How Synchronized are New EU Member States with the Euro Area? Evidence from a Structural Factor Model

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Abstract:

A high degree of cyclical synchronization between the new EU member states (NMS) from Central and Eastern Europe and the euro area is generally seen as a prerequisite for successful EMU enlargement. We establish stylized facts on economic linkages between NMS and the euro area using dynamic correlation and cohesion measures. We then identify the main structural common euro-area shocks and investigate their transmission to NMS by means of a large-scale factor model. We compare it to the propagation to current EMU members.

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1. Introduction

In May 2004, eight central and east European countries (and Malta and Cyprus) became new member states (NMS) of the European Union: the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovenia and Slovakia. These countries will all join European Monetary Union (EMU) as soon as they satisfy the Maastricht convergence criteria. Those stress the importance of long-run convergence of accession countries and members of the monetary union and include a high degree of price stability, a sound fiscal situation, stable exchange rates and converged long-term interest rates. The successful enlargement of EMU also requires a number of other, optimum currency area (OCA), criteria to be satisfied which are partly reflected by the Maastricht criteria. The OCA criteria go back to Mundell (1961), MacKinnon (1963) and Kenen (1969), among others. They require member states of a monetary union to have some common characteristics. One of these is a sufficient degree of business cycle synchronization. If business cycles are not synchronized, possibly as a result of asymmetric shocks or differences in the transmission of common shocks due to differences in economic structures and policies, forming a monetary union could be very costly. A common monetary policy whose task is to monitor aggregate inflation and output may create conflicts across countries about the preferred conduct of monetary policy. Giving up their national monetary policy instruments means that new members could potentially loose an important stabilization tool for responding to asymmetric shocks or to an asymmetric transmission of common shocks. Other adjustment mechanisms such as factor mobility, fiscal policy and nominal flexibility may be able to fill the gap.[1] If this is not the case and if the costs outweigh the benefits of forming a monetary union (i.e. reduction in transaction costs and uncertainty, more transparency in the price determination mechanisms), EMU enlargement may be premature. Therefore it is of interest to study synchronicity between NMS and the euro area as an important prerequisite for EMU. Nevertheless, when deciding about enlargement of EMU, it should also be taken into account that business cycle comovements are, like other OCA criteria, endogenous (cf. Frankel and Rose, 1998). Trade and the integration of financial markets will normally be enhanced in a monetary union. Although theoretically not clear (cf.

Kose, Prasad and Terrones, 2003), the impact of trade and financial integration on business cycle synchronization was shown to be positive in empirical studies (cf. von Hagen and Traistaru (2005) for NMS and Otto, Voss and Willard (2001), Kose, Otrok and Whiteman (2003), Baxter and Kouparitsas (2005) as well as Imbs (2004) for industrial and other countries). Moreover, business cycle linkages should strengthen after forming a monetary union when exchange rates previously did not act as shock absorbers, but were themselves sources of macroeconomic destabilization. Empirical findings by Borghijs and Kuijs (2004), for example, suggest that the latter holds for the NMS.

The present paper addresses the current discussion on whether the NMS are ready to join EMU by examining more closely the synchronization between economies of the eastern and central European NMS and the euro area since 1993. We first establish stylized facts on economic linkages in the euro area and between the euro area and the NMS and on their determinants. The latter are approximated with a similarity in industry specialization and trade and foreign direct investment (FDI) intensity measures. The former is examined by means of bilateral dynamic correlations and their multivariate extension, termed cohesion, both measures being based on Croux, Forni and Reichlin (2001). We then employ a large-scale structural dynamic factor model, developed by Giannone, Reichlin and Sala (2002), to investigate how important shocks to the euro-area business cycle are for NMS in comparison to the current EMU members and how they proliferate to these countries. As a byproduct, we determine the number of macroeconomic shocks which were common to all EMU countries and which explained a significant share of the overall variance during the underlying period, and identify them. This is particularly interesting for the period considered here where there was controversy about the determinants of macroeconomic developments.

Our paper is related to the burgeoning empirical literature on business cycle synchronization between the NMS and the euro area. A comprehensive survey is given by Fidrmuc and Korhonen (2004b). Most studies compute static correlations between real economic activity in the NMS and the euro area or Germany (cf. Darvas and Szapáry, 2005, Demanyk and Volosovych, 2005, von Hagen and Traistaru, 2005). Artis, Marcellino and Proietti (2005), in addition, use concordance measures to investigate whether business cycles of NMS are in or out of phase with business cycles of other NMS and of euro-area countries. Another bulk of the literature estimates supply and demand shocks in the euro area and in individual NMS by means of small-scale VAR models and assess their correlations (Frenkel and Nickel, 2005, Fidrmuc and Korhonen, 2004a). Barrell and Holland (2004) focus on the correlation of shocks estimated with the large macro model NIGEM. A third strand investigates the transmission of euro-area shocks in a VAR modeling framework (Korhonen, 2003, Darvas and Szapáry, 2005) and with single equation models (Boone and Maurel, 1999). We contribute to the first and the third strands of this literature.

Our paper is also related to other applications of large-scale structural dynamic factor models which have become popular in recent years (see, for example, Giannone, Reichlin and Sala (2002, 2004), Sala (2003), Cimadomo (2004) for monetary policy applications and Eickmeier (2004) for an international business cycle application).[2] We go beyond the literature in various respects.

First, economic linkages between NMS and the euro area have, to our knowledge, not been investigated with dynamic correlations and cohesion before. These measures account not only for contemporaneous covariances, but also for covariances at leads and lags.

Second, our study is the first to examine the transmission of euro-area shocks to the NMS in a large-dimensional structural factor framework. Performing macroeconomic analysis in general and studying international business cycles in such a framework has various advantages over VAR models or structural models which are more frequently used in this context. Much information can be exploited in dynamic factor models which should allow us to estimate the common driving forces and their propagation more precisely. This may play a particularly important role here, where macroeconomic time series of NMS are available only for a short time span. A large cross-dimension can partly mitigate this drawback.[3] VAR modelers, by contrast, rapidly run into scarce degrees of freedom problems.[4] It is also advantageous that we can remain agnostic about the structure of the economy and do not need to rely on overly tight restrictions as is sometimes the case in structural models.

Third, we assess the transmission of three structural euro-area shocks, a supply shock, a demand shock and a monetary policy shock, thereby extending the studies by Darvas and Szapáry (2005), Korhonen (2003) and Boone and Maurel (1999) who focus on shocks to European (or German) real economic activity which, however, have no structural interpretation.

This paper is organized as follows. Section 2 describes the data. Section 3 establishes stylized facts on economic correlations and their determinants. Section 4 outlines the factor model and describes the estimation and the identification of the common structural euro-area shocks. Section 4 also characterizes the shocks. Section 5 assesses the transmission to the NMS. Section 6 concludes.

2. Data

Our data set contains 41 aggregate euro-area macroeconomic time series, 19 or 20 key macro variables of each of the core euro-area countries (Austria, Belgium, France, Germany, Italy, Netherlands, Spain), real GDP, consumer prices, short-term interest rates and exchange rates for the remaining euro-area economies (Finland, Greece, Ireland, Luxembourg, Portugal) and for the eight central and east European NMS (Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovenia, Slovakia). In addition, we include some variables capturing global influences, among them US GDP and world energy prices. The aggregate euro-area series are taken from the data set underlying the ECB's Area Wide Model (AWM; for a detailed description see Fagan, Henry and Mestre, 2005). The remaining series mainly stem from OECD and IMF statistics. Overall, we include $N = 235$ quarterly series. The sample ranges from 1993Q1 to 2003Q4. Most series from the NMS are not available for earlier time spans. At the same time, this period has the advantage of largely excluding the transitional recessions experienced by the NMS in the early 1990s. The endpoint of our sample is determined by that fact that the AWM series were available up to 2003Q4. A few key series, namely individual countries' and aggregate euro-area GDP and CPI, were updated until 2005Q2 to established stylized facts on economic linkages in section 3.

The factor analysis requires some pre-treatment of the data. Series exhibiting a seasonal pattern were seasonally adjusted with the Census X11 seasonal adjustment method. Integrated series were made stationary through differencing. There are some nominal variables which are not treated consistently in the literature. For many countries, we found prices, unit labor costs and monetary aggregates to be I(2) and interest and exchange rates to be I(1). Since non-stationarities can distort factor estimates, we include the second and first differences of these variables for all countries and the euro-area aggregates in the set respectively. Logarithms were taken of the series which were not in rates or negative, and we removed outliers. We standardized the series to have a mean of zero and a variance of one. Table 1 contains a complete listing of the data included.

3. Stylized Facts on Economic Linkages

In this section, we establish stylized facts on economic linkages between NMS and the euro area and within the groups of NMS and of EMU countries. In a first step, we look at some descriptive statistics on the determinants of economic comovements. These are computed based on data that are not included in the data set described above. One statistic describes similarities in industry specialization. If structurally similar countries are hit by industry-specific shocks, this should lead business cycles to move in parallel, which is confirmed empirically for the NMS by von Hagen and Traistaru (2005). Other statistics we use measure the integration of NMS and EMU countries through trade and FDI. As pointed out in section 1, tighter trade and FDI linkages should lead to more synchronized business cycles. In a second step, we link output and inflation of NMS and the euro area with univariate and multivariate dynamic correlation measures. In addition, we test two hypotheses: whether establishment of EMU in 1999 has changed comovements between current members' and aggregate euro-area economic variables and whether EU accession of the NMS has altered comovements between them and the euro area.

Following Krugman (1991), we define structural similarities of a country j and the euro area, here denoted by EA, S_j, as follows:

$$S_j = \sum_{l=1}^{L} | s_{lj} - s_{lEA} | , \tag{1}$$

where s_{lj} and s_{lEA} denote the shares of industry l in total value added of country j and the euro area, respectively.[5] Small values indicate greater structural similarity.

