No. 14 july 2005

Sandra Eickmeier
Jörg Breitung

How Synchronized are Central and East European Economies with the Euro Area? Evidence from a Structural Factor model

Research Paper Series
Thurgauer Wirtschaftsinstitut

THURGAUER
WIRTSCHAFTSINSTITUT
an der Universität Konstanz

How Synchronized are Central and East European Economies with the Euro Area? Evidence from a Structural Factor model

Sandra Eickmeier
sandra.eickmeier@bundesbank.de
Deutsche Bundesbank and
University of Cologne

Jörg Breitung
breitung@uni-bonn.de
University of Bonn and
Deutsche Bundesbank

ABSTRACT

july 2005

A high degree of cyclical synchronization between central and east European countries (CEECs) and the euro area is generally seen as a pre-requisite for successful EMU enlargement. This paper investigates comovements between CEECs and the euro area. We first establish stylized facts on economic linkages using dynamic correlation and cohesion measures. By means of a large-scale dynamic factor model, we then identify the main structural common euro-area shocks and investigate their transmission to the CEECs in comparison to the current EMU members. We finally carry out a counterfactual experiment which allows us to assess costs and benefits of an accession to EMU for individual CEECs in terms of economic volatilities and implications of an enlargement for synchronization. Overall, our results are mixed. Dynamic business cycle and inflation correlations between CEECs and the euro area are lower on average than between individual EMU members and the euro area, but they are higher than for some small peripheral EMU countries. This is confirmed by our other measure, variance shares of output and inflation explained by common euro-area factors. The proliferation of euro-area shocks to the CEECs does not differ significantly from the propagation to EMU countries in most cases. Based on our counterfactual experiment, we do not find significant stabilizing or destabilizing effects through a common monetary policy and fixed exchange rates. We also find that business cycle synchronization between CEECs and between most CEECs and the euro area will increase. There seems to be considerable heterogeneity across CEECs implying that for some countries, accession to EMU would be more costly than for others. According to our analysis and based on our measures, Poland, Slovenia, Hungary and Estonia are more suitable EMU candidates than other countries.

Keywords: Dynamic factor models, international business cycles, EMU enlargement, counterfactual experiment

JEL: F02, F41, F42, F47, E5, C32, C50

Address: Deutsche Bundesbank, Economic Resarch Center, Wilhelm-Epstein-Str. 14, 60431 Frankfurt/M., Germany

Many thanks go to Axel Jochem, Wolfgang Lemke, Heinz Herrmann and Sabine Herrmann for helpful comments and discussions. The views expressed in this paper do not necessarily reflect the views of the Deutsche Bundesbank or its staff.

How Synchronized are Central and East European Economies with the Euro Area? Evidence from a Structural Factor model

1. Introduction

In May 2004, eight central and east European countries (CEECs), the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovenia and Slovakia, (as well as Malta and Cyprus) became members of the European Union. Sooner or later, these countries will all join European Monetary Union (EMU). The successful enlargement of EMU requires a number of criteria to be satisfied. Those are optimum currency area (OCA) criteria and (Maastricht) criteria which partly reflect the OCA criteria. The latter 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.[1] The OCA criteria go back to Mundell (1961), MacKinnon (1963) and Kenen (1969), among others, and focus on the integration through trade and the synchronization of business cycles between candidate and member countries. If business cycles are not synchronized, possibly as a result of asymmetric shocks or differences in the transmission of common shocks due to different economic structures and policies, 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, and an early enlargement of a monetary union may be very costly.

The present paper addresses the current discussion on whether the CEECs are ready to join EMU by closer examining the synchronization between economies of the CEECs and the euro area between 1993 and 2003. We first establish some stylized facts on economic linkages in the euro area and CEECs and 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 CEECs in comparison to the EMU members and how they proliferate to these countries. As a byproduct, we determine the dimension of the euro-area economy, i.e., 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. Finally, we carry out a

[1] See www.ecb.int/ecb/enlargement/html/index.en.html.

counterfactual experiment in the spirit of Bernanke, Gertler and Watson (1997) to assess the costs (or benefits) in terms of output and inflation variability that would have resulted if the CEECs had already been members of EMU, and to examine possible consequences of EMU enlargement on synchronization, thereby acknowledging the endogeneity of economic synchronization.

Our paper is related to the burgeoning empirical literature on business cycle synchronization between the CEECs and the euro area. A comprehensive survey is given by the meta-analysis carried out by Fidrmuc and Korhonen (2004). Most studies simply compute static correlations between real economic activity in the CEECs and the euro area or Germany (e.g. Darvás and Szapáry (2004), Demanyk and Volosovych (2005), von Hagen and Traistaru (2005)). Artis, Marcellino and Proietti (2004), in addition, use concordance measures to investigate whether business cycles of CEECs are in or out of phase with business cycles of other CEECs and of euro-area countries. Another bulk of the literature estimates supply and demand shocks in the euro area and in the CEECs by means of small-scale VAR models and assess their correlations (Frenkel and Nickel (2002), Fidrmuc and Korhonen (2003), Hall and Hondroyiannis (2004)). 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 (2004)) 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 (2003) for monetary policy applications and Eickmeier (2004) for an international business cycle application). Sala's (2003) study is probably most similar in terms of methodology. Based on the period 1985 to 1998, he identifies a common euro-area monetary policy shock and investigates its impact on key variables of individual EMU member countries. He also performs a counterfactual experiment where he restricts the national interest rate responses to the common monetary policy shock to equal the average euro-area interest rate response and examines the responses of industrial production in EMU countries under this scenario.[2]

We go beyond the literature in various respects.

- First, economic linkages between CEECs and the euro area have, to our knowledge, not been investigated with dynamic correlations and cohesion before. These measures have the favorable feature that not only contemporaneous covariances, but also covariances at leads and lags are accounted for.

[2] It is also in order to mention the study by Banerjee, Marcellino and Masten (2004) who fit national large-scale dynamic factor models to five CEECs 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.

