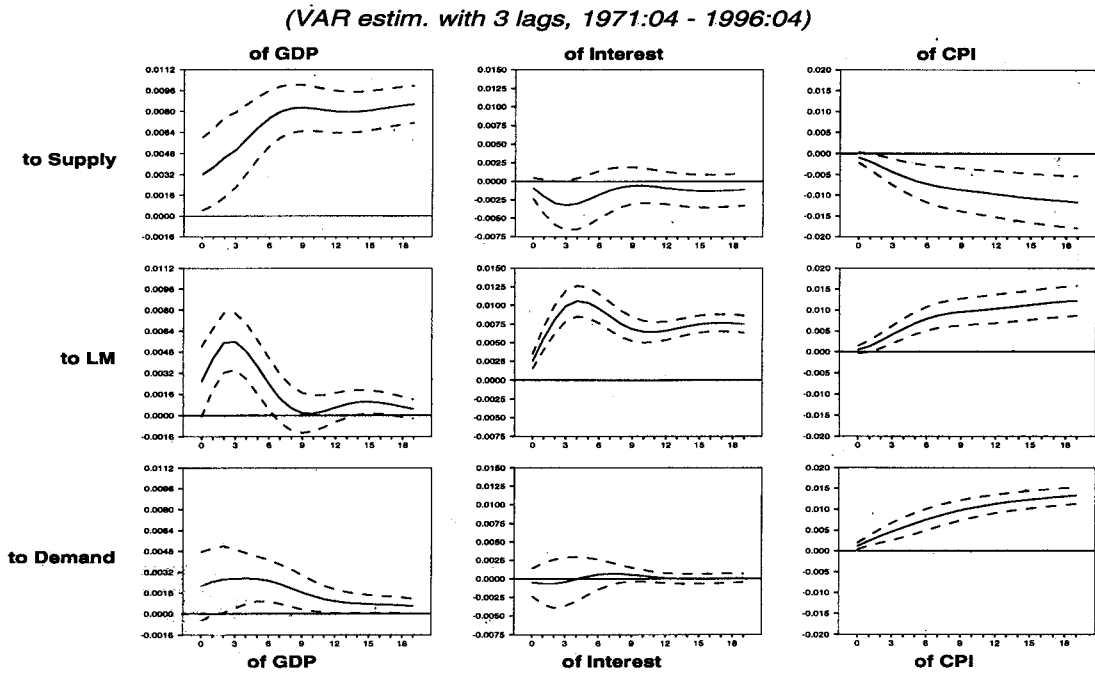**Variance decompositions (bivariate model) – Belgium**
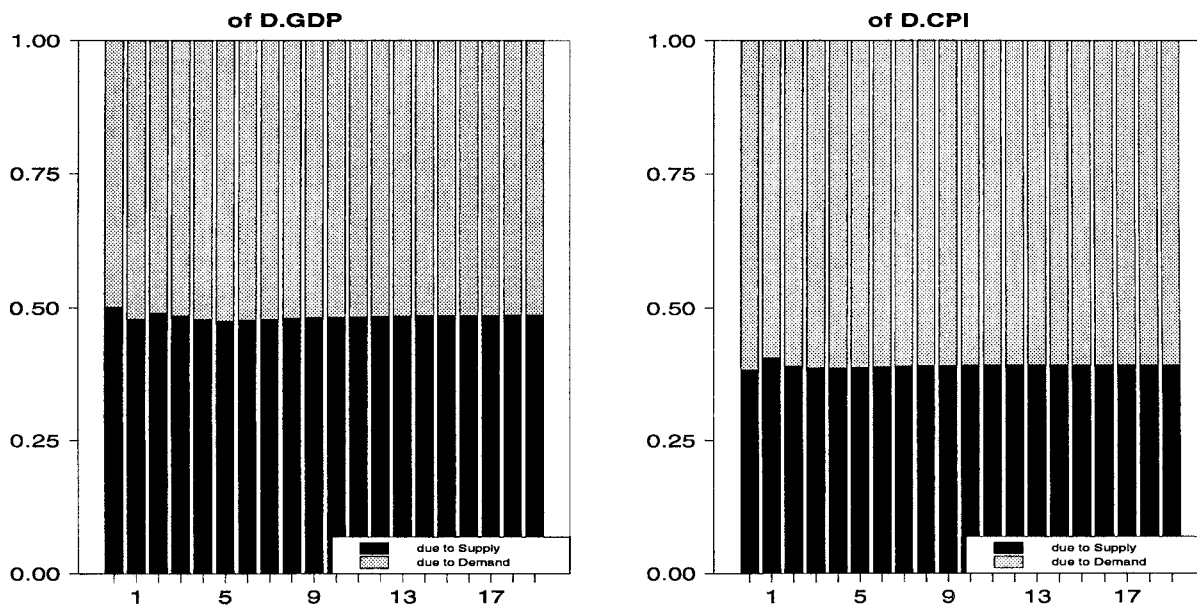
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 16

Impulse response functions (trivariate model) – Belgium
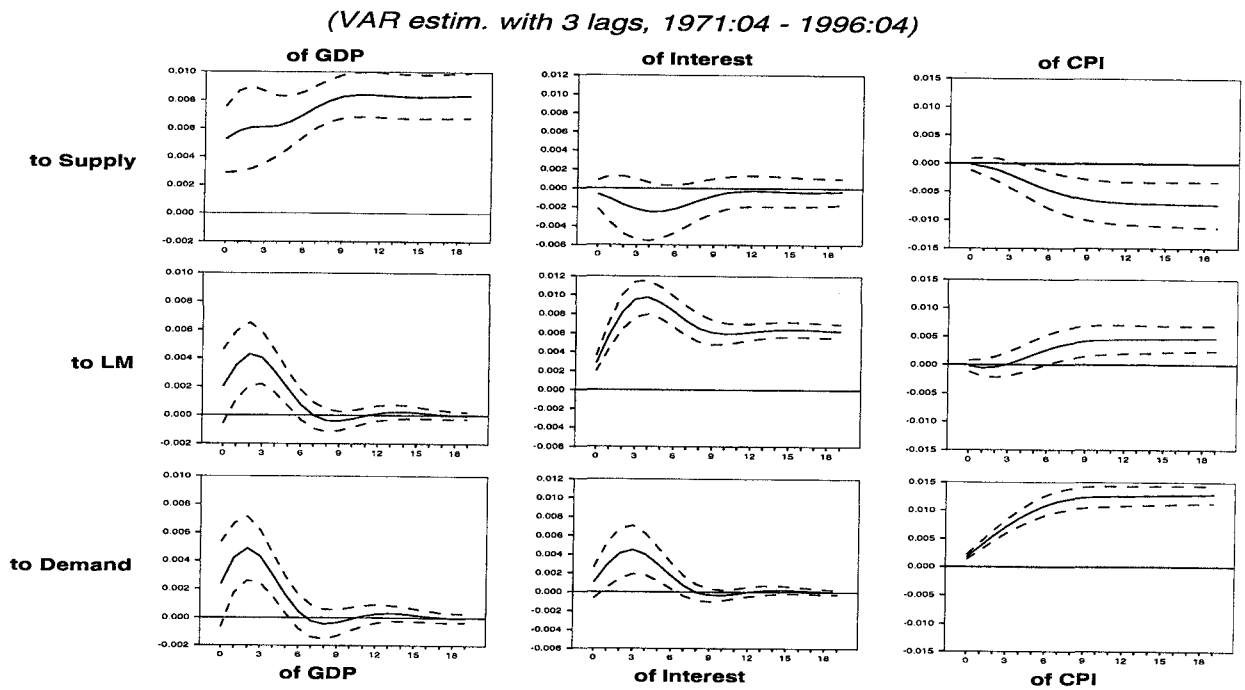
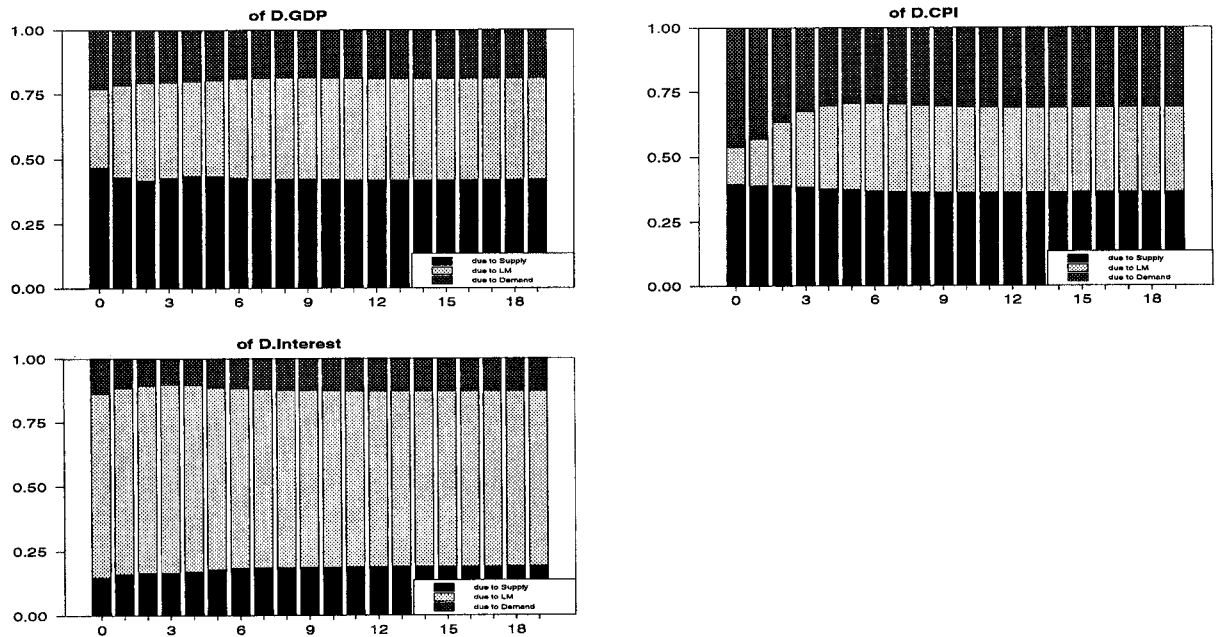*(VAR estim. with 3 lags, 1971:04 - 1996:04)*