Trade and FDI linkages of individual countries with the euro area are measured as follows:[6]

$$\mathrm{TR}^1_{jEA} = \frac{\mathrm{EX}_{jEA} + \mathrm{IM}_{jEA}}{\mathrm{GDP}_j + \mathrm{GDP}_{EA}} \text{ and, analogously, } \mathrm{FDI}^1_{jEA} = \frac{\mathrm{FDI}^{\mathrm{out}}_{jEA} + \mathrm{FDI}^{\mathrm{in}}_{jEA}}{\mathrm{GDP}_j + \mathrm{GDP}_{EA}}, \tag{2}$$

$$\mathrm{TR}^2_{jEA} = \frac{\mathrm{EX}_{jEA} + \mathrm{IM}_{jEA}}{\mathrm{GDP}_j \times \mathrm{GDP}_{EA}} \text{ and } \mathrm{FDI}^2_{jEA} = \frac{\mathrm{FDI}^{\mathrm{out}}_{jEA} + \mathrm{FDI}^{\mathrm{in}}_{jEA}}{\mathrm{GDP}_j \times \mathrm{GDP}_{EA}}. \tag{3}$$

$\mathrm{EX}_{jEA} / \mathrm{FDI}^{\mathrm{out}}_{jEA}$ and $\mathrm{IM}_{jEA} / \mathrm{FDI}^{\mathrm{in}}_{jEA}$ denote exports/direct investment of country j to the (rest of the) euro area and, respectively imports/direct investment from the (rest of the) euro area to country j. GDP_j and GDP_{EA} denote nominal GDP of country j and the euro area.[7] Those indexes are based on Frankel and Rose (1998) and Deardorff (1998) (and used and discussed in Clark and Wincoop, 2001).[8] TR^2 and FDI^2 are derived from gravity models.[9] In contrast to TR^1 and FDI^1, where large countries tend to exhibit large values, they do not depend on size effects and may be a more accurate measure of trade/FDI intensity between two countries/regions. For data availability, we focus on 2003 (for the structural similarities and trade measures) and 2002 (for the FDI measures).

On average, individual EMU countries exhibit an industry specialization which is more similar to the euro-area industry specialization than that of NMS (Table 2).[10] Of the NMS, Hungary and Estonia exhibit low values, whereas Lithuania and the Czech Republic are specialized in rather different industries than the euro area. Value added in the manufacturing industry is relatively high and in the finance and other business industry relatively low in the Czech Republic compared to the euro area, whereas Lithuania still has large agriculture and fishing as well as trade and transports industries and a small financial industry. According to von Hagen and Traistaru (2005) and based on four sectors, there is evidence of structural change in the NMS towards more similarity with the euro area between 1994 and 2002, except for Hungary which already exhibited a quite similar industry specialization in the beginning of the 1990s. This is, of course, not captured by our one-point-in-time analysis.

Of the EMU members, industry structures in Luxemburg, Greece and Ireland also differ quite greatly from those in the euro area, with Luxemburg being relatively specialized in the financial industry, Greece having large agriculture, construction as well as trade and transports industries and Ireland a relatively large manufacturing and small services industries. Interestingly, NMS seem to be less heterogeneous in terms of the industry specialization measure than EMU countries.

EMU countries are, on average, more integrated in terms of trade with each other than NMS are according to the TR^1 measures. This, however, does not hold anymore if size effects are excluded; see the TR^2 measures to which we refer in the following. Of the NMS, Slovakia, the Czech Republic, Hungary, Slovenia and Estonia are most highly integrated with the euro area. The measures for these countries are even larger than those for various EMU member countries; Greek trade with the rest of the euro area is especially low. Of the NMS, Latvia and Lithuania do not trade much with the euro area. As concerns FDI intensity, both the FDI^1 and, in contrast to trade integration, also the FDI^2 measures indicate that EMU countries are more deeply integrated than NMS. Note especially the high values for Luxembourg, Ireland and the Netherlands. Of the NMS, values are relatively high for the Czech Republic, Slovakia, Estonia and Poland.[11] FDI linkages seem to be unimportant for Lithuania and Latvia. In line with the industry specialization measure, the dispersion across NMS is smaller than across EMU countries, and this holds for all integration measures.

To establish stylized facts on cyclical synchronization, we now consider dynamic correlations between output growth and changes in inflation from individual countries and the corresponding euro-area aggregates between 1993Q1 and 2005Q2. This measure has recently been proposed by Croux, Forni and Reichlin (2001). The dynamic correlation between two series y_i and y_j at frequency ω is defined as

$$\rho_{y_i,y_j}(\omega) = \frac{C_{y_i,y_j}(\omega)}{\sqrt{S_{y_i}(\omega)S_{y_j}(\omega)}}, \tag{4}$$

where $S_{y_i}(\omega)$ and $S_{y_j}(\omega)$ denote the spectral density functions of the two series and $C_{y_i y_j}(\omega)$ the co-spectrum. It should be kept in mind that the euro-area aggregates include output growth and changes in inflation from individual EMU countries. Those should therefore, by construction, be more highly correlated with the euro-area aggregates than NMS' output growth and changes in inflation. In addition, output growth and changes in inflation in larger EMU countries can be expected to be more highly correlated to the euro-area aggregates, which are weighted averages, than output growth and changes in inflation in smaller EMU countries. Croux, Forni and Reichlin (2001) extended the dynamic correlation measure to the multivariate case. The so called cohesion is here defined as the (unweighted) arithmetic average of dynamic correlations between all possible pairs of series belonging to a certain group. We focus on the groups of NMS and EMU members.

In addition, we compute dynamic correlations between output and inflation growth of current EMU members and the euro-area aggregates and cohesion for the period 1993Q1 to 1998Q4, i.e. before the establishment of EMU.[12] This analysis may provide a benchmark as well as some information on whether synchronization between NMS and current euro-area countries might change if the former become EMU members at some time in the future. Correlations for this subsample are therefore compared with correlations between output/inflation growth of current EMU members and the euro area for the entire period to investigate whether linkages have strengthened. To that extent, we consider the hypothesis that synchronization is endogenous. Moreover, we estimate bivariate VAR(1) models which include output/inflation growth of individual countries and the corresponding euro-area aggregate. We perform sample split (Chow) tests with 1999Q1 as a breakpoint. We apply the bootstrap version of this test which has been shown to be more reliable in small samples than the test based on asymptotic distributions (cf. Candelon and Lütkepohl, 2001). If EMU has altered linkages significantly, we would expect rejection of the null hypothesis of no structural change. We finally investigate whether synchronization between NMS and the euro area has already changed with their accession to EU in 2004Q2. Since the second sub-sample is very short, we apply the Chow forecast test (cf. Lütkepohl, 2005). The following conclusions can be drawn.

From Table 3, it is apparent that output growth and changes in inflation in EMU countries are on average (this refers to the unweighted average) more highly correlated with the corresponding euro-area aggregates (respectively 0.61 and 0.47 at business cycle frequencies[13]) than the corresponding variables in the NMS (0.15 and 0.27). Not surprisingly, of the current EMU members, dynamic correlations are highest for France and Germany, the largest economies. With respect to output growth, they are low for Portugal and even negative for Greece. With respect to changes in inflation, Portugal and the Netherlands exhibit very low values.[14] Among the NMS, dynamic correlations of output growth are relatively high for Hungary, Slovenia and Estonia (but still lower than for most of the EMU countries). This reflects the fact established above that in Hungary and Estonia, industry structures are more similar to euro-area industry structures than in other NMS. These two countries are also particularly deeply integrated with the euro area through both trade and FDI. Large correlations between output and inflation growth in Slovenia and in the euro area can, according to our measures, be explained by tight trade linkages. Large differences in industry specialization and low trade and FDI intensities are, at the other extreme, reflected in slightly negative business cycle correlations between Lithuania and the euro area. The business cycle correlation between Slovakia and the euro area is also slightly negative. The Russian crisis in 1998/99 which mainly affected the Baltic countries and, albeit to a lesser extent, Slovakia may explain also these loose linkages. Correlations of inflation changes are finally highest for Poland, Lithuania, Slovenia, the Czech Republic and Hungary (but are, again, still lower than for most EMU countries) and, at the other extreme, low for Estonia and Latvia.

Inflation changes in the NMS seem to be somewhat more correlated to their euro-area counterpart than output growth. This may be explained by the main focus on disinflation of central and east European central banks in the 1990s.

The dispersion of dynamic correlations seems to be higher across EMU members than across NMS reflecting greater heterogeneity with respect to integration with the euro area and industry specialization of EMU countries compared to NMS.

Our cohesion measures suggest greater synchronization across EMU countries than across NMS. On average over business cycle frequencies it amounts to 0.37 in EMU and to

0.07 in the group of NMS with respect to output growth. The discrepancy between cohesion measures are smaller for inflation changes (0.22 for the EMU group and 0.20 for the NMS group).

Dynamic correlations between GDP and inflation growth of current EMU members and the euro-area aggregates are almost all larger for the 1993Q1 to 2005Q2 period than for the pre-EMU period. The same holds for cohesion within EMU. According to the Chow tests, however, the establishment of EMU was not at the root of these changes (Table 4). Output and inflation linkages do not seem to have changed for most euro-area countries after establishment of EMU. A break in 1999Q1 is only found for the Netherlands and Portugal for output growth and Greece for changes in inflation. Instead, other global influences such as the strong downturn of stock prices in 2001 may have altered economic linkages. Overall, our results cast some doubt that synchronization between NMS and the euro area will change once the former have become EMU members. It is also interesting to see that economic comovements between NMS and the euro area are generally smaller than comovements between current EMU member states and the euro area before the establishment of EMU.

Table 4 also shows that there is no evidence that accession to EU in May 2004 has already changed linkages between NMS and the euro area.

Our findings are roughly in line with existing studies. We find particularly high business cycle correlations between Hungary, Slovenia and Estonia and the euro area, which is consistent with the literature (Fidrmuc and Korhonen, 2004b). We also confirm previous findings that business cycle correlations are higher for many NMS than for Greece and Portugal. Dynamic correlations and determinants of comovements suggest that the group of EMU countries is more heterogeneous than the group of NMS. This result, however, differs from Fidrmuc and Korhonen (2004a) who find, based on static correlations between GDP growth and the level of inflation and a slightly different period, more heterogeneity across NMS than across EMU countries.