- Second, our study is the first examining the transmission of euro-area shocks to the CEECs 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 whereas VAR modelers rapidly run into scarce degrees of freedom problems 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 CEECs are available only for a short time span. A large cross-dimension can partly mitigate this drawback.[3] Another advantage is that the possibly heterogeneous responses of a large number of variables (all variables in the set) to common shocks can be investigated. This turns out to be very useful here. 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.[4] Here also lies an advantage over structural VAR (SVAR) models where the researcher has to take a stance on the variables to include which, in turn, influence the outcome, and where the number of variables determines the number of shocks. The only assumptions which are made in structural factor models serve to identify common structural shocks. However - and this represents another advantage -, the number of required identifying restrictions is generally much lower than the number of variables in the system, where in VAR models, the number of restrictions has to be at least equal to the number of variables.
- We assess the transmission of three structural euro-area shocks, a supply shock, a demand shock and a monetary policy shock. We therewith extend the studies by Darvás and Szapáry (2004), Korhonen (2003) and Boone and Maurel (1999) who focus on shocks to European (or German) real economic activity which, however, have no structural interpretation. Moreover, those studies do not provide confidence bands, which we will do here.
- Finally, we carry out a counterfactual experiment as in Sala (2003). We extend his analysis to the CEECs. In addition to restricting individual countries' interest rates to the euro-area average, we also restrict exchange rates. We believe that conditioning both interest and exchange rates better reproduces the EMU environment. Our focus on the cost and benefits in terms of economic volatilities and on synchronization which may result from an EMU enlargement also differs from Sala's (2003) focus which is mainly on the transmission of a common monetary policy.

This paper is organized as follows. Section 2 describes the data. Section 3 establishes some stylized facts on economic correlations and their determinants. Section 4 outlines the factor

3 Banerjee, Marcellino and Masten (2004) also stress this advantage.

4 These 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 (2004).

model and describes the estimation and the identification of the common structural euro-area shocks. Section 5 characterizes the shocks. Section 6 assesses the transmission to the CEECs. Section 7 carries out the counterfactual experiment, and Section 8 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 eight CEECs (Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Slovenia, Slovakia).[5] In addition, we include some global variables, among them US GDP and world energy prices. Studies have shown that fluctuations in these variables may influence the euro area (see, for example, IMF (2001), Jiménez-Rodríguez and Sánchez (2005), Dalsgaard, André and Richardson (2001), Peersman (2005)). The aggregate euro-area series are taken from the data set underlying the ECB's Area Wide Model (for a detailed description see Fagan, Henry and Mestre (2001)). 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 CEECs are not available for a longer time span. At the same time, this period has the favorable feature that the transitional recessions experienced by the CEECs in the early 1990s are largely excluded.

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, respectively, first differences of these variables for all countries and the euro-area aggregates in the set. Logarithms were taken of the series which were not in rates or negative, and we removed outliers.[6] 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.

[5] Of most countries (except for Lithuania - the reason will be given below), we include nominal bilateral exchange rates with the US Dollar. This is problematic since they are the same from 1999 on for the EMU countries (except for Greece which completed stage three of EMU accession in 2001). However, below, we will carry out a counterfactual experiment, which would become complicated if effective instead of bilateral exchange rates had been included in the set. Notice that we also estimated our factor model with effective exchange rates instead of bilateral exchange rates and obtain quasi identical factor estimates.

[6] Outliers are defined as observations that differed from the median by more than three times the sample interquartile range. Those were removed by setting them to this extreme bound.

3. Stylized facts on economic linkages

In this section, we establish stylized facts on economic linkages between the CEECs and the euro area and within the groups of CEECs and of EMU countries. In a first step, we have a look at some descriptive statistics on the determinants of economic comovements. These are not included in the data set. 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 CEECs by von Hagen and Traistaru (2005). Other statistics we use measure the integration of CEECs and EMU countries through trade and FDI. Although theoretically not clear, the impact of trade and financial integration on business cycle synchronization was shown to be positive in empirical studies (e.g. von Hagen and Traistaru (2005) for CEECs and Otto, Voss and Willard (2001), Kose, Otrok and Whiteman (2003a,b) as well as Imbs (2004) for industrial and other countries). In a second step, we link output and inflation of CEECs and the euro area with uni- and multivariate dynamic correlation measures.

Following Krugman (1991), we define structural similarities of a country *j* and the euro area S_j, here denoted by *EA*, 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, respectively, the euro area.[7] Small values indicate greater structural similarity.

Trade and FDI linkages of individual countries with the euro area and the rest of the world, the latter enabling us to account for third market effects, are measured as follows:

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

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

$\mathrm{EX}_{jk} / \mathrm{FDI}^{\mathrm{out}}_{jk}$ and $\mathrm{IM}_{jk} / \mathrm{FDI}^{\mathrm{in}}_{jk}$ denote exports/direct investment of country *j* to region *k* (which is the (rest of the) euro area or the world) and, respectively imports/direct investment

[7] The industries Agriculture and fishing, Manufacturing, Construction, Trade and transport, Finance and business as well as Other services are considered.

from region k to country j. GDP_j and GDP_k denote nominal GDP of country j and region k.[8] Those indexes are based on Frankel and Rose (1998) and Deardorff (1998) (and used and discussed in Clark and Wincoop (2001)).[9] TR^2 and FDI^2 are derived from gravity models.[10] 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 intensity between two countries/regions. For data availability reasons, we focus on 2003 (for the structural similarities and FDI measures) and 2002 (for the trade measure).

On average, individual EMU countries exhibit an industry specialization which is more similar to the euro-area industry specialization than CEECs (Table 2). The discrepancy is even larger when Portugal, Ireland and Greece are excluded from the group of EMU group. These three small peripheral countries were found to exhibit a relatively low synchronization with the rest of the euro area and are sometimes treated separately (e.g. Korhonen (2003), Fidrmuc and Korhonen (2004)). Of the CEECs, Hungary and Estonia exhibit low values, whereas Lithuania and the Czech Republic are specialized on 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 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 CEECs 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 not captured by our one-point-in-time-analysis.