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 17

Variance decompositions (trivariate model) – Belgium
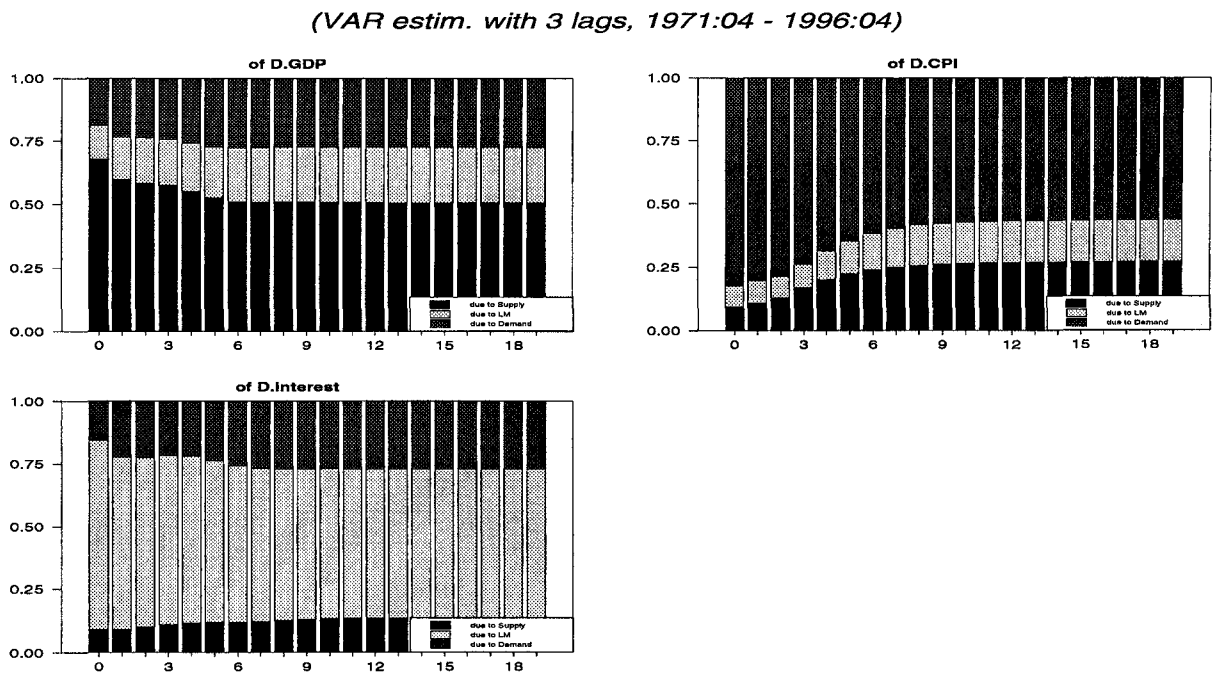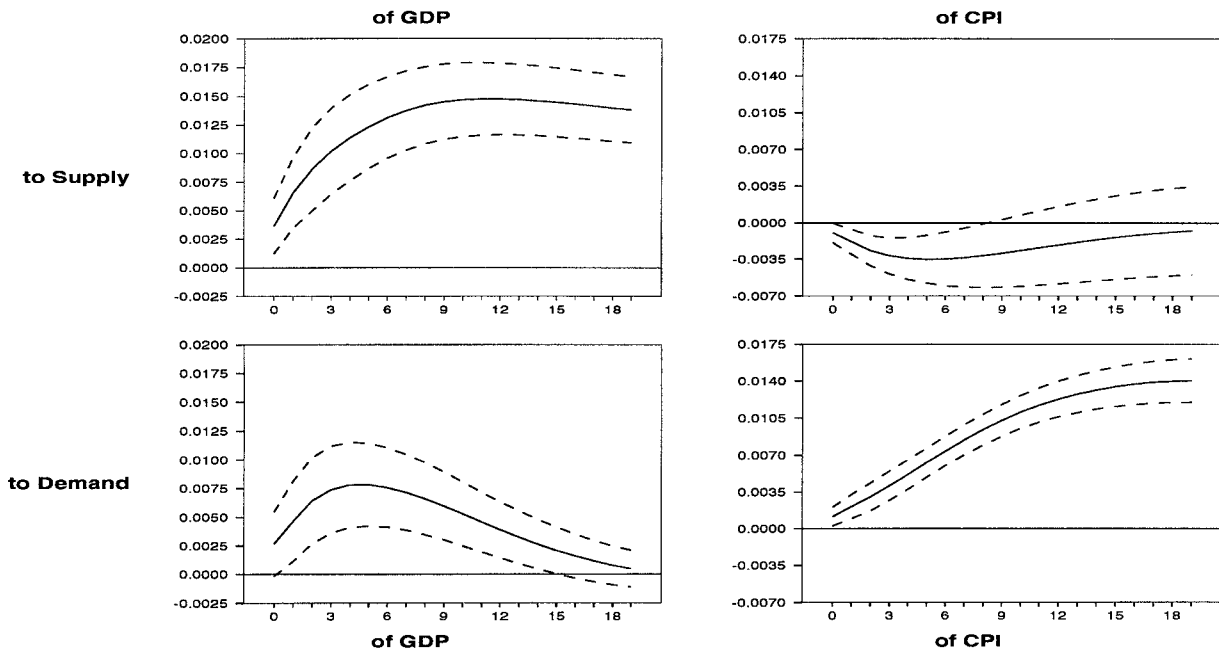
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 18

Impulse response functions (bivariate model) – Finland
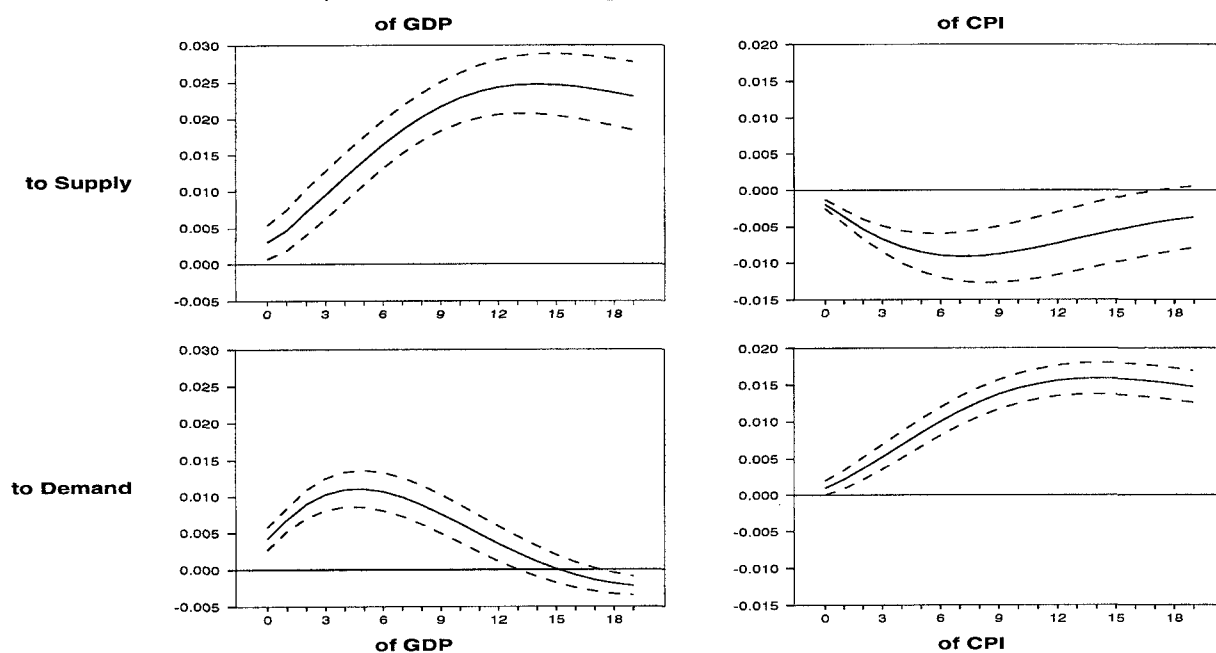
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 19

Variance decompositions (bivariate model) – Finland

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 20

Impulse response functions (trivariate model) – Finland

(VAR estim. with 3 lags, 1979:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 21

Variance decompositions (trivariate model) – Finland

(VAR estim. with 3 lags, 1979:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 22