4. Model, Estimation and Euro-area Shocks

This section introduces the factor model which will enable us to investigate the transmission of euro-area shocks to the NMS. The series are collected in the $N \times 1$ vector Y_t. It is assumed that Y_t follows an approximate dynamic factor model (e.g. Stock and Watson, 1998, 2002, Bai and Ng, 2002) and can be represented as:

$$\mathrm{Y}_t = \mathrm{X}_t + \Xi_t = \Lambda(L)\mathrm{f}_t + \Xi_t = \Lambda \mathrm{F}_t + \Xi_t , \tag{5}$$

where f_t is a $q \times 1$ vector of common dynamic euro-area factors and $\Lambda(L) = \Lambda_0 + \Lambda_1 L + ... + \Lambda_m L^m$ denotes the lag polynomial of $N \times q$ matrices of factor loadings associated with lags 0 to m. X_t and Ξ_t are $N \times 1$ vectors of common and idiosyncratic components. The latter are allowed to be weakly cross-correlated and weakly serially correlated in the sense of Bai and Ng (2002). The loadings can differ across variables. F_t is a vector of $r \geq q$ "static factors" that comprises the dynamic factors f_t and all lags of the factors that enter with at least one non-zero weight in the factor representation. The $N \times r$ matrix Λ comprises all non-zero columns of $(\Lambda_0,...,\Lambda_m)$. Typically, $r << N$. By construction, the vector F_t is driven by q shocks that result from the VAR(p) representation of the factors:

$$\mathrm{A}(L)\mathrm{f}_t = \mathrm{Q}\mathrm{v}_t , \tag{6}$$

with $\mathrm{A}(L) = \mathrm{I} - \mathrm{A}_1 L - ... - \mathrm{A}_p L^p$. Matrix Q is chosen such that the innovations v_t are orthonormal. The shocks w_t are related to v_t through the structural equation

$$\mathrm{w}_t = \mathrm{R}\mathrm{v}_t , \tag{7}$$

where $\mathrm{R}'\mathrm{R} = \mathrm{I}_q$. Provided that there are enough identifying restrictions on R, the structural shocks w_t can be recovered from the factor innovations. The $q \times N$ matrix of impulse responses to the shocks $\mathrm{w}_t = (\mathrm{w}_{1t} \quad ... \quad \mathrm{w}_{qt})'$ at horizon h, $\partial \mathrm{Y}_{t+h} / \partial \mathrm{w}_t' = \Theta_h$, is obtained from

$$\Theta(L) = \Theta_0 + \Theta_1 L + \Theta_2 L^2 + ... = \Lambda(L)\mathrm{A}(L)^{-1}\mathrm{Q}\mathrm{R}' . \tag{8}$$

The ultimate goal is to identify w_t and to assess impulse responses of individual variables to these shocks. For this purpose, we first estimate F_t by applying static principal component analysis to Y_t. Stock and Watson (1998) have shown that the principal component estimator remains consistent if there is some time variation in Λ as long as $T/N \to 0$. This may be relevant here, since the NMS go through a phase of structural change and their sensitivity to fluctuations in the euro-area economies may have changed over time. The dimension of F_t, r, was estimated to be 5 on the basis of the Bai and Ng (2002) IC_{p3} criterion, although the criteria IC_{p1} and IC_{p2} suggest an estimate of r of 2.[15] One reason for our choice is that factors are still estimated consistently if the number of common factors is overestimated, but not if it is underestimated (Stock and Watson, 1998, Kapetanios and Marcellino, 2004, Artis, Banerjee and Marcellino, 2005). Another reason is that five factors explain 44% of the total variance, which is consistent with previous findings for macroeconomic euro-area data sets,[16] whereas the share accounted for by two factors is relatively low (26%): see Table 5.

To estimate the innovations v_t, we follow Giannone, Reichlin and Sala (2002) and fit a VAR(1) model to the estimated vector of static factors $\hat{F}_t$. The lag order of the VAR model was estimated with the Schwarz information criterion. It is important to note that the VAR representation for $\hat{F}_t$ is singular if the r-dimensional vector $\hat{F}_t$ is driven by $q < r$ shocks. To estimate the q-dimensional vector v_t from the r-dimensional vector of residuals of the fitted VAR based on $\hat{F}_t$, a principal component analysis is employed. This yields the linear combination of the q non-zero components in the residual vector of the VAR model. Let $\hat{v}_t$ denote the resulting vector of orthogonal factor innovations. The number of dynamic factors q was estimated to be 3 with the consistent Schwarz criterion of Breitung and Kretschmer (2005). This estimate is also consistent with our estimate of r: three dynamic factors, estimated with dynamic principal component analysis, roughly account for the same total variance share as five static principal components (Table 5).[17] See the appendix for a detailed description of the estimation of the factors and innovations.

The common structural shocks w_t can now be recovered as in the SVAR literature. The matrix R is chosen such that certain identifying restrictions that need to be specified are satisfied. We aim at estimating an aggregate euro-area supply shock, an aggregate euro-area real demand shock and a common monetary policy shock.[18] This is achieved by applying the identification scheme recently proposed by Peersman (2005) which consists in imposing short-run sign restrictions on impulse responses of key aggregate euro-area variables. This prevents us from using long-run restrictions which are common in the structural VAR (and structural dynamic factor) literature, but which may be problematic here given the small number of observations available. We can also avoid commonly employed zero restrictions which are at odds with some theoretical models (see the discussions in Peersman, 2005 and in Canova and de Nicólo, 2003).

Following Peersman (2005), we impose the following restrictions. A positive supply shock has non-negative effects on output and non-positive effects on prices contemporaneously and during the first four quarters after the shock; the short-term interest rate does not increase on impact. A positive demand shock affects output and prices non-negatively instantaneously and during the first four quarters after the shock; the immediate effect on the short-term interest rate is non-negative. A positive monetary policy shock finally does not raise the short-term interest rate on impact; output and prices do not decrease contemporaneously and during the first four quarters after the shock. These conditions are consistent with the standard aggregate supply-aggregate demand framework and with more complex structural models like the DSGE model outlined in Smets and Wouters (2003). We report the median impulse responses and 90% confidence bands which were constructed using bootstrap techniques. For details on the identification of the shocks and the bootstrap, see the appendix.

As already pointed out in the introduction, the fact that we can assess the impact of the shocks on all variables in the system enables us to better characterize the shocks. This is particularly interesting for the period considered here. In this period, the euro area experienced an expansion until the end of 2000, followed by a slowdown and a phase of stabilization.[19] There was (and still is) some controversy about the underlying shocks.

In the following, we identify the main sources of economic fluctuations in the euro area. Table 6 shows that the overwhelming majority of key euro-area aggregate variables are explained by the common factors: 88% of output growth and more than 70% of changes in inflation and the short-term interest rates. Exceptions are consumption and employment growth. The variance of these variables is mainly explained by the idiosyncratic component.[20]

Impulse responses, shown in Figure 1, look roughly consistent with those found in the literature. However, some differences relative to Peersman (2005) appear.[21] We find persistent effects of the demand and the monetary policy shocks on output and prices and of the demand shock on interest rates, whereas these shocks display only transitory effects in Peersman (2005). These differences are partly due to the fact that he includes inflation and interest rates in levels (as well as a linear time trend) in the VAR model whereas we rely on first differences of these variables. Differences in time periods are another reason; Peersman (2005) focuses on 1980 to 2002.[22]

Most of the variance of the forecast error of the common component of euro-area output associated with the entire 1993 to 2003 period can be explained by the demand and monetary policy shocks (41% and 38%) at forecast horizons zero to five years (Table 6). Only 21% is accounted for by the supply shock. By contrast, the common component of euro-area inflation was mainly driven by the supply shock (74%). The demand shock accounts for 16% and the monetary policy shock for 10%.

By means of historical decompositions, we also estimated the contributions of the three shocks separately for the phase of expansion (until 2000Q4) and the subsequent slowdown (and stabilization) phase (from 2001Q1 to 2003Q4); see Table 7. During the expansion, the demand shock mainly stimulated real economic activity in the euro area (after some stimulus from the monetary policy and the supply shocks at the beginning of this phase). The contribution of the monetary policy shock to the forecast error was also positive, but smaller. The contribution of the supply shock was zero. The forecast error of inflation during this period increased only modestly - in contrast to what is typically observed in periods of economic expansion. It was mainly held down by the supply shock. We therefore can partly confirm the ‘new economy’ hypothesis for the euro area in the 1990s; the new technologies may not have had a particularly favorable impact on output, but dampened inflation. As concerns the slowdown and subsequent stabilization period, output was depressed by the monetary policy and demand shocks. Inflation remained relatively high: inflationary pressures from the negative supply shock seem to have compensated for the effects of the negative demand shock.

5. Business Cycle Transmission from the Euro Area to the NMS

This section investigates the propagation of euro-area shocks to the NMS. Table 8 shows how much of the variance of output growth and inflation changes in NMS and EMU countries is explained by the euro-area factors. On average, the common factors explain a larger percentage of output and inflation changes in EMU economies (44% and 37%) compared to the NMS (27% and 25%). Of all the countries concerned, France and Germany exhibit the highest explained variance shares (between 63% and 77%). Among the EMU economies, the euro-area factors are least important for output growth in Greece and Portugal (14% and 16%) and for inflation changes in the Netherlands and in Portugal (2% and 19%).[23] Interestingly, these shares are smaller than the corresponding shares in a number of NMS. Of the latter, Poland, Lithuania, Slovakia and Hungary exhibit the largest variance shares explained by the euro-area factors in terms of output growth (between 28% and 43%) and Poland, Lithuania, Hungary and Latvia in terms of changes in inflation (between 31% and 42%). Relatively little is explained by the euro-area factors of output growth variations in Latvia (6%) and inflation growth variations in Slovakia and the Czech Republic (6% and 10%). The dispersion across EMU countries is almost twice the dispersion across the NMS.