Of the EMU members, industry structures in Luxemburg, Greece and Ireland also differ quite much 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, CEECs seem to be more 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 and the rest of the world than CEECs are with the euro area and the rest of the world 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 CEECs, Slovakia, the Czech Republic, Hungary and Estonia are most highly integrated with the euro area and the rest of the world. The measures for these countries are even larger than those for various EMU members countries; Greek trade with the euro area and the rest of the world is especially low. Of the

8 When j refers to a EMU country, GDP_k is GDP of the rest of the euro area or world.

9 The authors, however, construct them only with respect to trade, not FDI.

10 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.

CEECs, Latvia and Lithuania do not trade much with the euro area and the rest of the world. As concerns FDI intensity, both the FDI^1 and, in contrast to trade integration, also the FDI^2 measures indicate higher integration of EMU countries compared to CEECs. Notice especially the high values for Ireland, the Netherlands and Belgium. Of the CEECs, values are relatively high for the Czech Republic, Estonia, Slovakia and Hungary, whereas FDI linkages seem to be unimportant for Lithuania. In contrast to the industry specialization measure, the dispersion across CEECs is smaller, and this holds for all integration measures.

We now extract GDP growth and changes in CPI inflation of individual countries and the corresponding euro-area aggregates from our large data set. Those are shown in Figure 1. There is evidence of some economic comovement between CEECs and the euro area. Output linkages seem looser than inflation linkages, and the comovements with the euro-area aggregates are stronger for individual EMU countries than for CEECs. It should be kept in mind that the euro-area aggregates include output and inflation growth from individual EMU countries. Those should therefore, by construction, be more highly correlated with the euro-area aggregates than CEECs' output and inflation growth. In addition, output and inflation growth in larger EMU countries can be expected to be more highly correlated to the euro-area aggregates which are weighted averages, than output and inflation growth in smaller EMU countries.

To establish stylized facts on cyclical synchronization, we compute three statistics. Our first statistic is dynamic correlations between output and inflation growth from individual countries and the corresponding euro-area aggregates. 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

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

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. Dynamic correlations have the convenient property that they lie between -1 and 1. Phase shifts are eliminated and, besides contemporaneous covariances, covariances at leads and lags are taken into account. It should again be kept in mind that a bias in the measure results from the fact that the euro-area aggregates contain output and inflation growth from individual EMU countries. Nevertheless, we will be able to derive some interesting conclusions when comparing correlations of output and inflation growth in smaller EMU countries and the CEECs.

Our second statistic is the lags or leads at which aggregate euro-area variables exhibit the maximum correlation with variables of individual countries. We allow for a maximum of four leads and four lags. Positive values indicate by how many quarters the euro-area aggregate leads the corresponding individual country's variable.

Croux, Forni and Reichlin (2001) extended the dynamic correlation measure to the multivariate case. The so called cohesion, which is the third statistic to which we refer, is defined as the weighted average of dynamic correlations between all possible pairs of series belonging to a certain group $\tilde{y}$:

$$coh_{\tilde{y}}(\omega) = \sum_{i \neq j} w_i w_j \rho_{y_i, y_j}(\omega) / \sum_{i \neq j} w_i w_j \,, \qquad (5)$$

where w_i denotes the weight for variable y_i. We give equal weight to the variables, so that $w_i = 1, \forall i$. We focus on the groups of all countries, CEECs, EMU member countries and EMU member countries without Portugal, Ireland and Greece. The three statistics are reported in Tables 3 and 4 and in Figure 2. The following conclusions can be drawn.

- Output and inflation growth in EMU countries are on average (this refers to the unweighted average) more highly correlated with the corresponding euro-area aggregates (0.63 and, respectively, 0.47 at business cycle frequencies[11]) than in the CEECs (0.17 to 0.20). The discrepancy is larger when Greece, Portugal and Ireland are excluded from the EMU group. Not surprisingly (as mentioned above), of the current EMU members, dynamic correlations are highest for the largest economies France and Germany. With respect to output growth, they are very low for Portugal and even negative for Greece. With respect to changes in inflation, Portugal and - perhaps surprisingly - the Netherlands exhibit very low values.[12] There is also considerable heterogeneity within the group of CEECs. Dynamic correlations of output growth are relatively high for Slovenia, Hungary, Poland and Estonia (but still lower than for most of the EMU countries), whereas they are very low or even slightly negative for the Czech Republic, Lithuania and Slovakia. The Russian crisis in 1998/99 which mainly affected the Baltic countries and, although to a lesser extent, Slovakia as well as the Czech financial crisis in 1996/97 may explain these loose linkages. Correlations of inflation growth are highest for Lithuania, Poland, Slovenia and Hungary (but are, again, still lower than for most EMU countries) and, on the other extreme, virtually zero for Slovakia.
- Inflation growth of the CEECs seems to be somewhat more correlated to its 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 CEECs. The difference, however, falls when Greece, Portugal and Ireland are not

[11] We focus in this section on business cycle frequencies (6 to 32 quarters which corresponds to the frequency band 0.2 to 1.0 and 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.

[12] Value added and ecological tax increases in the Netherlands may have influenced Dutch consumer prices and led them to move independently from euro-area consumer prices. Notice that the Dutch GDP deflator and producer prices move much more in parallel with euro-area prices.

taken into account (relative positions even change for output growth at business cycle frequencies).

- Fluctuations in aggregate euro-area output and inflation growth generally do not (or barely) lead or lag fluctuations in individual countries' output and inflation growth. An exception is Luxemburg which lags the euro area in terms of output growth by one quarter and where the correlation is notable. Results for other countries which lag behind or lead the euro-area aggregate should be interpreted with caution; the correlations are quite low (all lower than 0.4) and they vary substantially across different leads and lags. In some cases, the sign is even reversed when contemporaneous and maximum correlations are compared.
- Our cohesion measures suggest more synchronization across EMU countries than across CEECs. On average over all frequencies it amounts to 0.21 in EMU and to 0.10 in the group of CEECs with respect to output growth. This difference increases when Greece, Portugal and Ireland are not taken into account and when only business cycle frequencies are considered. The cohesion measures are higher for inflation growth (0.28 for the EMU group and 0.16 for the CEECs' group).