Impulse response functions (bivariate model) – France

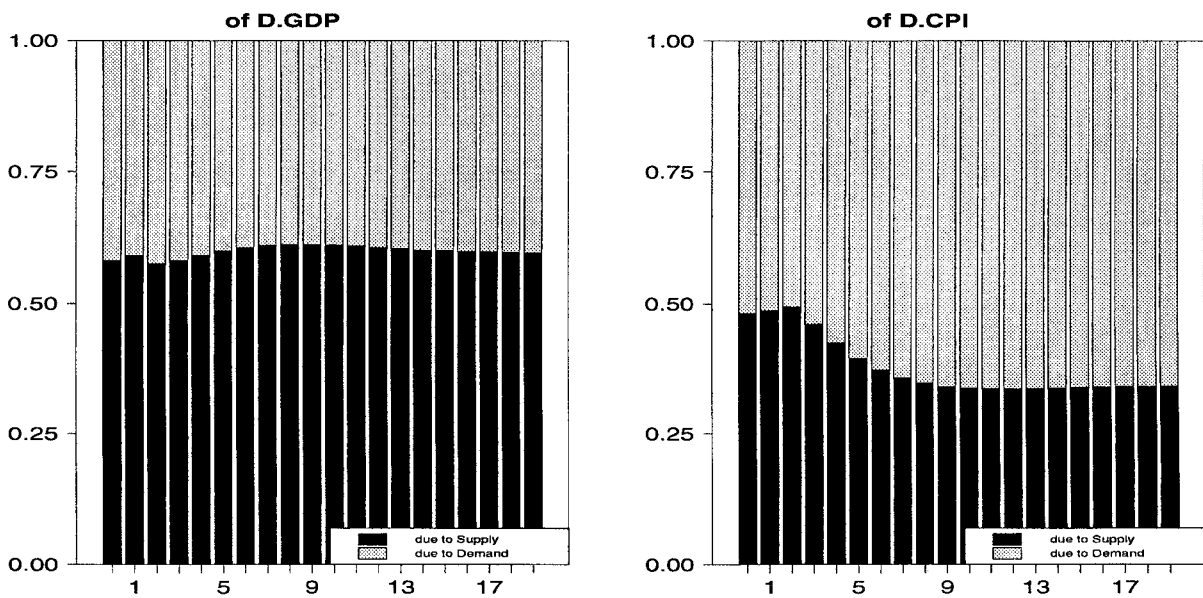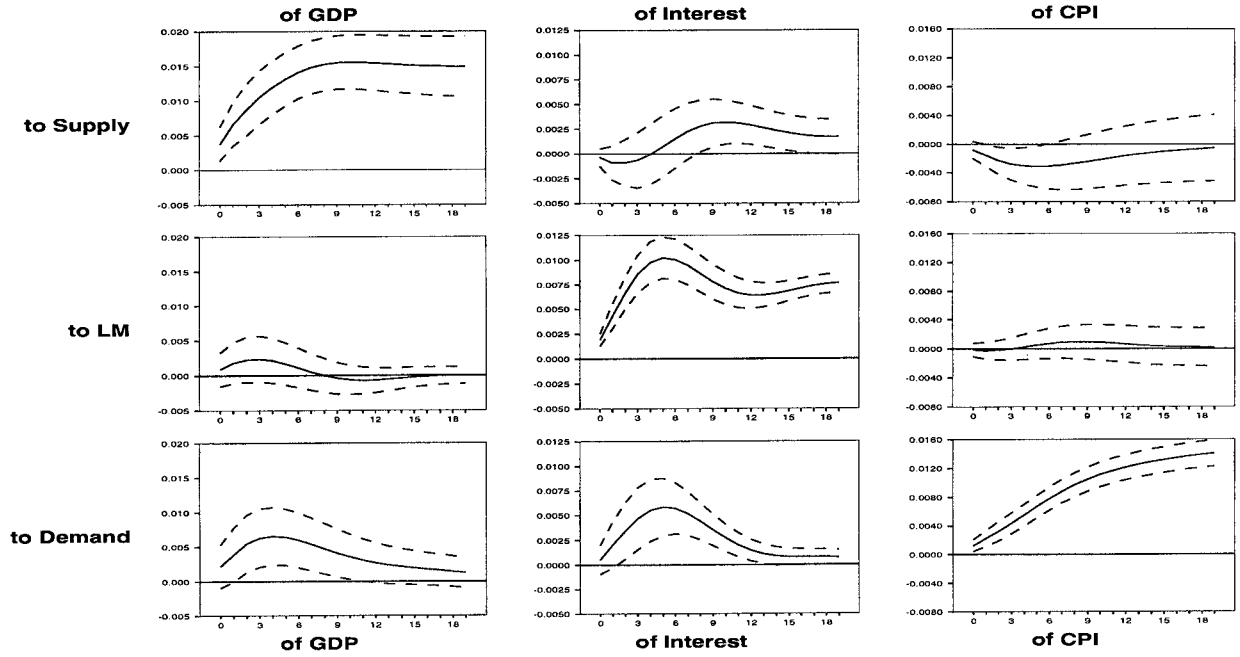*(VAR estim. with 3 lags, 1971:04 - 1996:04)*

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 23

Variance decompositions (bivariate model) – France

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 24

Impulse response functions (trivariate model) – France
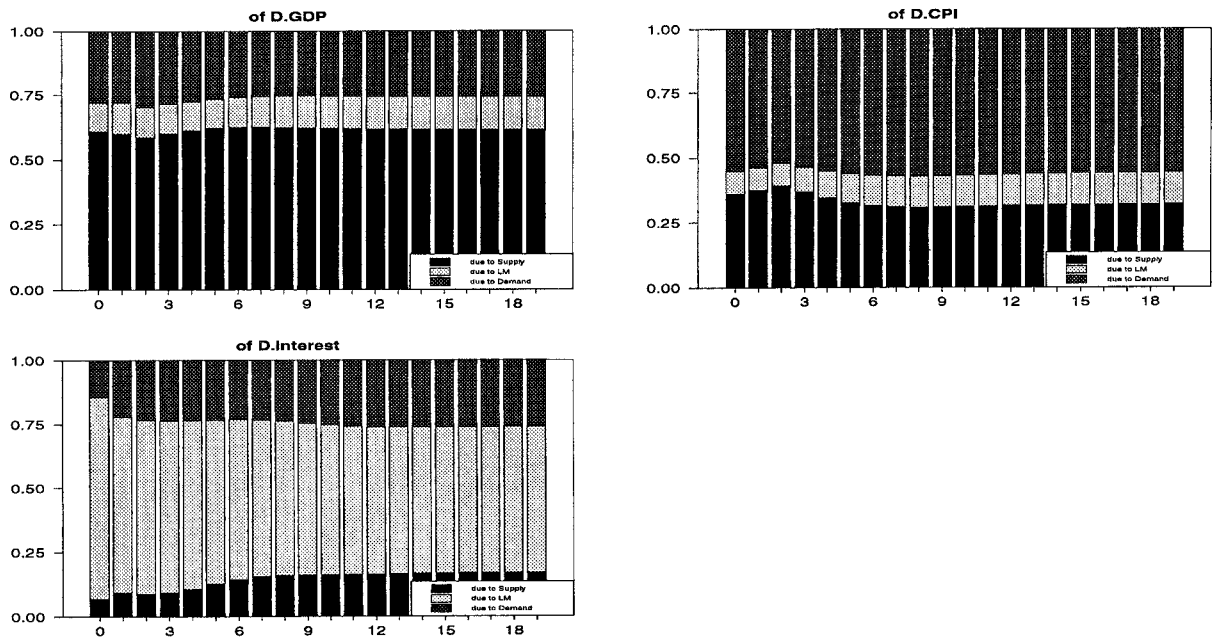
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 25

Variance decompositions (trivariate model) – France
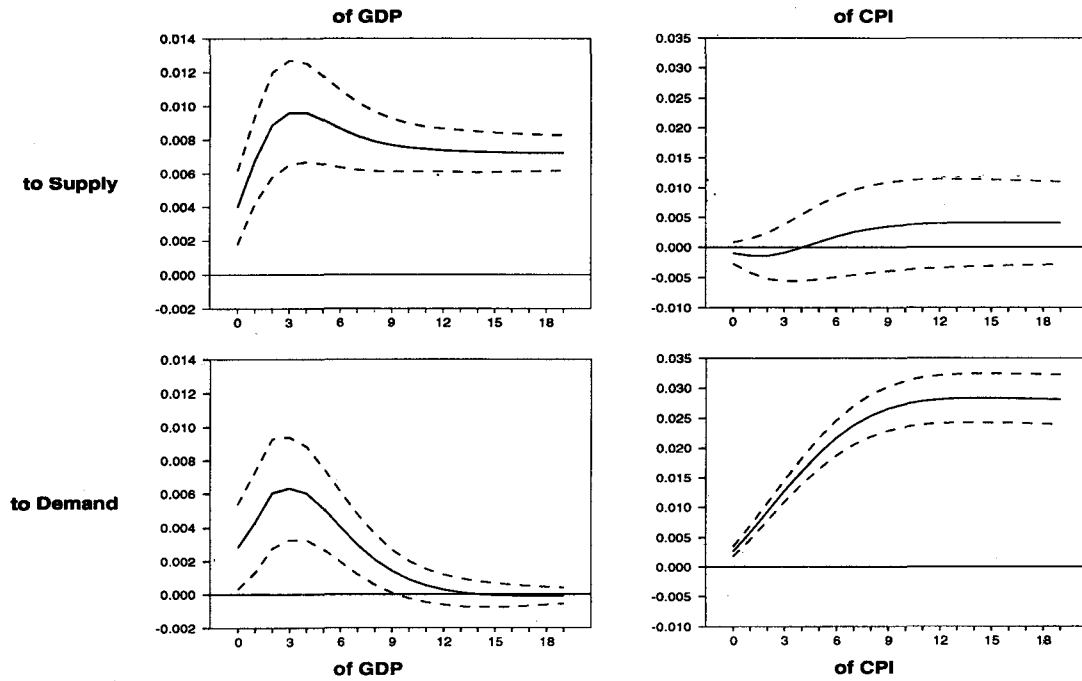
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 26