Figure 2 presents impulse responses of output and inflation in individual countries against aggregate euro-area impulse responses. Again, one should be aware of the fact that, by construction, impulse responses of EMU countries are more likely to coincide with aggregate euro-area impulse responses than impulse responses of NMS. Confidence bands are relatively wide and some impulse responses do not differ significantly from zero, which is not surprising given the limited number of time periods.[24] It is, nevertheless, encouraging from the point of view of EMU enlargement that impulse responses of individual countries do not differ significantly from aggregate euro-area impulse responses in most cases. Of the current EMU members, Greek output responds negatively to both the supply and the monetary policy shocks which is, however, difficult to interpret. Of the candidate countries, the supply shock proliferates negatively to output in Latvia; the response is, however, significant only in the short run. The euro-area demand shock leads to a decrease or a smaller increase compared to the euro-area aggregate in the Czech Republic, Slovakia and, on impact, Estonia. Output responses to the monetary policy shock are not significantly different. Responses of inflation in the NMS are very similar to the euro-area responses. Of the EMU countries, the relatively weak inflation responses in Portugal and the Netherlands to all three shocks and Austria to the supply shock are noticeable. Variance decompositions lead to similar conclusions (Table 8).

We now examine the standard deviations of impulse responses across countries. According to Figure 3, the dispersion of impulse responses across NMS is larger than across EMU members. Confidence bands of the standard deviation, however, overlap for output responses to all shocks and slightly for inflation responses to the monetary policy shock. These estimates thus point to different results than those obtained above where dynamic correlations and variance shares explained by the euro-area factors indicated more heterogeneity across EMU countries than across candidate countries.

It is somewhat difficult to relate our results to the literature since no consensus seems to exist yet on the extent to which euro-area shocks affect individual NMS. According to Korhonen (2003), the variance shares of industrial production fluctuations in the NMS accounted for by euro-area shocks range from 11% to 34%. Boone and Maurel (1999) who only consider the Czech Republic, Slovakia, Hungary and Poland, report variance shares of unemployment rates which they use as proxies for economic activity between 55% and 80% when explained by a German shock and between 24% and 35% when explained by a European Union shock. Our variance shares lie in this large range. Boone and Maurel (1999) find relatively large variance shares explained by euro-area shocks for Hungary, followed by Slovakia, and rank Poland last. By contrast, according to Korhonen (2003), euro-area shocks explain the most in Latvia and Slovenia, but relatively little in Estonia, Lithuania, the Czech Republic and Poland. We can only partly support these results, finding that euro-area factors explain relatively much of the variance shares of business cycles in Poland, Lithuania, Slovakia and Hungary, but little in Latvia.

Darvas and Szapáry (2005) and Korhonen (2003) also compare impulse responses to euro-area shocks of economic activity in NMS and in the euro area. The former find responses that are larger than the euro-area average in Slovenia, the Czech Republic, Poland and Hungary and smaller than the euro-area average responses in other NMS. Of the NMS, Korhonen (2003) finds a much larger impact of euro-area shocks on Latvia than on the euro area, a smaller impact on Slovakia and Lithuania and similarly large effects in the remaining NMS. The author also reports some initial "overshooting" in the smallest accession countries (Estonia, Lithuania and Slovenia), where he refers to an output reaction in these countries larger than in the euro area, in response to a euro-area shock. We also find output responses of some NMS to the monetary policy shock which are larger than the euro-area average output response. However, this "overshooting" is not statistically reliable. According to Boone and Maurel (1999), impulse responses of NMS are quite homogeneous. Comparison with our study is exacerbated by the fact that these studies do not report significance levels. This may, however, be important, since our analysis suggests that differences between impulse responses of NMS and the euro area are not significant in most cases.

6. Conclusion

Overall, the results are mixed. Business cycle correlations between the NMS and the euro area are lower on average than between EMU countries and the euro area, but they are larger than in some smaller peripheral countries such as Greece and Portugal. A similar picture is found for inflation correlations and for variance shares explained by common euro-area shocks. The transmission of common euro-area shocks to the NMS does not seem to differ significantly from the propagation to EMU countries in most cases, basically with the noticeable exceptions of output responses of Latvia after the euro-area supply shock and the Czech Republic and Slovakia to euro-area demand shocks. Those responses are weaker than the corresponding euro-area responses or even negative.

According to our analysis and based on the criteria used here, Hungary, Estonia, Slovenia and Poland are more suitable accession candidates than other NMS. Of those countries, Hungary and Estonia are particularly deeply integrated in terms of trade and FDI and exhibit industry structures which are similar to those in the euro area. The Slovenian economy is closely connected through trade with the euro area which can explain comovements. Lithuania seems to be a special case: its output growth correlation with the euro area is very low, being consistent with our three measures covering the determinants of comovements. By contrast, inflation growth correlations and the variance of output growth and changes in inflation explained by euro-area factors are quite high.

No clear conclusions can be drawn on whether NMS or EMU countries are the more heterogeneous group. Our various estimates point in different directions. Nevertheless, there seems to be considerable heterogeneity across NMS, implying that, for some countries, accession to EMU would be more costly than for others.

As a byproduct we also identified the main sources of economic fluctuations in the euro area between 1993 and 2003. We find that the favorable economic performance of the euro area between 1993 and 2000 can mainly be explained by demand shocks which stimulated output and supply shocks which held down inflation. Positive demand impulses then vanished. Together with contractionary monetary policy shocks which triggered the sharp downturn in European stock markets, this seems to have caused the subsequent economic slowdown.

Our analysis has a number of caveats to be kept in mind. One is the backward-looking nature of the analysis. This seems particularly relevant for the NMS, which are undergoing a phase of structural changes and where the relationship with the euro area is already different from the relationship in the previous decade. We addressed this concern partly by testing whether economic linkages between NMS and the euro area have changed after accession of the NMS to the EU in 2004, but could not confirm this hypothesis. Moreover and as already pointed out in the introduction, one should be aware that synchronization is not the only criterion that should be satisfied before a country joins a monetary union. Others like the various Maastricht criteria are not investigated here. It finally seems appropriate to reemphasize the endogeneity of OCA criteria. It can be expected that economies will become more synchronized mainly through increased trade linkages and financial integration.

Appendix

This appendix describes the estimation of the factor model and the identification of the structural shocks. We first estimate F_t by applying static principal component analysis to Y_t, i.e.

$$\hat{\mathrm{F}}_t = \hat{\mathrm{V}}'\mathrm{Y}_t, \tag{A1}$$

where $\hat{\mathrm{V}}$ is the $N \times r$ matrix of eigenvectors corresponding to the largest r eigenvalues of the sample correlation matrix. $\hat{\mathrm{V}}$ is an estimate of the matrix of factor loadings Λ. The estimated vector of static factors $\hat{\mathrm{F}}_t$ has the VAR(1) representation

$$\hat{\mathrm{F}}_t = \Psi\hat{\mathrm{F}}_{t-1} + \mathrm{u}_t, \tag{A2}$$

and OLS is applied to each equation yielding the reduced form VAR residuals $\hat{\mathrm{u}}_t$. The q-vector of orthogonalized residuals v_t is estimated as

$$\hat{\mathrm{v}}_t = \hat{\mathrm{M}}^{-1/2}\hat{\mathrm{P}}'\hat{\mathrm{u}}_t, \tag{A3}$$

where $\hat{\mathrm{M}}$ is a $q \times q$ matrix with the largest q eigenvalues of $\mathrm{cov}(\hat{\mathrm{u}}_t)$ on the main diagonal and zeros elsewhere such that $\mathrm{cov}(\hat{\mathrm{v}}_t) = \mathrm{I}_q$. $\hat{\mathrm{P}}$ is the corresponding $r \times q$ matrix of eigenvectors. The vector $\hat{\mathrm{v}}_\mathrm{t}$ is a consistent estimator of v_t. The estimated vector of structural shocks $\hat{\mathrm{w}}_t$ is related to $\hat{\mathrm{v}}_\mathrm{t}$ through the $q \times q$ rotation matrix R:

$$\hat{\mathrm{w}}_t = \mathrm{R}\hat{\mathrm{v}}_t, \tag{A4}$$

where $\mathrm{R}'\mathrm{R} = \mathrm{I}_q$. Note that by construction $\mathrm{cov}(\hat{\mathrm{w}}_t) = \mathrm{I}_q$. The matrix of impulse response functions at horizon h with respect to the innovations u_t is obtained as $\partial\mathrm{Y}_{t+h} / \partial\mathrm{u}_t' = \Lambda\Psi^h$ and the matrix of impulse responses with respect to the structural shocks results as[25]

$$\frac{\partial\mathrm{Y}_{t+h}}{\partial\mathrm{w}_t'} = \Lambda\Psi^h\mathrm{P}\mathrm{M}^{1/2}\mathrm{R}' \tag{A5}$$

(cf. Giannone, Reichlin and Sala, 2002). The rotation matrix R has to be chosen such that the identifying restrictions specified in the main text are satisfied. Any rotation matrix can be parametrized as follows

$$\mathrm{R}(\theta_1,\theta_2,\theta_3)=\begin{pmatrix}\cos(\theta_1) & -\sin(\theta_1) & 0\\ \sin(\theta_1) & \cos(\theta_1) & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\cos(\theta_2) & 0 & -\sin(\theta_2)\\ 0 & 1 & 0\\ \sin(\theta_2) & 0 & \cos(\theta_2)\end{pmatrix}\begin{pmatrix}1 & 0 & 0\\ 0 & \cos(\theta_3) & -\sin(\theta_3)\\ 0 & \sin(\theta_3) & \cos(\theta_3)\end{pmatrix}. \quad \text{(A6)}$$

To systematically explore the factor space, the rotation angles θ_1, θ_2 and θ_3 are varied on a grid from 0 to $\pi/2$. The number of grids are chosen to be 12 for computational reasons, and θ_1, θ_2 and θ_3 are fixed, so that the imposed restrictions are satisfied. 31 rotations satisfy our restrictions. Canova and de Nicólo (2003), who apply a similar identification scheme, suggest, in this case, imposing more restrictions which allow to fix only one rotation. We decide not to do so but give equal probability to all of them. One reason is that we will not focus on the point estimates but on the median impulse responses and the confidence bands below. As we will explain below, those are obtained with bootstrap techniques, and for each draw, a different number of rotations satisfying the restrictions may arise. Imposing more restrictions in order to get one single point estimate therefore would not help much. A possibility to cope with this issue is to apply Uhlig's (2004) Bayesian based method. This is, however, left for future work.