Our findings are roughly in line with existing studies. We find particularly high business cycle correlations between Hungary, Poland and Slovenia and the euro area, which is consistent with the literature (Fidrmuc and Korhonen (2004)). In addition, we confirm previous findings that correlations are higher for many CEECs than for Greece and Portugal. Dynamic correlations suggest that the group of EMU countries is more heterogeneous than the group of CEECs. This result, however, differs from Artis, Marcellino and Proietti (2004) and Fidrmuc and Korhonen (2003) who find the opposite.

4. Model, estimation and identification of shocks

This section introduces the factor model which will serve us to investigate the transmission of euro-area shocks to the CEECs. 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:

$$\mathrm{Y}_t = \mathrm{X}_t + \Xi_t = \sum_{j=0}^{m} \Lambda_j \mathrm{f}_{t-j} + \Xi_t = \Lambda \mathrm{F}_t + \Xi_t, \tag{6}$$

where f_t is a $q \times 1$ vector of common dynamic euro-area factors and $\Lambda_j (j = 0,...,m)$ is a $N \times q$ matrix of factor loadings associated with lag *j*. X_t and Ξ_t are a $N \times 1$ 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 $r \geq q$ so called 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 representation of the factors:

$$\mathrm{f}_t = \sum_{l=1}^{p} \mathrm{A}_l \mathrm{f}_{t\text{-}l} + \mathrm{v}_t . \qquad (8)$$

The shocks w_t are related to the orthogonal innovations v_t through the structural equation

$$\mathrm{w}_t = \mathrm{R}'\mathrm{v}_t . \qquad (9)$$

Provided that there are enough identifying restrictions on R, the structural shocks w_t can be recovered from the factor innovations.

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 CEECs 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 (Table 5).[13] 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 (2003), Artis, Banerjee and Marcellino (2004)). Another reason is that five factors explain 44% of the total variance, which is consistent with previous findings for macroeconomic euro-area data sets[14], whereas the share accounted for by two factors is relatively low (26%), see Table 6.

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 $\hat{\mathrm{F}}_t$. The lag order of the VAR model was estimated with the Schwarz information criterion. It is important to note that the VAR representation for $\hat{\mathrm{F}}_t$ is singular if the r-dimensional vector $\hat{\mathrm{F}}_t$ 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 $\hat{\mathrm{F}}_t$, 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 $\hat{\mathrm{v}}_t$

[13] 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.

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

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 (2004) (Table 7). 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 6).[15]

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.[16] This is achieved by applying the identification scheme recently proposed by Peersman (2005) which consists in imposing short-run sign restrictions on impulse responses. 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.[17] 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 (2002). The $q \times 1$ vector of impulse response functions of variable i to the shocks $\mathrm{w}_t = (\mathrm{w}_{1t} \ \ldots \ \mathrm{w}_{qt})'$ at horizon h is given by $\Phi_{ih} = \partial y_{it+h} / \partial \mathrm{w}_t$. We report the median impulse responses and 90% confidence bands which were constructed using bootstrap techniques. For details on the estimation and the bootstrap, see Appendix A.

5. Characterization of euro-area shocks

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

[16] It is not unusual to identify euro-area monetary policy shocks even before the ECB replaced the national central banks as monetary authorities in 1999. Peersman and Smets (2001) and Sala (2003), for example, also identified common monetary policy shocks using synthetic data.

[17] This has already been pointed out by Darvás and Szapáry (2004).

Figure 3 plots the median point estimates of the structural shock series. As already pointed out in the introduction, the fact that we can estimate 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.[18] There was (and still is) some controversy about the underlying shocks.

In what follows, we identify the main sources of economic fluctuations in the euro area. Table 8 shows that the overwhelming part of key euro-area aggregate variables is 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.[19]

Impulse responses, shown in Figure 4, look roughly consistent with those found in the literature. However, some differences to Peersman (2005) appear.[20] 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). There are three possible explanations for the different shapes of impulse responses. First, remember that we differenced the series unless they were already stationary as has become the usual proceeding in large-dimensional factor analysis. I.e. our panel contains prices in second and interest rates in first differences. Peersman (2005), by contrast, includes prices and interest rates in first differences and, respectively, in levels and a linear time trend in his VAR model. Second, we focus on a different period (Peersman's (2005) period is from 1980Q1 to 2002Q2), and the nature of the shocks may have changed over time. Third, we estimate a factor model with many variables as opposed to Peersman (2005) whose VAR model contains four variables. If important variables are omitted, this may lead to biased parameter estimates and may yield counterintuitive impulse response functions, as shown, for example, by Bernanke, Boivin and Eliasz (2003). To find out, which of the three explanations is valid, we fitted a VAR model to consumer prices in second differences and short-term interest rates and GDP in first differences for the period underlying our analysis as well as for the period 1980 to 2003. This yielded impulse response functions very similar to those obtained based on the factor model, suggesting that the shock identification does not hinge much on the variables not included in the VAR model. We are able to replicate Peersman's (2005) results when we included prices in first differences and interest rates in levels as well as a linear time trend in

---

18 See www.cepr.org/data/Dating/.

19 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). The puzzle is that international risk sharing theoretically implies high correlations of consumption across countries and lower cross-country output correlations, whereas empirically, consumption is found to be correlated to a weaker extent than output.

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

the VAR model and when we estimated the model for the period 1980 to 2003. When we estimated the model for the more recent period, the demand shock displays temporary effects on output and interest rates, but still permanent effects on prices. The monetary policy shock has still long-lasting effects on output and prices. Overall, this exercise leads us to conclude that it is the treatment of the data and our focus on a more recent period that can explain differences between our and Peersman's (2005) findings.