Impulse response functions (bivariate model) – Germany

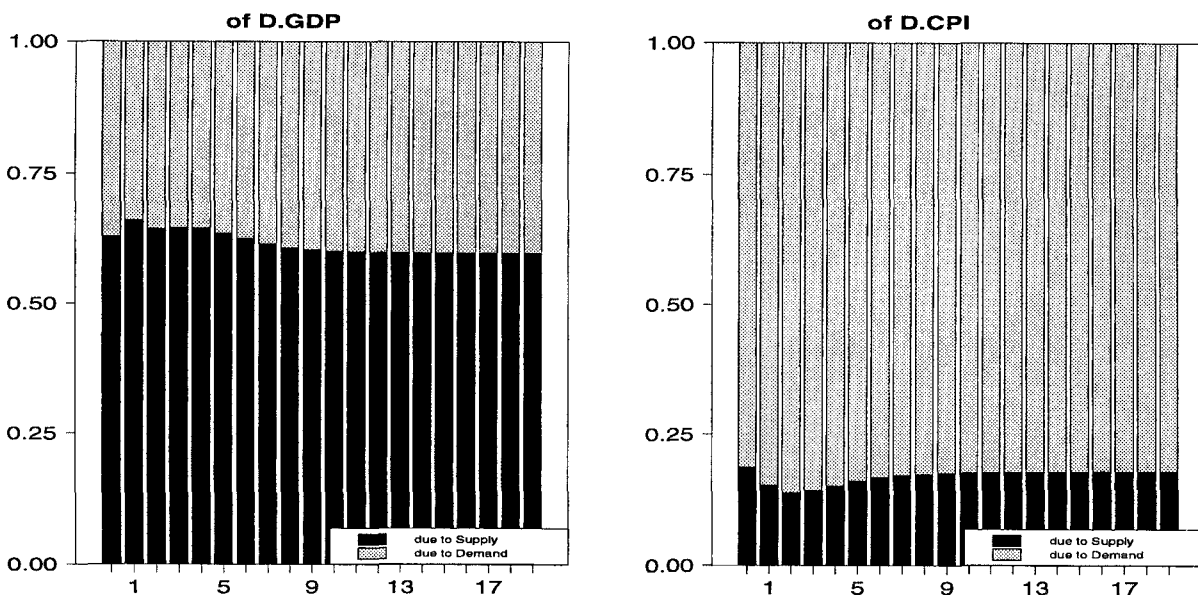*(VAR estim. with 3 lags, 1971:04 - 1996:04)*

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 27

Variance decompositions (bivariate model) – Germany

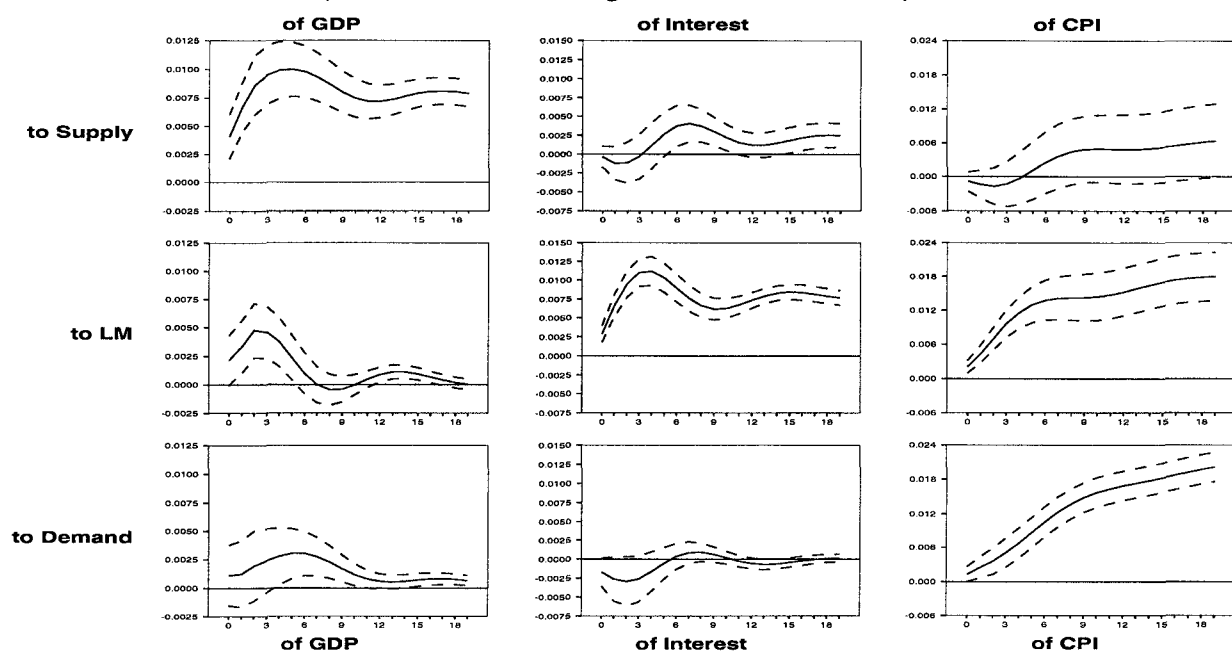*(VAR estim. with 3 lags, 1971:04 - 1996:04)*

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 28

Impulse response functions (trivariate model) – Germany

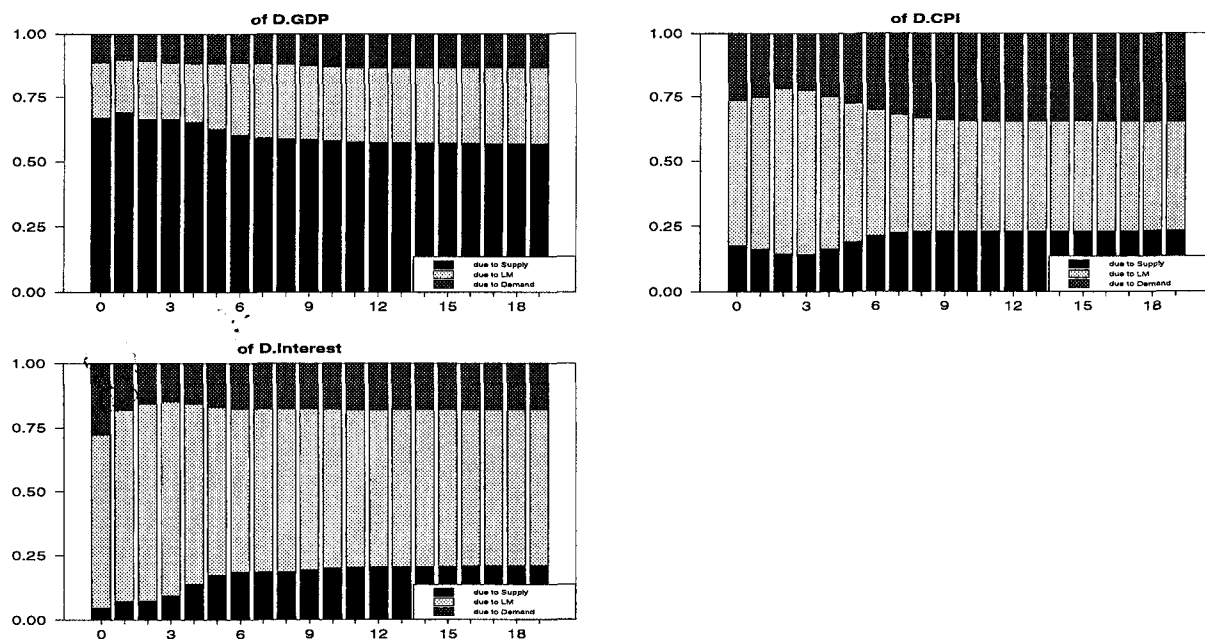### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 29

Variance decompositions (trivariate model) – Germany

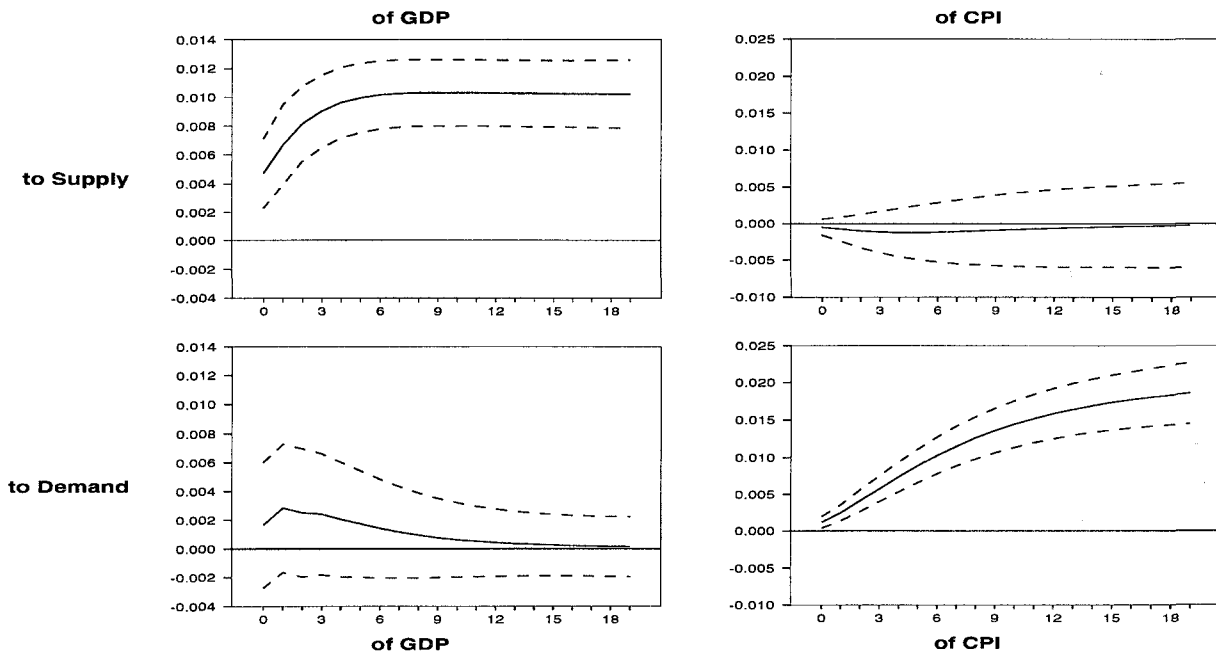### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 30