Since $N >> T$, the uncertainty involved with the factor estimation can be neglected (see e.g. Bernanke, Boivin and Eliasz, 2005). In order to account for the uncertainty involved with the estimation of the VAR model on the factors, we construct confidence bands by means of the bootstrap-after-bootstrap techniques based on Kilian (1998). These techniques allow us to remove a possible bias in the VAR coefficients which can arise due to the small sample size of the VAR model. Most draws deliver not just one, but a set of shocks which all satisfy the restrictions. In this case, we follow Peersman (2005) and draw and save one of them. Some draws, however, do not deliver any shocks satisfying the restrictions. We draw until we have saved 500 shocks (626 draws were needed). For more details on the identification, the reader is referred to Peersman (2005).

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Table 1: Data

Country/region	Variable	Country/region	Variable
Euro area (aggregate variables)	Current account balance	Core EMU member countries (AUT, BEL, FRA, GER, ITA, NLD, ESP)	GDP, volume, market prices
	Effective exchange rate nominal		Private final consumption expenditure
	Effective exchange rate real		Private total fixed capital formation, vol.
	Total demand		Industrial production
	Public debt		Capacity utilization rate manufacturing
	Government expenditure nominal		Total employment
	HICP		Unit labor costs (business sector)
	Gross investment deflator		Productivity
	Real gross investment		CPI, harmonized
	Whole-economy capital stock		PPI
	Employees (persons)		GDP deflator, market prices
	Labour force		Short-term interest rate nominal
	Total employment (persons)		Long-term int. rate (gvt. bonds) nom.
	Labour productivity		M1
	Long-term interest rate		M3
	Imports of goods and services deflator		Main stock price index
	Imports of goods and services real		Imports (goods and services), vol.
	Net foreign assets		Exports (goods and services), vol.
	Net factor income from abroad		Bilat. exch. rate with US Dollar nom.
	Net factor income from abroad/GDP		Current account balance
	Consumption deflator		
	Consumption real	Remaining EMU countries (FIN, GRC, IRE, LUX, PRT) and NMS (CZ, ES, HUN, LT, LV, PL, SI, SK)	GDP, volume, market prices
	Household's disposable income nom.		CPI, harmonized
	Household's disposable income real		Short-term interest rate nominal
	Variation of stocks deflator		Bilat. exch. rate with US Dollar nom.
	Variation of stocks real		
	Short-term interest rate nominal		
	Short-term quarterly interest rate real	World	US CPI
	Trade balance nominal		US GDP, volume
	Trade balance real		Energy prices
	Unit labour costs		World trade
	Number of unemployed		Euro/US Dollar nominal
	Unemployment		
	Compensation to employees		
	Wealth nominal		
	Wealth real		
	Wage rate		
	Exports of goods and services deflator		
	Exports of goods and services real		
	GDP deflator		
	GDP real		

Notes
The data set does not contain private total fixed investment, but total fixed investment for Spain. Productivity in Belgium, Italy and Spain are not included. Not PPI, but WPI for Austria is included. For Lithuania, it is referred to the bilateral exchange rate with the Euro, not with the US Dollar.

Table 2: Similarities in industry specialization and trade and FDI integration with the (rest of the) euro area – some descriptive statistics

	Structural simi-laritires	Trade integration		FDI integration	
		TR^1	TR^2	FDI^1	FDI^2
AUT	17.0	1.42	0.65	0.52	0.24
BEL	9.4	3.70	1.43	-	-
FIN	18.4	0.41	0.29	0.36	0.26
FRA	14.4	5.28	0.43	5.97	0.50
GER	16.0	7.30	0.48	7.90	0.53
GRC	43.7	0.33	0.22	0.17	0.12
IRE	41.7	0.62	0.47	1.38	1.09
ITA	6.6	3.51	0.33	2.41	0.23
LUX	52.6	0.26	1.10	4.82	21.57
NLD	9.6	3.65	0.86	4.22	1.01
PRT	22.9	0.67	0.52	0.62	0.49
ESP	26.8	2.63	0.39	-	-
CZ	41.5	0.71	0.89	0.42	0.55
ES	24.8	0.06	0.71	0.02	0.30
HU	19.7	0.63	0.87	-	-
LT	48.2	0.06	0.39	0.01	0.08
LV	37.8	0.04	0.36	0.01	0.12
PL	28.0	0.80	0.44	0.47	0.24
SI	27.9	0.19	0.78	0.05	0.20
SK	28.8	0.28	0.98	0.09	0.33
Mean all countries	26.8	1.63	0.63	1.73	1.64
Mean EMU	23.3	2.48	0.60	2.84	2.61
Mean NMS	32.1	0.35	0.68	0.15	0.26
Std. all countries	13.5	2.04	0.32	2.46	5.14
Std. EMU	15.0	2.27	0.36	2.73	6.67
Std. NMS	9.5	0.32	0.25	0.20	0.16

Notes

Structural similarities refer to similarities in industry specialization in 2003 as defined in equation (1). Trade and FDI integration measures are defined in equations (2) and (3). The TR^1 and FDI^1 measures are multiplied by 100, the TR^2 and FDI^2 measures by 10^{13}. Trade integration measures are computed based on trade flows in 2003. The source is ECB. World GDP is taken from the IMF. FDI integration measures are computed based on stocks of FDI at the end of 2002. Irish FDI to the rest of the euro area refers to 2001. The source is Eurostat. Data on FDI integration with the euro area are not available for Belgium, Spain and Hungary. See section 3 of the present article as well as Clark and Wincoop (2001) for more details on the measures. The means are unweighted arithmetic averages.

Table 3: Dynamic correlations between output and inflation growth in individual countries and the euro area and cohesion

	1993Q1 - 2005Q2				1993Q1 - 1998Q4			
	Y		Π		Y		Π	
	all frequ.	bc frequ.	all frequ.	bc frequ.	all frequ.	bc frequ.	all frequ.	bc frequ.
AUT	0.46	0.68	0.50	0.51	0.47	0.65	0.25	0.24
BEL	0.54	0.76	0.65	0.50	0.36	0.65	0.50	0.43
FIN	0.27	0.52	0.52	0.41	0.31	0.44	0.32	0.29
FRA	0.59	0.88	0.87	0.83	0.44	0.77	0.82	0.76
GER	0.75	0.86	0.86	0.78	0.66	0.68	0.70	0.51
GRC	-0.10	-0.11	0.55	0.42	-0.12	-0.23	0.45	0.40
IRE	0.50	0.62	0.50	0.30	0.48	0.36	0.19	0.16
ITA	0.56	0.77	0.37	0.35	0.58	0.67	0.27	0.30
LUX	0.32	0.57	0.64	0.58	0.05	0.13	0.47	0.47
NLD	0.60	0.78	0.26	0.23	0.50	0.59	0.57	0.39
PRT	0.15	0.36	0.08	0.19	0.24	0.17	0.29	0.19
ESP	0.40	0.59	0.62	0.56	0.35	0.42	0.51	0.45
CZ	0.15	0.15	0.15	0.27	-	-	-	-
ES	0.13	0.22	0.18	0.12	-	-	-	-
HU	0.37	0.38	0.21	0.26	-	-	-	-
LT	0.05	-0.02	0.39	0.38	-	-	-	-
LV	-0.10	0.12	0.20	0.17	-	-	-	-
PL	0.25	0.13	0.39	0.40	-	-	-	-
SI	0.17	0.23	0.35	0.31	-	-	-	-
SK	0.07	-0.02	0.13	0.23	-	-	-	-
Mean all countries	0.31	0.42	0.42	0.39	-	-	-	-
Mean EMU	0.42	0.61	0.53	0.47	0.36	0.44	0.45	0.38
Mean NMS	0.14	0.15	0.25	0.27	-	-	-	-
Std. all countries	0.24	0.32	0.23	0.19	-	-	-	-
Std. EMU	0.23	0.27	0.23	0.20	0.22	0.29	0.19	0.17
Std. NMS	0.14	0.13	0.11	0.10	-	-	-	-
Cohesion all countries	0.10	0.17	0.20	0.19	-	-	-	-
Cohesion EMU	0.20	0.37	0.28	0.22	0.12	0.21	0.19	0.12
Cohesion NMS	0.09	0.07	0.17	0.20	-	-	-	-

Notes
It is referred to average dynamic correlations/cohesion over all/business cycle (bc) frequencies. Business cycle frequencies correspond to 6 to 32 quarters. Dynamic correlations and cohesion measures lie between -1 and 1. They are defined in section 3. Y and Π are real GDP growth and CPI inflation growth. Means refer to unweighted arithmetic averages.

Table 4: Testing the stability of economic linkages (p-values)

Chow sample split test Breakpoint: 1999Q1			Chow forecast test Breakpoint: 2004Q2		
	Y	Π		Y	Π
AUT	0.40	0.50	CZ	0.96	0.53
BEL	0.44	0.44	ES	0.86	0.54
FIN	0.30	0.58	HU	0.96	0.56
FRA	0.08	0.06	LT	0.84	0.80
GER	0.67	0.94	LV	0.65	0.79
GRC	0.39	0.00	PL	0.96	0.81
IRE	0.07	0.41	SI	0.63	0.79
ITA	0.53	0.17	SK	0.93	0.48
LUX	0.71	0.92			
NLD	0.01	0.14			
PRT	0.01	0.22			
ESP	0.68	0.44			

Notes

Tests are based on bivariate VAR(1) models including GDP growth denoted by Y/changes in CPI inflation denoted by Π of an individual country and the euro area as endogenous variables. The models are estimated for the period 1993Q3 to 2005Q2. A constant is included. The null hypotheses of no structural changes in 1999Q1 and 2004Q2, respectively, are tested. The test statistics are computed based on 500 bootstrap replications. Cf. Candelon and Lütkepohl (2001).