Most of the variance of the forecast error of the common component of euro-area output associated with the entire period 1993 to 2003 can be explained by the demand and monetary policy shocks (40% and 39%) at forecast horizons zero to five years (Table 9).[21] Only 19% is accounted for by the supply shock. By contrast, the common component of inflation was mainly affected by the supply shock (76%). The demand shock accounts for 16% and the monetary policy shock for 7% at all horizons.

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 10 and Figure 5. 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 virtually zero. Inflation during this period increased only modestly - in contrast to what is typically observed in periods of economic expansion - mainly due to the positive supply shock. It is striking how much in parallel the paths of the total forecast error of the common component of inflation and of the corresponding forecast error explained only by the supply shock move. 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 on 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 effects from the negative demand shock.

Other questions raised in view of the two economic phases were on the reasons for the massive depreciation of the Euro (against the Dollar) during the expansion, and on the determinants of stock prices. In particular, it is controversial whether monetary policy fueled the stock market bubble in the second half of the 1990s and provoked its subsequent bursting. Figure 4 shows that the euro-area real effective exchange rate does not react significantly to supply and demand shocks. But it depreciates significantly in response to the monetary policy shock, which is consistent with theory (see, for example, the model outlined in Clarida and

[21] It is referred to the median estimate and to forecast horizons zero to five years. Variance decompositions for the short run (zero to one year) and the medium run (three to five years) are available upon request.

Galí (1994)). Most of the forecast error variance of the common component of the exchange rate is also explained by the monetary policy shock (64% at all horizons), followed by the demand shock (26%) and the supply shock (9%). This is in line with empirical findings by Canzoneri, Vallés and Viñals (1996) for euro-area countries and those by Clarida and Galí (1994) for Germany at short-term forecast horizons. By contrast, demand shocks explain most of medium-run exchange rate fluctuations in Clarida and Galí (1994). This is, however, partly due to the identification scheme, which imposes zero long-run responses of the exchange rate to the monetary policy shock. According to our historical decompositions, the real effective euro-area exchange rate was mainly driven by the demand, but also by the monetary policy shocks during the expansion (Table 10).

Fluctuations of the common components of stock prices were mainly determined by the monetary policy shock. It explained on average over all core euro-area countries[22] 51% of the forecast error variance at horizons zero to five years. The remaining variance is accounted for by the supply and the demand shocks in roughly equal shares. This is in line with our findings based on historical decompositions. The stock market boom during the expansion was mainly due to the monetary policy shock. The demand shock also had a stimulating, although smaller, impact on stock prices. Perhaps surprisingly, the supply shock barely contributed to stock prices increases. The subsequent strong downturn can also be explained by the monetary policy shock; the supply shock also contributed negatively to stock price fluctuations, but to a smaller extent. [23]

It is often argued that external shocks, and in particular US shocks, played a major role for the euro area during the period on which our analysis is based. We cannot exclude that external shocks underlie our identified euro-area shocks. In the literature, there are two views on shocks that have an international impact. One is to consider them as global shocks that hit countries roughly simultaneously. The other view is to consider them as country-specific (i.e. US) shocks that spread internationally. The latter clearly takes a stance on the origin of the shocks. Those would be recovered based on identifying restrictions on variables associated with the country where the shocks emerge. The former view, by contrast, does not take a stance on the origin of the shocks, and global shocks can be recovered as correlated national shocks. This is the view we adopt here.

6. Business cycle transmission from the euro area to the CEECs

Let us now turn to the original focus of our analysis. Table 11 shows how much of the variance of output and inflation growth in CEECs and EMU countries is explained by the

[22] Recall that only stock prices of the core euro-area countries are included in our data set.

[23] The median forecast error of the common components of core euro-area countries' stock prices increased by 17.4% during the expansion. The forecast error only explained by the supply/demand/monetary policy shock changes by -1.7/5.6/12.5%. The total forecast error declined by 15.7% during the recession; a change by -4.3%/0.4%/-13.0% can be explained by the supply/demand/monetary policy shock.

euro-area factors. On average, the common factors explain a larger part of output and inflation growth in EMU economies (44% and 37%) compared to the CEECs (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 growth in the Netherlands and in Portugal (2% and 19%).[24] Interestingly, these shares are smaller than the corresponding shares in a number of CEECs. Of the latter, Poland, Lithuania, Slovakia, Hungary and Estonia exhibit the largest variance shares explained by the euro-area factors in terms of output growth (between 28% and 43%) and Latvia, Hungary, Lithuania and Poland 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 of inflation growth variations in Slovakia and the Czech Republic (6% and 10%). The dispersion across EMU countries is almost twice the dispersion across the CEECs. The difference is somewhat lower with respect to output growth when Greece, Portugal and Ireland are excluded from the EMU group.

Figure 6 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 CEECs. Confidence bands are relatively wide. It is, nevertheless, good news 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. 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, Lithuania, Poland and, on impact, Estonia. Output responses to the monetary policy shock are not significantly different. Responses of inflation in the CEECs are very similar to the euro-area responses, with the exception of Slovakia, which exhibits a negative reaction of inflation to the euro-area monetary policy shock, which is, however, barely significant. Of the EMU countries, the relatively weak inflation responses in Portugal to all three shocks, the Netherlands to the supply and demand shocks, Austria to the supply shock and Luxemburg to the monetary policy shocks are noticeable. Variance decompositions lead to similar conclusions (Table 11).

We now examine the standard deviations of impulse responses across countries. According to Figure 7, the dispersion of inflation responses across CEECs is in all cases larger than across EMU members, whereas confidence bands of the standard deviation of output responses across CEECs overlap with the corresponding confidence bands across EMU countries.

[24] As already mentioned above, the low value for the Netherlands seems surprising. The corresponding value for Dutch changes of the GDP deflator is much higher (62%).