Impulse response functions (bivariate model) – Italy

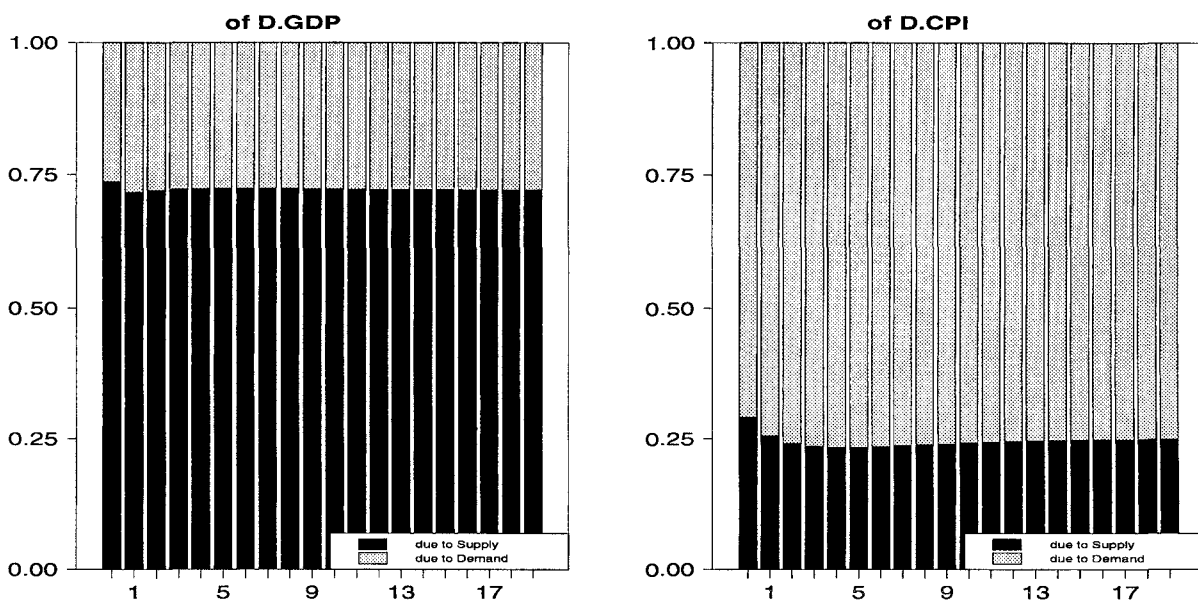### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 31

Variance decompositions (bivariate model) – Italy

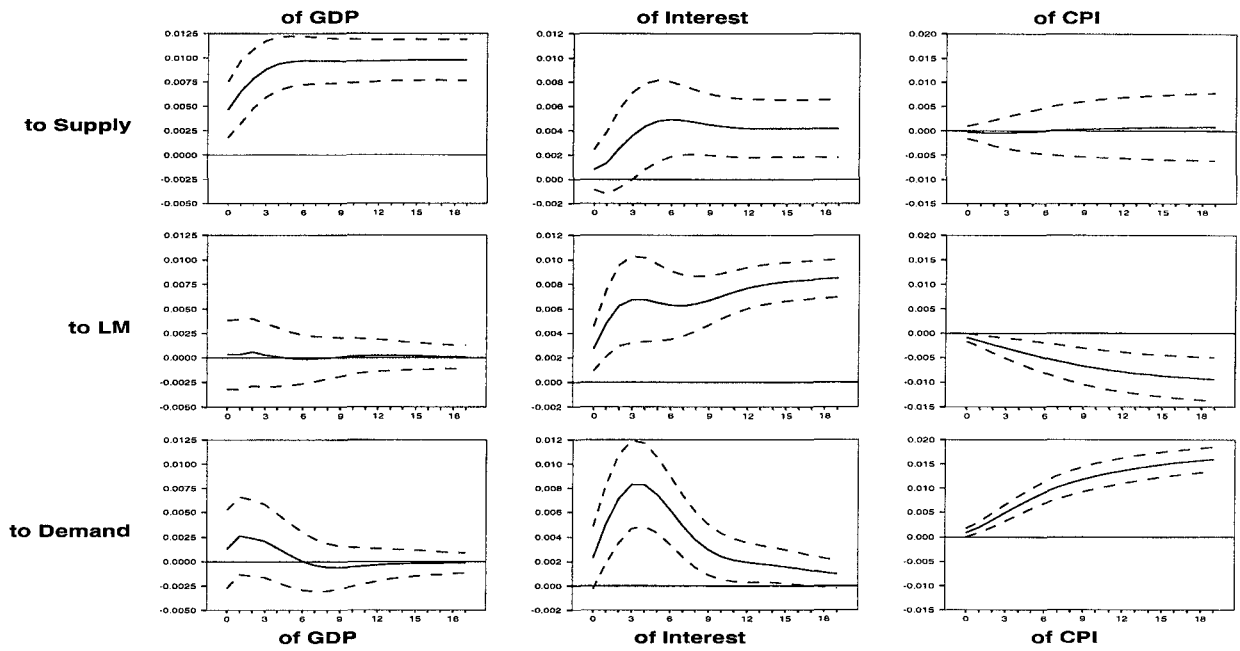### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 32

Impulse response functions (trivariate model) – Italy

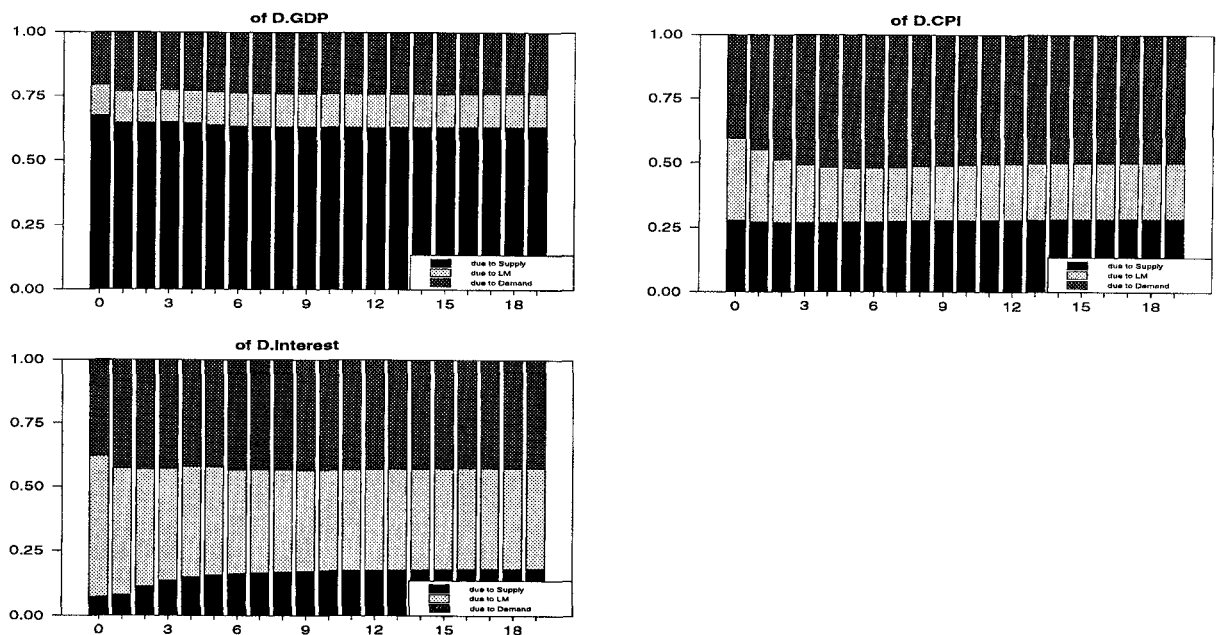### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 33