Table 5: Cumulated total variance shares explained by the first ten principal components (PCs)

	Static PCs	Dynamic PCs
1	0.16	0.22
2	0.26	0.35
3	0.33	0.44
4	0.39	0.51
5	0.44	0.57
6	0.48	0.62
7	0.52	0.67
8	0.56	0.71
9	0.59	0.75
10	0.62	0.78

Table 6: Variance decompositions of selected aggregate euro-area variables

	Variance shares expl. by the common factors	Forecast error variance explained by the supply shock	demand shock	mon. pol. shock
GDP	0.88	0.21	0.41	0.38
Investment	0.65	0.26	0.55	0.20
Consumption	0.38	0.09	0.70	0.20
Employment	0.34	0.64	0.25	0.13
Productivity	0.78	0.46	0.18	0.37
CPI inflation	0.73	0.74	0.16	0.10
Short-term interest rate	0.72	0.04	0.76	0.20
Long-term interest rate	0.67	0.14	0.62	0.21
Effect. exchange rate real	0.85	0.09	0.25	0.65
Current account	0.53	0.25	0.63	0.13

Notes
The variance shares explained by the common factors refer to first differences of the variables. The forecast error variance explained by the structural shocks refers to common components of the levels of the variables and to horizons 0 to 5 years.

Table 7: Historical decomposition of selected aggregate euro-area variables

	Total forecast error	Forecast error explained by the		
		supply shock	demand shock	mon. pol. shock
Phase of expansion (1994Q4-2000Q4)				
GDP	3.10	0.00	2.28	0.79
Investment	7.60	-0.05	6.36	1.23
Consumption	1.72	0.04	1.39	0.29
Employment	0.28	-0.01	0.24	0.05
Productivity	1.23	-0.05	0.81	0.47
CPI inflation	0.68	0.04	0.55	0.10
Short-term interest rate	3.21	0.10	2.63	0.49
Long-term interest rate	2.15	0.06	1.83	0.26
Effect. exchange rate real	-31.34	0.84	-21.41	-13.39
Current account balance	-3.04	0.05	-2.83	-0.25
Phase of slowdown/stabilization (2001Q1-2003Q4)				
GDP	-2.73	-0.38	-1.13	-1.25
Investment	-5.35	-1.04	-2.39	-2.01
Consumption	-1.61	-0.14	-0.93	-0.54
Employment	-0.25	-0.10	-0.07	-0.08
Productivity	-1.35	-0.32	-0.27	-0.76
CPI inflation	0.26	0.34	-0.03	-0.05
Short-term interest rate	-2.25	0.09	-1.49	-0.85
Long-term interest rate	-0.89	0.18	-0.63	-0.44
Effect. exchange rate real	35.27	1.67	10.36	20.53
Current account balance	1.89	0.50	0.99	0.40

Notes
It is referred to the change of the 8-quarters ahead forecast error of the common component between the last and the first quarter of the considered period. The forecast horizon was chosen such that the path of the forecast error of the common component of euro-area GDP is consistent with the CEPR dating of the euro-area slowdown in 2001Q1. Values for interest rates are in percentage points, for the current account balance in levels divided by 10000. Values for all other series are in percent.

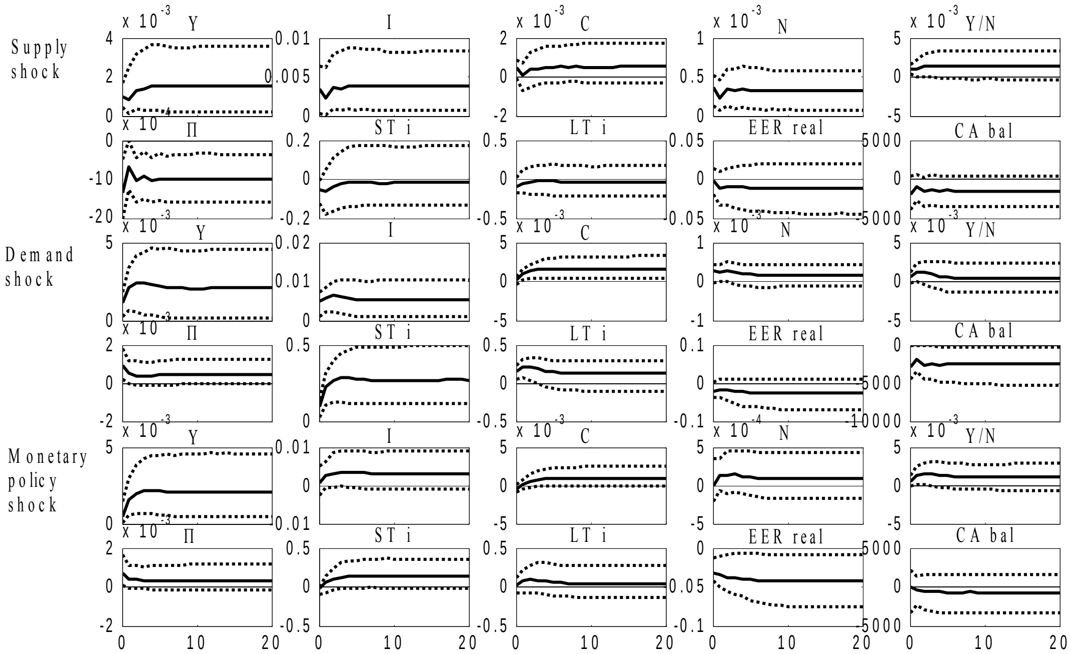
Table 8: Variance decompositions of changes in output and inflation in individual countries

	Variance shares expl. by the common factors		Forecast error variance explained by structural shocks					
			supply	demand	mon. pol.	supply	demand	mon. pol.
	Y	Π		Y			Π	
AUT	0.42	0.24	0.38	0.20	0.42	0.28	0.17	0.54
BEL	0.62	0.36	0.21	0.38	0.41	0.34	0.39	0.27
FIN	0.40	0.44	0.25	0.18	0.58	0.63	0.07	0.35
FRA	0.63	0.77	0.11	0.37	0.52	0.72	0.17	0.11
GER	0.69	0.68	0.45	0.39	0.16	0.65	0.08	0.27
GRC	0.14	0.55	0.55	0.14	0.28	0.63	0.06	0.33
IRE	0.29	0.22	0.21	0.40	0.39	0.49	0.29	0.22
ITA	0.47	0.23	0.17	0.22	0.62	0.52	0.46	0.07
LUX	0.58	0.53	0.11	0.37	0.52	0.18	0.35	0.47
NLD	0.59	0.02	0.24	0.39	0.36	0.28	0.17	0.52
PRT	0.16	0.19	0.08	0.47	0.45	0.09	0.69	0.16
ESP	0.26	0.23	0.11	0.50	0.38	0.60	0.29	0.12
CZ	0.24	0.10	0.10	0.69	0.15	0.61	0.19	0.19
ES	0.24	0.16	0.34	0.14	0.53	0.19	0.12	0.64
HU	0.28	0.33	0.22	0.13	0.66	0.45	0.50	0.08
LT	0.40	0.36	0.23	0.72	0.12	0.76	0.23	0.06
LV	0.06	0.31	0.26	0.47	0.26	0.76	0.21	0.08
PL	0.43	0.42	0.54	0.34	0.14	0.47	0.46	0.11
SI	0.23	0.27	0.22	0.12	0.67	0.17	0.52	0.30
SK	0.30	0.06	0.43	0.51	0.07	0.17	0.17	0.66
Mean all countries	0.37	0.32	0.26	0.36	0.38	0.45	0.28	0.28
Mean EMU	0.44	0.37	0.24	0.34	0.42	0.45	0.27	0.29
Mean NMS	0.27	0.25	0.29	0.39	0.32	0.45	0.30	0.26
Std. all countries	0.18	0.20	0.14	0.18	0.19	0.22	0.17	0.19
Std. EMU	0.19	0.23	0.15	0.12	0.13	0.21	0.19	0.16
Std. NMS	0.11	0.13	0.14	0.25	0.25	0.25	0.17	0.25

Notes

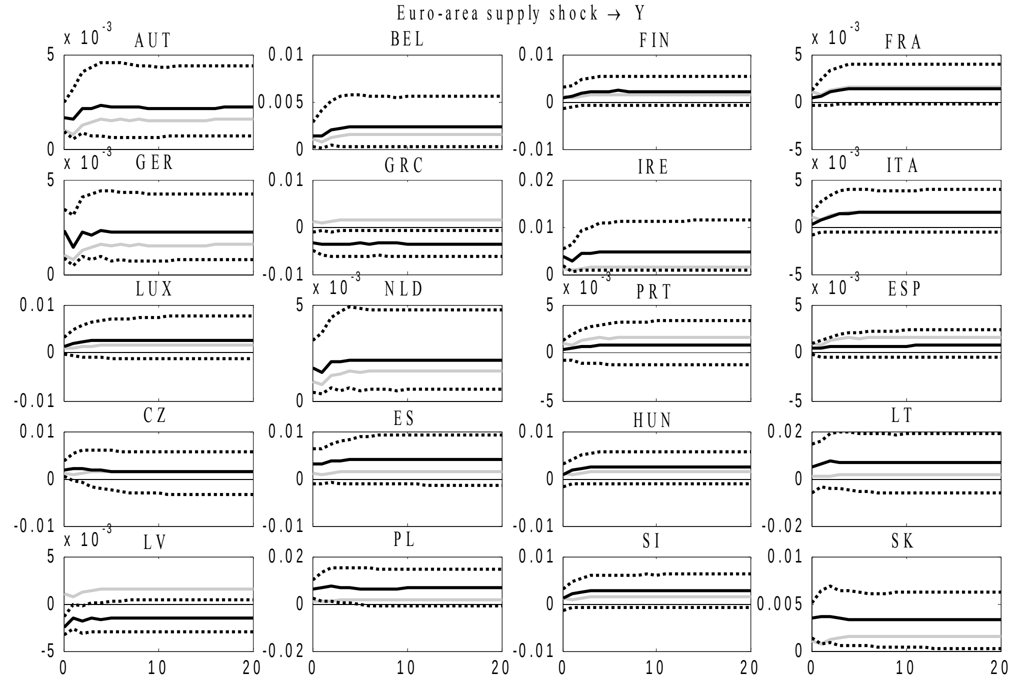
Variance shares explained by the common factors refer to first differences of the variables. The forecast error variance explained by the structural shocks refers to the common components of the levels of the variables and to horizons 0 to 5 years. Y and Π are real GDP growth and CPI inflation growth. The means are unweighted arithmetic averages.