Output responses are in some periods, however, more heterogeneous across CEECs than across EMU countries without Greece, Portugal and Ireland. These findings differ from our previous results 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 to what extent euro-area shocks affect individual CEECs. According to Korhonen (2003), the variance shares of industrial production fluctuations in the CEECs 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 between 55% and 80% when explained by a German shock and between 24% and 35% when explained by a European Union shock. The size of our variance shares lies 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 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, Hungary and Estonia, but very little in Latvia.

Darvás and Szapáry (2004) and Korhonen (2003) also compare impulse responses to euro-area shocks of economic activity in CEECs 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 CEECs. Of the CEECs, 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 CEECs. 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 CEECs 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 CEECs 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 CEECs and the euro area are not significant in most cases.

7. Counterfactual experiment

In this section, we investigate how output and inflation in the CEECs (and EMU member countries) would have evolved if EMU had already been established in 1993 and if the CEECs had been members. We address two hypothetical questions. The first is whether the

CEECs would have gained or lost in terms of output and inflation growth variabilities in this counterfactual case compared to the effective baseline case. The variances of output and inflation (as deviations from their steady states) are generally arguments in the loss function of a central bank. We therefore take the variabilities of output growth and changes in inflation as proxies for economic welfare. The second question is how an early membership would have influenced synchronization. We thereby acknowledge that synchronization is, like other OCA criteria, endogenous (e.g. Frankel and Rose (1998)), i.e. accession to EMU would lead to more synchronization between new and old members.

From a theoretical perspective, the answers to the two questions are not clear. Abandoning its independent monetary policy and fixing the exchange rate may mean that a country looses important stabilization tools that can be employed to respond to asymmetric shocks. Joining a monetary union would, in this case, *ceteris paribus* raise the volatility in the economy and lower synchronization if other adjustment mechanisms like wage and price flexibility or factor mobility do not fill the gap.[25] If, however, national monetary policies and exchange rates were themselves sources of destabilization, a country could benefit from joining a monetary union.[26] An accession would then, *ceteris paribus*, lead to a more stable economic environment and tighter cyclical linkages between the members of the monetary union. The two questions thus need to be addressed empirically.

We carry out a counterfactual experiment. The experiment consists in restricting the paths of national short-term nominal interest rates, which we take as proxies for monetary policy instruments, and national nominal exchange rates to coincide with the paths of the corresponding euro-area aggregates. This is achieved by collecting the idiosyncratic components of changes in output, inflation, short-term nominal interest rates and exchange rates specific to an individual country and by fitting a VAR model to them. This is done for each country. In the spirit of Bernanke, Gertler and Watson (1997)[27], we then add innovations to the residuals of the idiosyncratic components of the interest and exchange rate equations (which are the differences between the series and the common components multiplied by their standard deviations) so that the restrictions are satisfied.[28] [29] One may want to think of this experiment as a national central bank that intervenes whenever interest rates and exchange rates deviate from their aggregate euro-area counterparts in order to realign them. It should be

---

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

[26] This has been discussed and investigated for the UK, Canada, Denmark and Sweden in Artis and Ehrmann (2000).

[27] Their focus is on the role of systematic monetary policy in response to oil price shocks. They add innovations to the short-term interest rate equation in order to shut down monetary policy responses to oil price shocks.

[28] We restrict interest rates and exchange rates separately and both at the same time. To conserve space, we do not report the former results here and solely focus on the case where both interest and exchange rates are restricted. Findings based on experiments where either interest or exchange rates are restricted are available upon request.

[29] Since Lithuania had fixed its currency to the Dollar between 1994 and 2001, we do not use the bilateral exchange rate with the US Dollar but with the Euro for Lithuania and restrict it to be constant in the counterfactual scenario.

kept in mind that our model is able to account for the effects described in the preceding paragraph. However, medium-run effects of accession to a monetary union, like those resulting from stronger trade and financial market linkages, cannot be captured. In addition, one needs to be aware that this experiment is subject to the Lucas critique. Details on the counterfactual experiment are described and the underlying assumptions are discussed in Appendix B.

According to Figure 8, output is significantly higher in the mid-1990s and for a somewhat sustained period of time in Latvia and Poland and inflation significantly lower in Hungary under the counterfactual scenario compared to the baseline scenario. Let us now address the first hypothetical question raised at the beginning of this section. It can be seen from Table 13, that output growth variabilities are lower in the counterfactual case than in the baseline case in Estonia, Poland and Latvia. Inflation growth variabilities are lower for Slovakia, Slovenia, Poland and Lithuania, suggesting that these countries would benefit from joining EMU. The volatility of both interest rates and exchange rates declines in most cases (except for the Czech Republic, where interest rate volatility increases, and for Latvia, where exchange rate volatility rises). Differences between the counterfactual and the baseline cases are, however, not statistically significant.

We also restrict the interest and exchange rate paths of individual current EMU members to the corresponding aggregate euro-area paths from 1993 to 1998 (and to 2000 in the case of Greece) to provide some comparison. We are aware that focusing on different periods does no provide full comparability since one period may be characterized by more or larger asymmetric than symmetric shocks, whereas this does not need to hold for other periods. Output would have been lower in the Netherlands and Portugal during the entire period, whereas inflation would have been lower in Germany in the first half of the period. Output variability would have declined in most cases had these countries already started to form a monetary union in 1993, except for Portugal, the Netherlands, Ireland and Belgium, where output volatility would have risen. Austria, Finland, France, Greece and Portugal would have benefited from lower inflation growth variability. The impact of a monetary union on output and inflation growth volatilities seems to be larger for EMU countries than for new EU member states. But as was the case for the CEECs, differences between the counterfactual and the baseline scenarios are not significant.