Variance decompositions (trivariate model) – Italy

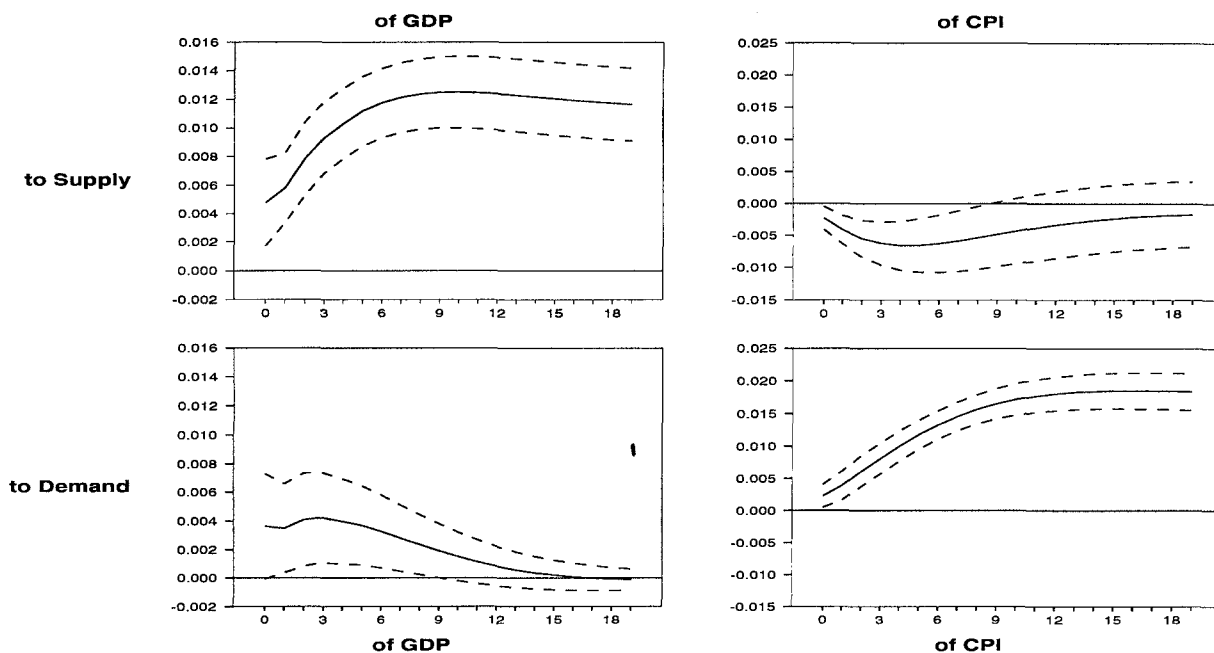### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 34

Impulse response functions (bivariate model) – Netherlands

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 35

Variance decompositions (bivariate model) – Netherlands

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

Figure 36

Impulse response functions (trivariate model) – Netherlands

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 37

Variance decompositions (trivariate model) – Netherlands

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 38

Impulse response functions (bivariate model) – Sweden

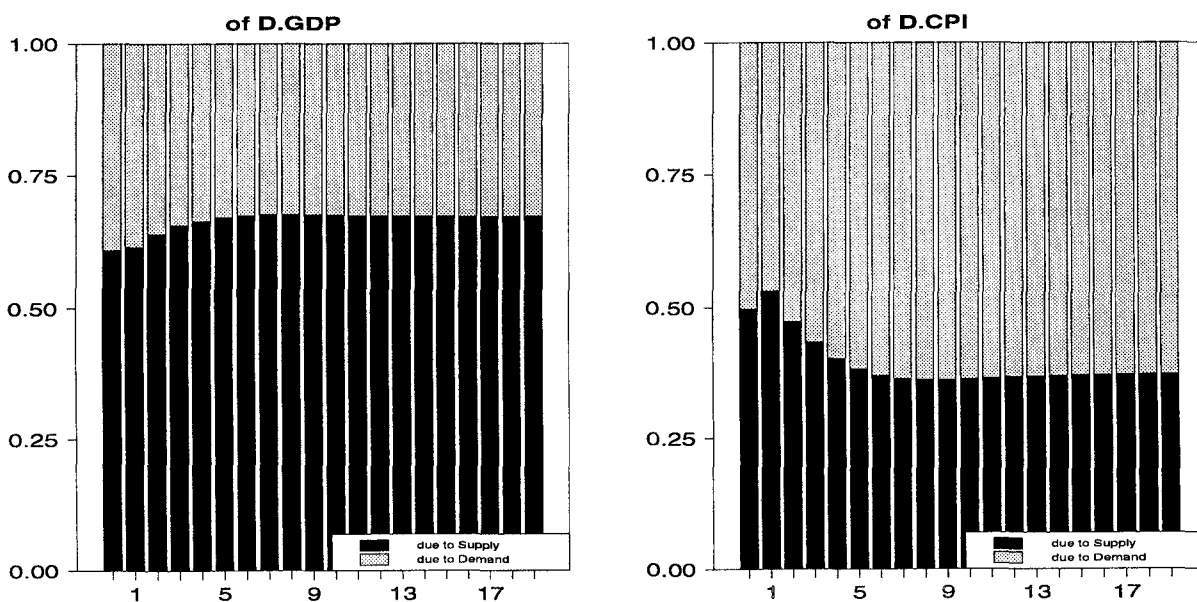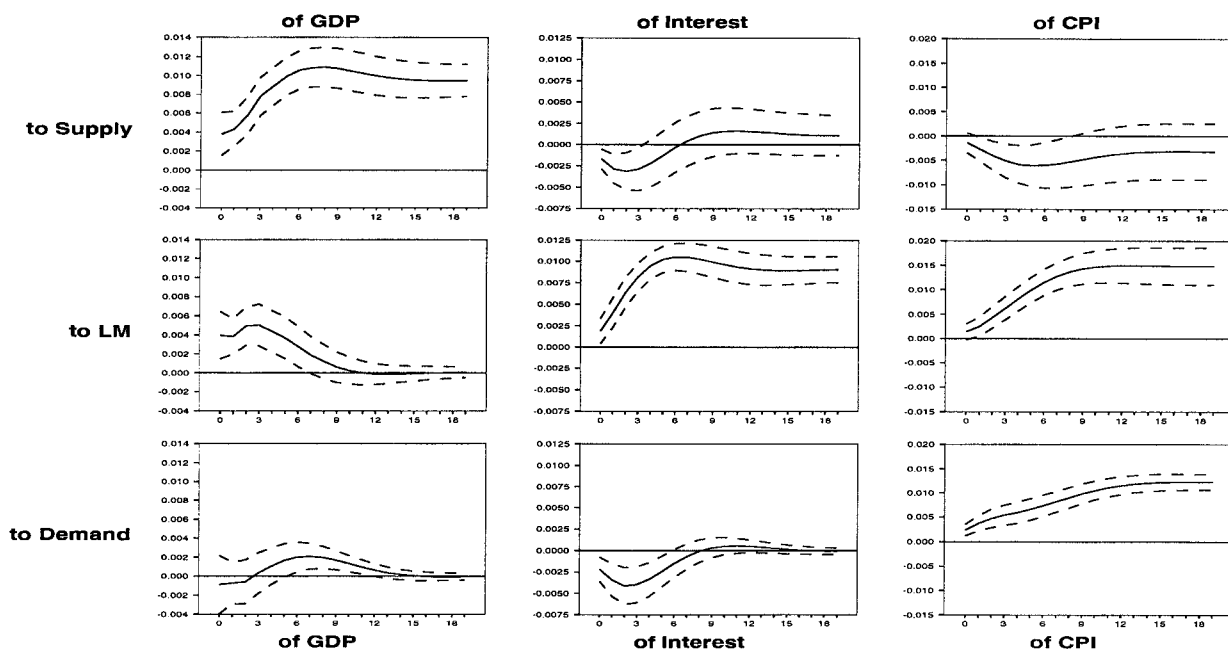### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 39

Variance decompositions (bivariate model) – Sweden

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 40

Impulse response functions (trivariate model) – Sweden

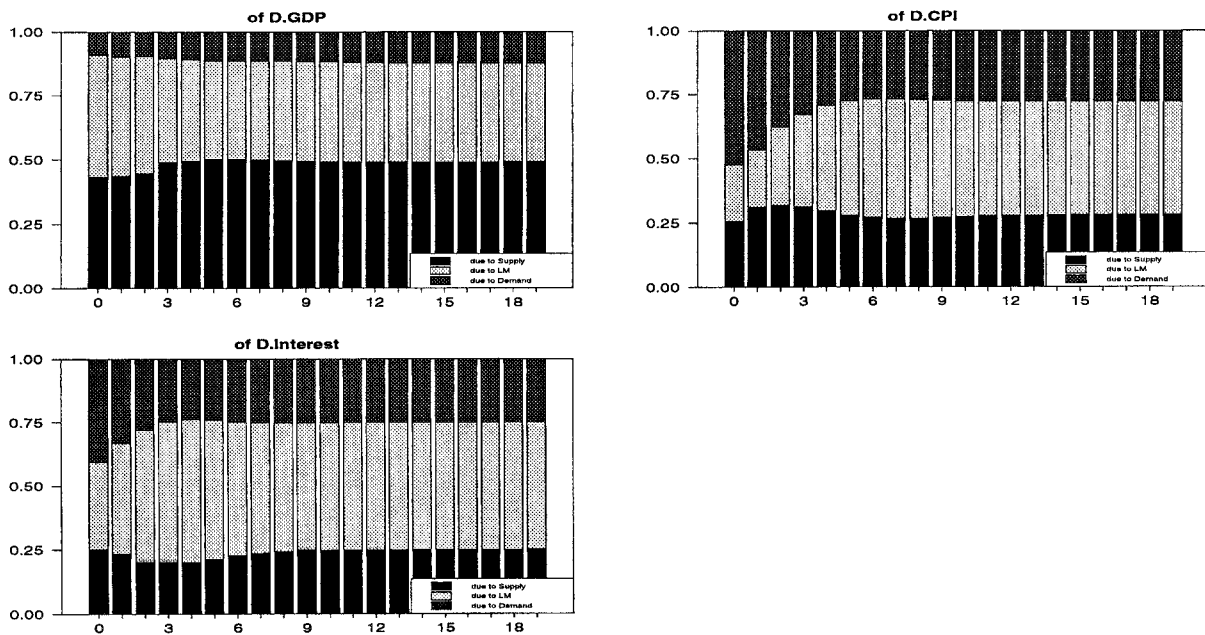### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 41