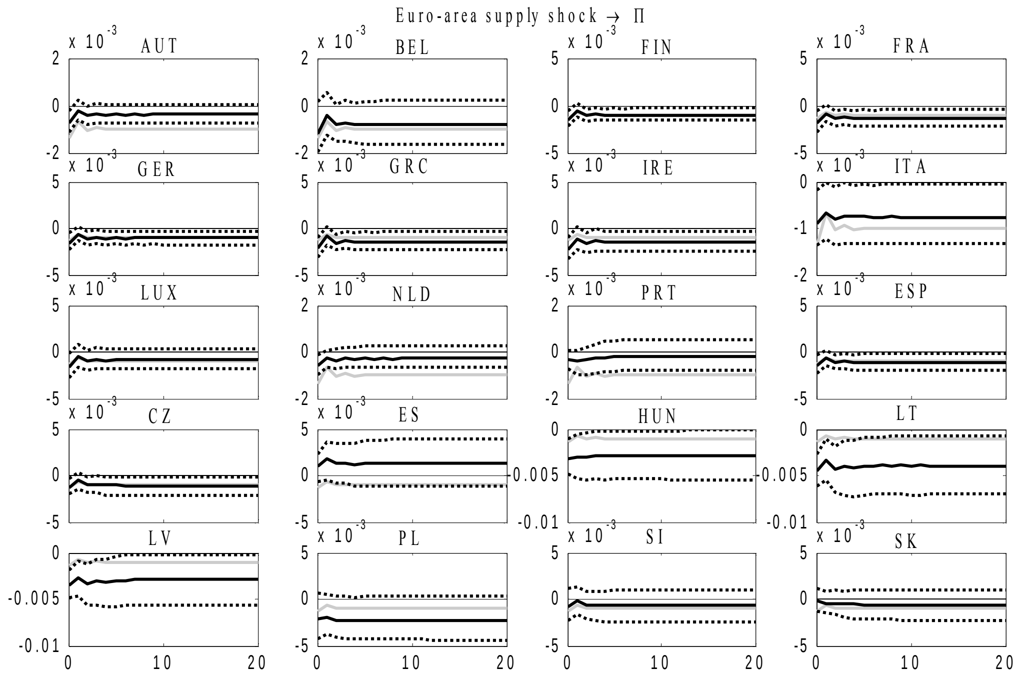
Figure 1: Responses of selected aggregate euro-area variables to euro-area shocks

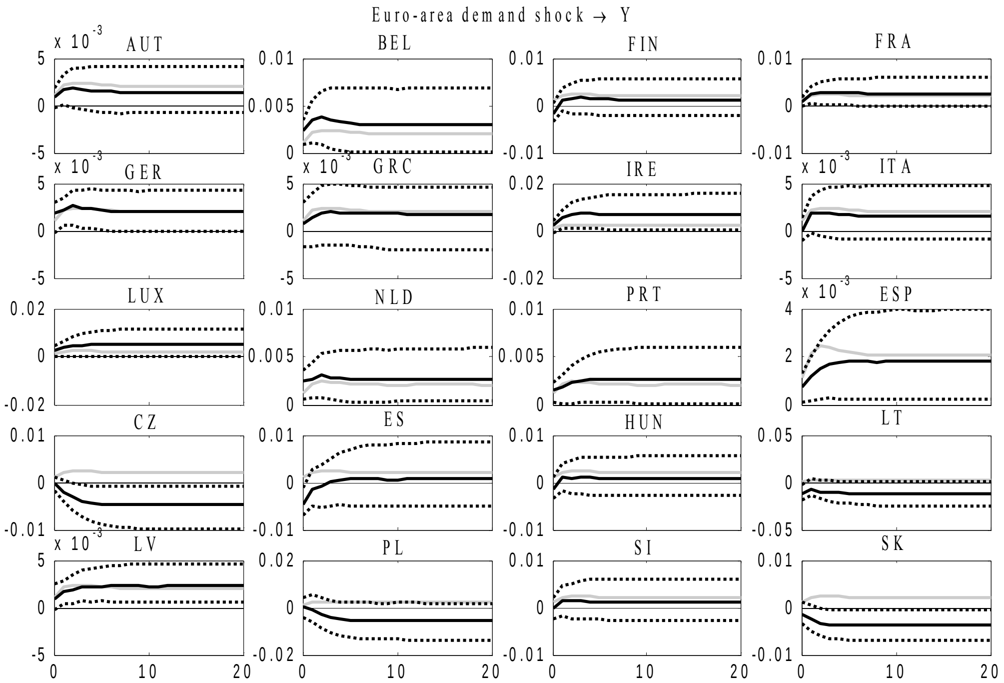


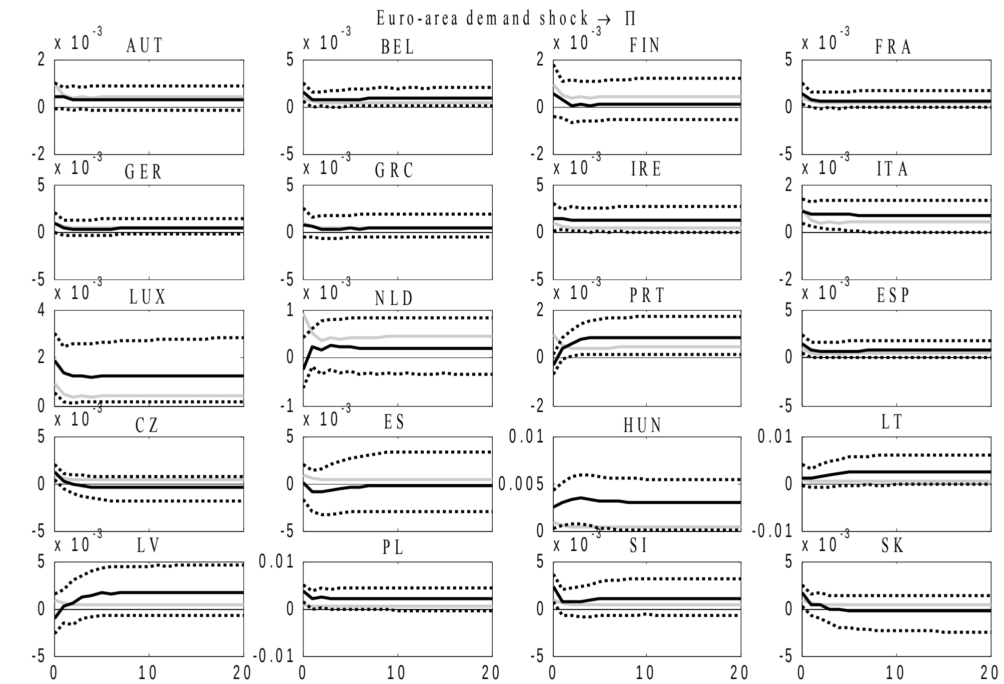
Notes
Impulse responses to shocks of size one standard deviation are shown. The median is represented by the solid line, 90% confidence bands by the dotted lines. Abbreviations are Y: real GDP, I: real investment, C: real consumption, N: employment, Y/N: labor productivity, Π: CPI inflation, ST i: short-term nominal interest rate, LT i: long-term nominal interest rate, EER real: real effective exchange rate, CA bal: current account balance.

Figure 2: Impulse responses of output and inflation of individual countries (black) and euro-area aggregates (gray) to euro-area shocks






Euro-area demand shock → Y
AUT
BEL
FIN
FRA
GER
GRC
IRE
ITA
LUX
NLD
PRT
ESP
CZ
ES
HUN
LT
LV
PL
SI
SK