To investigate the implications of an enlargement for synchronization between CEECs and the euro area and within the different groups of countries, we compare dynamic correlations between output and inflation growth in individual countries and the corresponding euro-area aggregates as well as cohesion across members of each of the groups in the baseline case with the counterfactual cases. The estimation relies on the median estimates of the counterfactual series. Overall, our results confirm the endogeneity of the business cycle synchronization criterion, whereas this evidence is less clear for inflation linkages. On average, dynamic correlations between individual countries' and euro-area output growth in the EMU countries and in the CEECs are higher in the counterfactual case than in the baseline case (Table 14). Of the CEECs, Hungary and Slovenia would exhibit the largest increases in the case of EMU enlargement. Dynamic correlations would also rise in the Czech Republic, Latvia and Poland, whereas they would decline or remain roughly constant in the other CEECs. Had EMU already be formed in 1993, synchronization between output growth in individual countries, except for France, Germany and Greece, and the euro-area aggregate would have been higher than it actually was. Changes in inflation in EMU countries are slightly more correlated on average with the euro-area aggregate in the counterfactual compared to the baseline case. The opposite holds for the CEECs. Of the CEECs, a larger positive correlation with euro-area inflation growth can, however, be observed in Estonia and a smaller negative correlation in Slovakia. Of the EMU countries, the correlation is lower in the counterfactual case compared to the baseline case in France, Spain and Portugal.

The cohesion measure was constructed for the CEECs for the period 1993 to 2003 and for the other groups (EMU, EMU without Greece, Ireland and Portugal, all countries) for the period 1993 to 1998. Figure 7 shows the measures for both scenarios. It suggests that synchronization is more pronounced in all groups in the counterfactual case compared to the baseline case.[30]

8. Conclusion

Overall, results are mixed. Business cycle correlations between the CEECs 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 like Greece and Portugal. A similar picture is found for inflation correlations and for variance shares explained by common euro-area shocks. Based on all these criteria, Poland, Slovenia, Hungary and Estonia seem to qualify for accession to EMU. Of those countries, Hungary and Estonia are particularly strongly integrated in terms of trade and FDI with the euro area and exhibit similary industry structures. For the Czech Republic, Slovakia and Latvia, it may be too early to become EMU members. Lithuania seems to be a special case: its output growth correlation with the euro area is very low, whereas inflation growth correlations and the variance of output and inflation growth explained by euro-area factors are quite high.

As a byproduct we identify the main sources of economic fluctuations in the euro area between 1993 and 2003. We estimate three common euro-area shocks, a supply shock, a demand shock and a monetary policy shock. Based on historical decompositions, we find that

[30] In order to account for the different periods, which are considered for different groups of countries, we also computed cohesion measures for the CEECs for the period 1993 to 1998. Results are very similar for output growth correlations. However, the cohesion of inflation growth is slightly smaller at business cycle frequencies in the counterfactual scenario compared to the baseline scenario.

the favorable economic performance of the euro area between 1993 and 2000 can mainly be explained by the demand shock which stimulated output and the supply shock 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.

It is good news that the transmission of common euro-area shocks to the CEECs does not seem to differ significantly from the propagation to EMU countries in most cases, basically with the exceptions of output responses of Latvia after the euro-area supply shock and the Czech Republic, Slovakia and Lithuania to euro-area demand shocks and the inflation response of Slovakia after the monetary policy shock. Those responses are weaker than the corresponding euro-area responses or even negative.

According to our counterfactual experiment, accession to EMU would basically be beneficial for Poland and Latvia in terms of higher output growth and lower output growth variability, for Estonia in terms of lower output growth variability, for Hungary in terms of lower inflation and Poland, Slovakia, Slovenia and Lithuania in terms of lower inflation growth variability. Stabilizing effects through a common monetary policy and fixed exchange rates, however, are not found to be significant. Business cycle linkages with the euro area can be expected to get closer in Hungary, Slovenia, the Czech Republic, Latvia and Poland, inflation growth linkages in Estonia. The cohesion within the group of the CEECs is expected to rise.

No clear conclusions can be drawn on whether CEECs or EMU countries form the more heterogeneous group. Our various estimates point in different directions. Nevertheless, there seems to be considerable heterogeneity across CEECs implying that for some countries, accession to EMU would be more costly than for others. According to our analysis and based on the measures used here, Poland, Hungary, Slovenia and Estonia are more suitable accession candidates than other countries. The two latter countries also signaled their intention to quickly become members of EMU.

Our analysis has a number of caveats to be kept in mind. One is the relatively short time span. This may imply that shocks, which were estimated here, may not be fully representative for the future. Another is the backward-looking nature of the analysis. This seems particularly relevant for the CEECs which go through a phase of structural changes and where the relationship with the euro area already differs nowadays from the relationship in the previous decade. 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 integration via trade and various Maastricht criteria are not investigated in this paper. It finally seems appropriate to re-stress the endogeneity of OCA criteria. It can be expected that economies will become more synchronized mainly through increased trade linkages and financial integration. Those channels are, however, not captured by our model. We therefore probably have underestimated the impact of EMU enlargement on economic comovements.

Appendix A

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.

$$\hat{F}_t = \hat{V}'Y_t, \qquad \text{(A1)}$$

where $\hat{V}$ is the $N \times r$ matrix of eigenvectors corresponding to the largest r eigenvalues of the sample correlation matrix. $\hat{V}$ is an estimate of the matrix of factor loadings Λ. The estimated vector of static factors $\hat{F}_t$ has a VAR(1) representation, and OLS is applied to each equation yielding the reduced form VAR residuals $\hat{u}_t$.