Variance decompositions (trivariate model) – Sweden
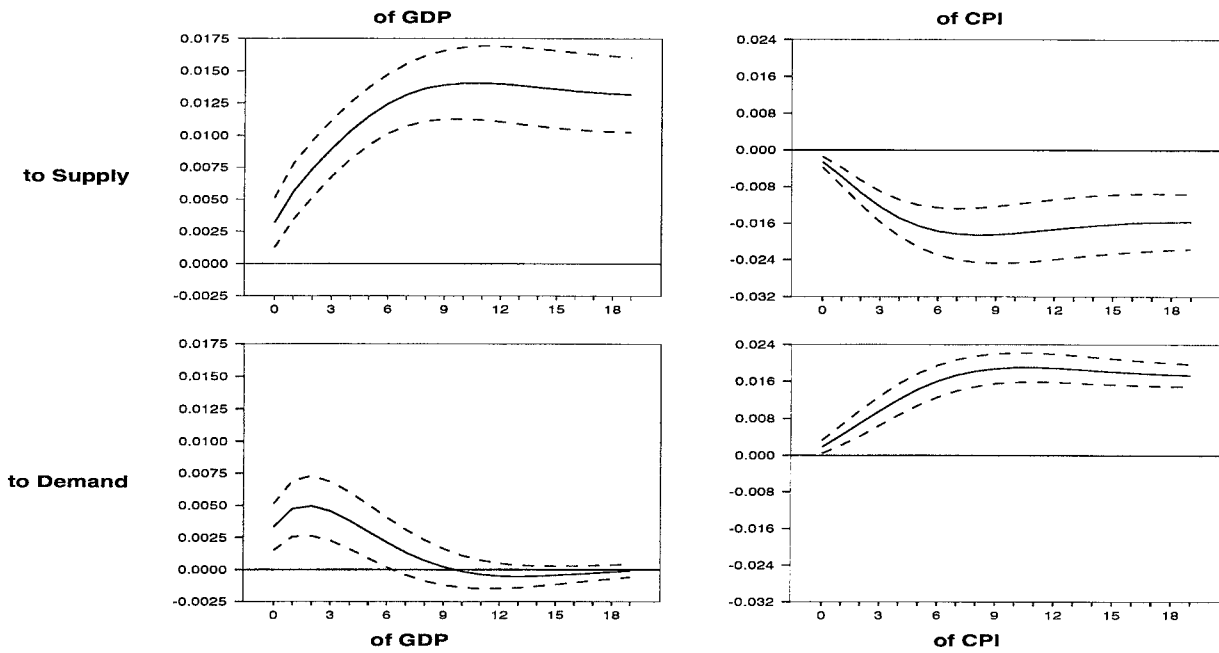
(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 42

Impulse response functions (bivariate model) – United Kingdom

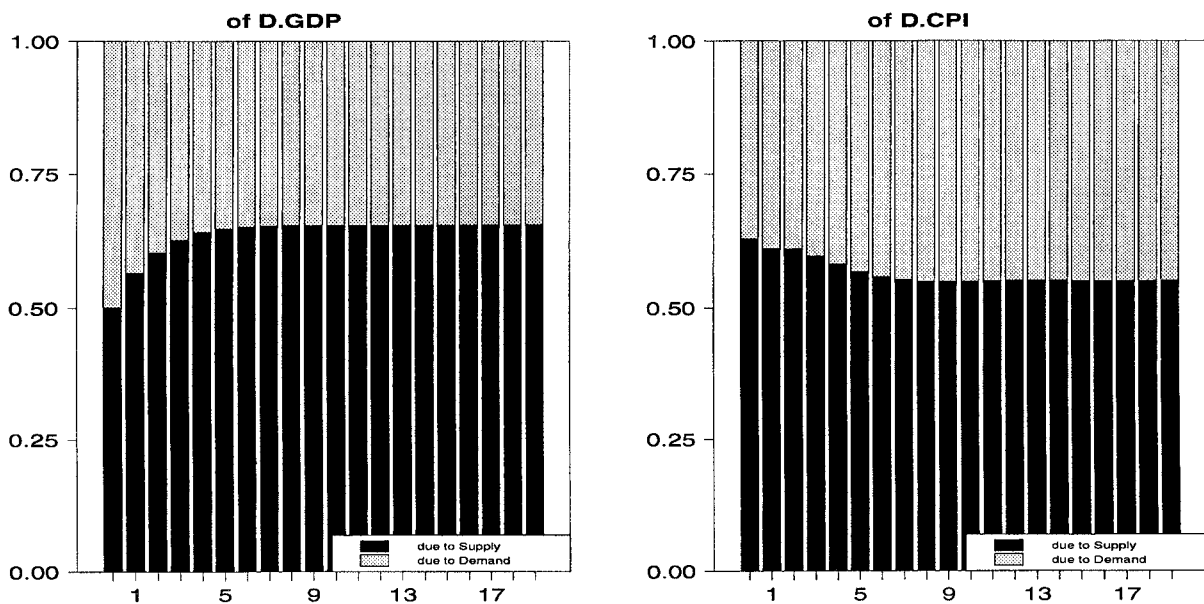### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 43

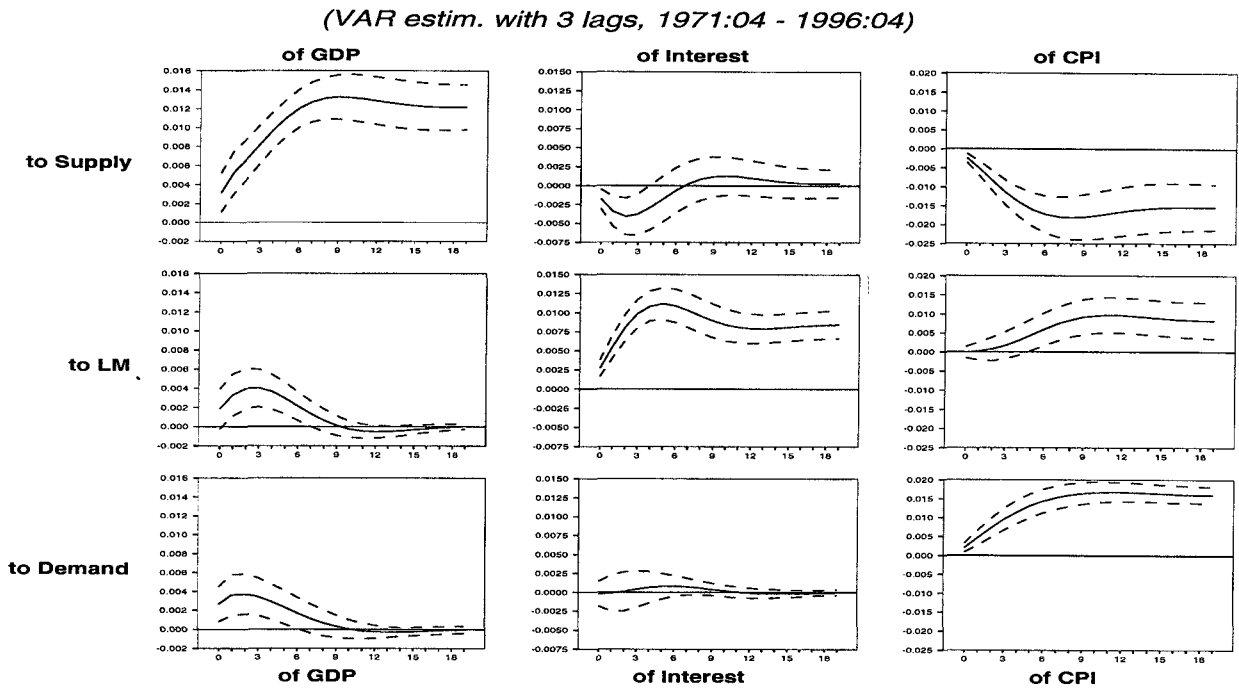## Variance decompositions (bivariate model) – United Kingdom

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the bivariate model (output and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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Figure 44

Impulse response functions (trivariate model) – United Kingdom

### (VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The solid lines indicate the estimated and accumulated response to the respective first period structural unit shock, dashed lines above and below are the upper and lower two standard deviation bounds computed from a simulation as described in Appendix A.

Figure 45

Variance decompositions (trivariate model) – United Kingdom

(VAR estim. with 3 lags, 1971:04 - 1996:04)

Note: Results are those of the trivariate model (output, interest rate and inflation). The heights of the respective bars indicate the relative contribution of a specific structural shock to the forecast error variance of the respective series.