Euro-area demand shock → Π
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BEL
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FRA
GER
GRC
IRE
ITA
LUX
NLD
PRT
ESP
CZ
ES
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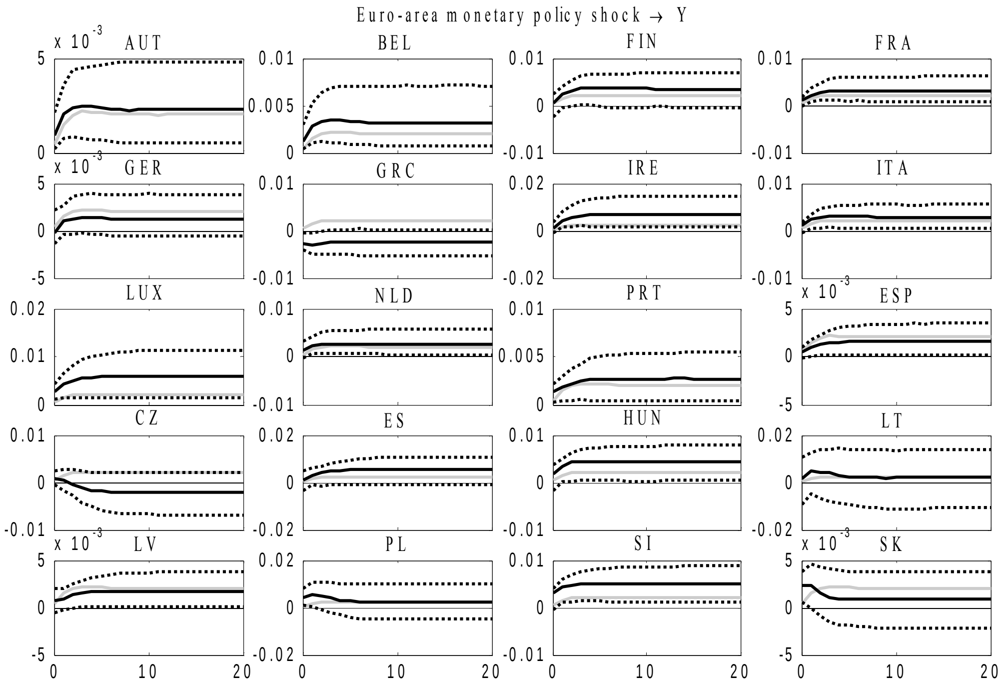
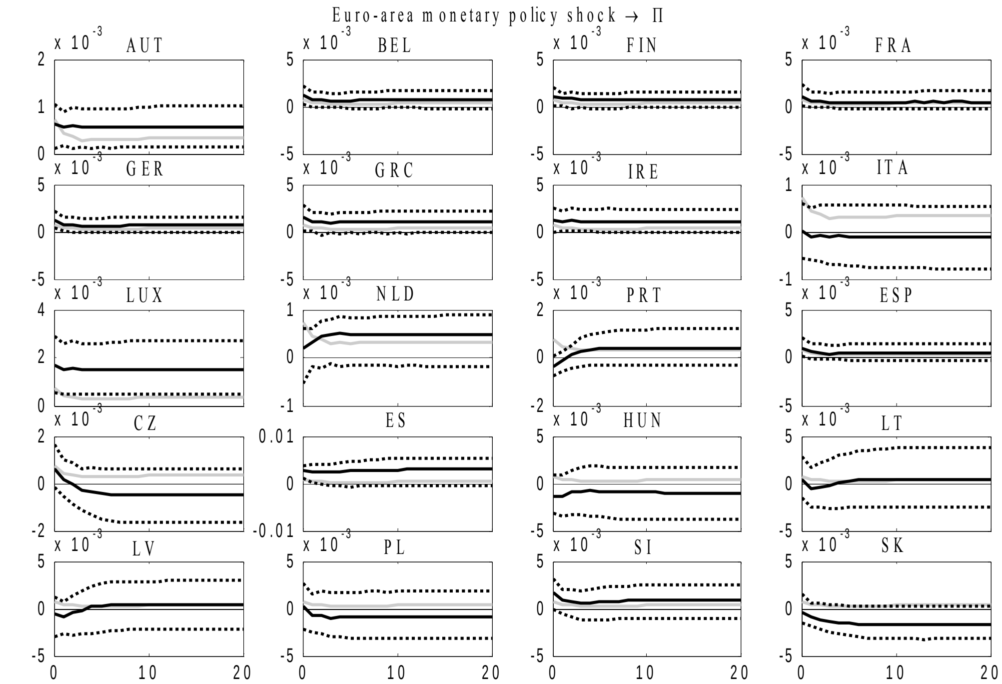
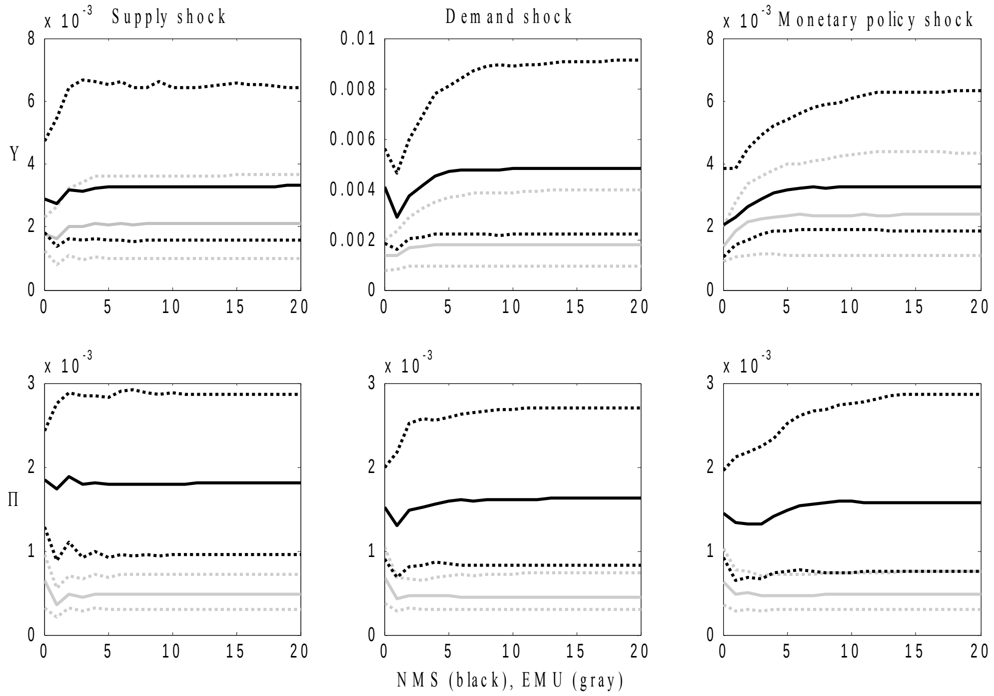




Notes
Impulse responses to shocks of size one standard deviation are shown. The medians are represented by the solid lines, 90% confidence bands by the dotted lines. Y refers to real GDP and Π to CPI inflation.

Figure 3: Standard deviations of impulse responses to euro-area shocks



Notes

Impulse responses to shocks of size one standard deviation are shown. The medians are represented by the solid lines, 90% confidence bands by the dotted lines. Y refers to real GDP and Π to CPI inflation.

Acknowledgement Note

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Endnotes

[1] See, for example, Ramos and Suriñach (2004) who discuss in detail alternative adjustment mechanisms and sketch possible benefits and costs of a monetary union. Von Hagen and Traistaru (2005) investigate wage flexibility in the NMS.

[2] It is also appropriate to mention the study by Banerjee, Marcellino and Masten (2005) who fit national large-scale dynamic factor models to five NMS to forecast GDP growth and inflation in these countries. The authors find that, in some cases, namely for Hungary and Slovenia, the inclusion of euro-area information can improve the forecasting performance of the national factor models.

[3] Banerjee, Marcellino and Masten (2005) also stress this advantage.

[4] This and other drawbacks inherent in traditional small-scale VAR models are not present in the Global VAR model recently brought forward by Dees, di Mauro, Pesaran and Smith (2005).

[5] The Agriculture and fishing, Manufacturing, Construction, Trade and transport, Finance and business as well as Other services industries are considered. Thus, $L = 6$ here.

[6] We also investigated linkages of individual countries with the rest of the world to account for third market effects. However, due to space constraints, statistics are not reported here, but are available upon request.

[7] When j refers to a EMU country, GDP_{EA} is GDP of the rest of the euro area.

[8] The authors, however, construct them only with respect to trade, not FDI.

[9] We omit the scale factors included in the Deardorff (1998) measures since we are not interested in the values themselves, but only in the trade and FDI intensities of some countries relative to other countries.

[10] In a previous version of the paper, we also reported all statistics for the EMU group excluding Portugal, Ireland and Greece. These three small peripheral countries were found to exhibit a relatively low synchronization with the rest of the euro area (which was confirmed by our findings) and are sometimes treated separately (cf. Korhonen, 2003, Fidrmuc and Korhonen, 2004b). Due to space constraints, we only consider the entire group of EMU countries here.

[11] Data covering the integration of Hungary with the euro area through FDI are not available. However, measures for Hungary's integration through FDI with the rest of the world suggest large FDI intensity compared with other NMS.

[12] We thank an anonymous referee for suggesting this analysis.

[13] We focus in this section on business cycle frequencies (6 to 32 quarters which is usually assumed), since only focusing on all frequencies may mask high values in some frequency bands and low or negative values in others.

[14] Value added and ecological tax increases in the Netherlands may have influenced Dutch consumer prices and caused them to move independently of euro-area consumer prices. The Dutch GDP deflator and producer prices move much more in parallel with euro-area prices.

[15] Bai and Ng (2002) suggest three other criteria which, however, depend on the maximum number of factors allowed for and which we do not consider here.

[16] These range between 32% and 55% (Eickmeier, 2005, Marcellino, Stock and Watson, 2000, Altissimo, Bassanetti, Cristadoro, Forni, Hallin, Lippi and Reichlin, 2001).

[17] Forni, Hallin, Lippi and Reichlin (2000) derived informal criteria to select q which are also based on dynamic principal component analysis.

[18] It is not unusual to identify euro-area monetary policy shocks even before the ECB superseded the national central banks as monetary authorities in 1999. Peersman and Smets (2002) and Sala (2003), for example, also identified common monetary policy shocks using synthetic euro-area data.

[19] See www.cepr.org/data/Dating/.

[20] This is consistent with Kose, Otrok and Whiteman (2003) and Eickmeier (2005) who find that world and regional factors explain a smaller share of consumption growth than of output growth in most euro-area countries and with the quantity anomaly puzzle emphasized in Backus, Kehoe and Kydland (1992).

[21] We compare our results with Peersman's (2005) since we use his identification scheme. Findings from other studies employing zero restrictions should already differ by construction.

[22] This was checked by fitting VAR models to output, prices and interest rates and by experimenting with different time periods and different data treatment. The omission of potentially relevant variables from the VAR model does not seem to play a role.

[23] The corresponding value for Dutch changes of the GDP deflator is much higher (62%).

[24] In order to improve the precision of the estimates we fitted a subset VAR model to the factors (cf. Lütkepohl, 1993). This, however, only led to very minor improvements. Results are not reported here, but are available upon request.

[25] Impulse responses are also multiplied by the variables' standard deviations.