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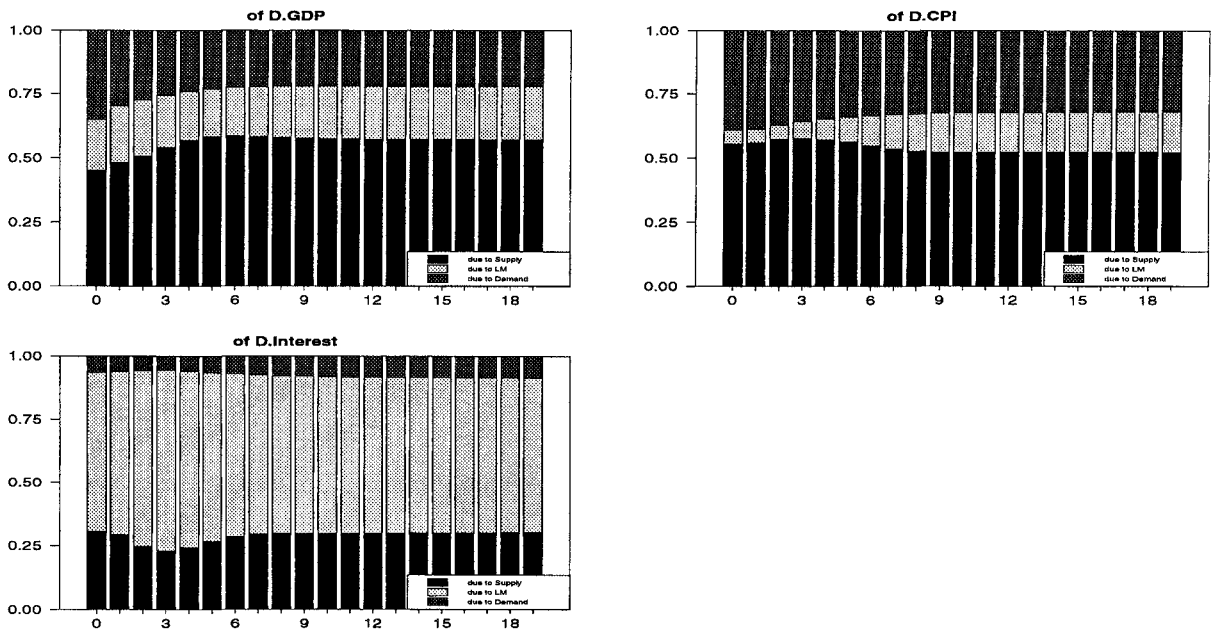
References

Akaike, H. (1973): "*Information theory and an extension of the maximum likelihood principle*", in B. Petrov and F. Csake (eds.), Second International Symposium on Information Theory, Budapest.

Bank of England (1994): *Inflation Report*, February.

Bernanke, Ben S. (1986): "*Alternative explanations of the money-income correlation*". Carnegie-Rochester Conference Series on Public Policy, Vol. 25, pp. 49-100.

Bernanke, Ben S., Mark Gertler and Mark Watson (1997): *Systematic monetary policy and the effects of oil price shocks*. Brookings Papers on Economic Activity 1.

Blanchard, Olivier J. and Danny Quah (1989): "*The dynamic effects of aggregate demand and supply disturbances*". American Economic Review, Vol. 79 (September), pp. 655-73.

Blix, Mårten (1995): "*Underlying inflation - a common trends approach*". Sveriges Riksbank Arbetsrapport, Nr. 23, Stockholm.

Bjørnland, Hilde Ch. (1997): "*Estimating core inflation - the role of oil price shocks and imported inflation*". Statistics Norway, Research Department Discussion Paper No. 200, Oslo.

Bryan, Michael F. and Stephen G. Cecchetti (1994): "*Measuring core inflation*", in N. G. Mankiw (ed.), Monetary Policy, Chicago, pp. 95-215.

Bryan, Michael F., Stephen G. Cecchetti and Rodney L. Wiggins II (1997): "*Efficient inflation estimation*". NBER Working Paper, No. 6183, Cambridge, MA.

Cecchetti, Stephen G. (1996): "*Measuring short-run inflation for central bankers*". Paper presented at the 21st Economic Policy Conference, Federal Reserve Bank of St. Louis, mimeo, October.

Debelle, Guy (1997): "*Inflation targeting in practice*". IMF Working Paper, No. 35, Washington, D.C.

Debelle, Guy and Douglas Laxton (1997): "*Is the Phillips curve really a curve? Some evidence for Canada, the United Kingdom and the United States*". IMF-Staff Papers, No. 44 (2), pp. 249-82.

Dewachter, Hans and Hanno Lustig (1997): "*A cross-country comparison of CPI as a measure of inflation*". Centre for Economic Studies Discussion Paper DPS 97/06, Leuven.

Dickey, D. A. and Wayne A. Fuller (1979): "*Distribution of the estimators for autoregressive time series with a unit root*". Journal of the American Statistical Association, 74, pp. 427-31.

Dickey, D. A. and Wayne A. Fuller (1981): "*Likelihood ratio statistics for autoregressive time series with a unit root*". Econometrica, 49, pp. 1057-72.

Doan, Thomas A. (1992): "*RATS - Regression Analysis of Time Series*", Version 4.0. Evanston (Ill.), Estima.

Eckstein, Otto (1981): "*Core inflation*". Englewood Cliffs, N. J.

Engle, Robert F. and C. W. J. Granger (1987): "*Co-integration and error correction: representation, estimation, and testing*". Econometrica, 55 (2), pp. 251-76.

European Monetary Institute (1995): "*The role of underlying inflation in the framework for monetary policy in EU countries*". Background Study, mimeo, Frankfurt a.M., October.

European Monetary Institute (1996): "*Common underlying inflation indicators: a proposal*". Mimeo, Frankfurt a.M., February.

European Monetary Institute (1996): "*Common underlying inflation indicators: guidelines for data submissions*". Background Study, mimeo, Frankfurt a.M., March.

Fase, Martin M. G. and Carsten K. Folkertsma (1997): "*Measuring inflation: an attempt to operationalize Carl Menger's concept of the inner value of money*". De Nederlandsche Bank Staff Report 8/97, Amsterdam.

Fluch, Manfred and Christine Gartner (1997): "*Measures of core/underlying inflation applied to the Austrian CPI*". Oesterreichische Nationalbank, mimeo, Vienna.

Gartner, Christine (1995): "*The Austrian economy: an overview*". De Pecunia Vol. VII (1), pp. 83-116.

Haldane, Andrew (1995a): "*Inflation targets*". Bank of England Bulletin, London.

Haldane, Andrew (1995b): "*Targeting inflation: a conference of Central Banks on the use of inflation targets organised by the Bank of England*". Bank of England Bulletin, London.

Hamilton, James D. (1994): "*Time series analysis*". Princeton, N.J.

Hannan and Quinn (1979): "*The determination of the order of an autoregression*". Journal of the Royal Statistical Society B41, pp. 190-5.

Hansen, Gerd and Kim Jeong-Ryeol (1996): "*Money and inflation in Germany: a cointegration analysis*". Empirical Economics, 21, pp. 601-16.

Hochreiter, Eduard and Georg Winckler (1995): "*The advantages of tying Austria's hands: the success of the hard currency strategy*". European Journal of Political Economy, 11(1), pp. 83-111.

Hylleberg, S., R. F. Engle, C. W. Granger and B. S. Yoo (1990): "*Seasonal Integration and Cointegration*". Journal of Econometrics, 44, pp. 215-38.

Jacquinot, Pascal (1998): "*L'inflation sous-jacente a partir d'une approche structurelle des VAR: une application a la France, l'Allemagne et au Royaume-Uni*". Banque de France, Paris, Note d'études et de recherche, No. 51.

Johansen, Søren (1991): "*Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models*". Econometrica, 59, pp. 1551-80.

Judge, George G., William E. Griffiths, R. Carter Hill, Helmut Lütkepohl and Lee Tsoung-Chao (1985): "*The theory and practice of econometrics*". Second Edition, New York et al.

Judge, George G., William E. Griffiths, R. Carter Hill, Helmut Lütkepohl and Lee Tsoung-Chao (1988): "*Introduction to the theory and practice of econometrics*". Second Edition, New York et al.

Leiderman, Leonardo and Lars E. O. Svensson (eds.) (1995): "*Inflation targets*". London.

Lütkepohl, Helmut (1993): "*Introduction to multiple time series analysis*". Second Edition, Berlin et al.

Mélitz, Jacques and Axel A. Weber (1996): "*The costs/benefits of a common monetary policy in France and Germany and possible lessons for monetary union*". Centre for Economic Policy Research (CEPR), Discussion Paper, No. 1374, London.

Parkin, Michael (1984): "*On core inflation by Otto Eckstein - a review essay*". Journal of Monetary Economics, 14, pp. 251-64.

Perron, Pierre (1988): "*Trends and random walks in macroeconomic time series, further evidence from a new approach*". Journal of Economic Dynamics and Control, 12, pp. 297-332.

Phillips, Peter C. B. and Pierre Perron (1988): "*Testing for a unit root in time series regression*". Biometrika, 75, pp. 335-46.

Quah, Danny and Shaun P. Vahey (1995): "*Measuring core inflation*". The Economic Journal, pp. 1130-44, September.

Shapiro, Matthew D. and Mark W. Watson (1988): "*Sources of Business Cycle Fluctuations*". NBER Macroeconomics Annual, Cambridge, MA, et al., pp. 111-48.

Shiratsuka, Shigenori (1997): "*Inflation measures for monetary policy: measuring underlying inflation trend and its implication for monetary policy implementation*". Bank of Japan, Institute for Monetary and Economic Studies Discussion Paper, No. 97-E-7, Tokio.

Soejima, Yutaka (1996): "*The long-run relationship between real GDP, money supply and price level: unit root and cointegration tests with structural changes*". Monetary and Economic Studies, pp. 23-52, September.

Spolander, M. (1994): "*The indicator of underlying inflation: basic idea and use*". Bank of Finland, Discussion Paper, No. 24/94, Helsinki.

Vlaar, Peter J. G. (1997): "*On the asymptotic distribution of impulse response functions with long run restrictions*". Working paper, Amsterdam (mimeo, De Nederlandsche Bank).

Wynne, Mark (1998): "*Background paper on the measurement of core inflation*". Working paper, Frankfurt (mimeo, European Monetary Institute).