The q-vector of orthogonalized residuals is estimated as

$$\hat{v}_t = M^{-1/2}P'\hat{u}_t, \qquad \text{(A2)}$$

where M is a $q \times q$ matrix with the largest q eigenvalues of $\text{cov}(\hat{u}_t)$ on the main diagonal and zeros elsewhere and $\text{cov}(\hat{v}_t) = I_q$. P is the corresponding $r \times q$ matrix of eigenvectors. The vector of orthogonalized residuals $\hat{v}_t$ is linearly related to the vector of structural shocks w_t through the $q \times q$ orthonormal rotation matrix R:

$$\hat{w}_t = R'\hat{v}_t, \qquad \text{(A3)}$$

with $\text{cov}(\hat{w}_t) = I_q$ and $R'R = I_q$. The $q \times 1$ vector of impulse response functions of variable i to the shocks $(w_{1t} \quad \ldots \quad w_{qt})$ at horizon h is given by[31]

$$\Phi_{ih} = (\lambda_i' A^h P M^{1/2} R)', \qquad \text{(A4)}$$

where λ_i is the ith row of Λ. R has to be chosen such that the identifying restrictions specified in the main text are satisfied. Any rotation matrix R can be parametrized as follows

$$R(\theta_1,\theta_2,\theta_3) = \begin{pmatrix} \cos(\theta_1) & -\sin(\theta_1) & 0 \\ \sin(\theta_1) & \cos(\theta_1) & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \cos(\theta_2) & 0 & -\sin(\theta_2) \\ 0 & 1 & 0 \\ \sin(\theta_2) & 0 & \cos(\theta_2) \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(\theta_3) & -\sin(\theta_3) \\ 0 & \sin(\theta_3) & \cos(\theta_3) \end{pmatrix}. \qquad \text{(A5)}$$

To systematically explore the factor space, the rotation angles θ_1, θ_2 and θ_3 are varied on a grid from 0 to $\pi/2$. Further rotations would only result in repetitions, possibly with a flipped

[31] Impulse responses are also multiplied with the variables' standard deviations.

sign. The number of grids are chosen to be 12 for computational reasons[32], 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. A 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 and Boivin (2003)). 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 (for details on the bootstrap see Kilian (1998)). 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 (614 draws were needed). For more details on the identification, the reader is referred to Peersman (2005).

[32] In the case of a 3×3 rotation, there are $3(3-1)/2$ bivariate rotations of different elements of the VAR model for a fixed angle. If we choose the number of grids to equal 12, this amounts to $12^{3(3-1)/2} = 1728$ rotations.

Appendix B

In this appendix, the counterfactual experiment is described in more detail. We proceed in four steps.

Step 1. The estimated idiosyncratic components of changes in output, inflation, interest rates and exchange rates of each country j (which are the differences between the series and the common components multiplied by their standard deviations) are collected in the 4×1 vector $\hat{\Xi}_{jt} = (\hat{\xi}_{i1jt} \quad \hat{\xi}_{i2jt} \quad \hat{\xi}_{i3jt} \quad \hat{\xi}_{i4jt})'$. $\hat{\xi}_{kjt}$ denotes the estimate of the idiosyncratic component of variable $k = \{i1, i2, i3, i4\}$ of country j in period t, $i1$ refers to output growth, $i2$ to changes in inflation, $i3$ to changes in interest rates and $i4$ to exchange rate changes.

Step 2. A VAR(p_j) model is fitted to $\hat{\Xi}_{jt}$:

$$\hat{\Xi}_{jt} = \mathrm{c}_j + \sum_{l=1}^{p_j} \mathrm{A}_{jl}\hat{\Xi}_{jt-l} + \mathrm{u}_{jt}. \quad \text{(B1)}$$

This yields the estimates $\hat{\mathrm{c}}_j = (\hat{c}_{i1j} \quad \hat{c}_{i2j} \quad \hat{c}_{i3j} \quad \hat{c}_{i4j})'$, $\hat{\mathrm{A}}_{jl}, l = 1,\ldots, p_j$ and $\hat{\mathrm{u}}_{jt} = (\hat{u}_{i1jt} \quad \hat{u}_{i2jt} \quad \hat{u}_{i3jt} \quad \hat{u}_{i4jt})'$. The Schwarz information criterion suggests $p_j = 1$ for each j. This and the following steps are done for all j.

Step 3. Three counterfactual scenarios are considered. Under the first scenario, the paths of both national interest and exchange rates are restricted to coincide with the paths of the corresponding euro-area aggregates. I.e. y_{i3jt} is restricted to equal y_{i3EAt} for each j and t, where EA refers to the euro-area aggregate. In addition, y_{i4jt} is restricted to equal y_{i4EAt}. Under the second and the third scenarios, either the path of y_{i3jt} or the path of y_{i4jt} is restricted. In this appendix we only describe and in the main text we only refer to the first scenario. It is straightforward to carry out the other two experiments.

Following Bernanke, Gertler and Watson (1997), we add some innovations ε_{i3jt} and ε_{i4jt} to the residuals of the idiosyncratic components of the interest and exchange rate equations,

$$\Xi^{CF}_{jt} = \hat{\mathrm{c}}_j + \sum_{l=1}^{p_j} \hat{\mathrm{A}}_{jl}\Xi^{CF}_{jt-l} + \mathrm{u}^{CF}_{jt}, \quad \text{(B2)}$$

where CF refers to the counterfactual scenario and $\mathrm{u}^{CF}_{jt} = (\hat{u}_{i1jt} \quad \hat{u}_{i2jt} \quad \hat{u}_{i3jt} + \varepsilon_{i3jt} \quad \hat{u}_{i4jt} + \varepsilon_{i4jt})'$ to the new counterfactual shocks. Technically, those are generated by selecting ε_{i3jt} and ε_{i4jt}, so that $y^{CF}_{i3jt} = y_{i3EAt}$ and $y^{CF}_{i4jt} = y_{i4EAt}$, i.e.

$$\varepsilon_{i3t} = y_{i3EAt} - \hat{\lambda}_{i3j}'\hat{\mathrm{F}}_t - \hat{c}_{i3j} - \sum_{l=1}^{p_j} \hat{\mathrm{A}}_{i3jl}\Xi^{CF}_{jt-l} - \hat{u}_{i3jt} \text{ and}$$

$$\varepsilon_{i4t} = y_{i4EAt} - \hat{\lambda}_{i4j}'\hat{F}_t - \hat{c}_{i4j} - \sum_{l=1}^{p_j} \hat{A}_{i4jl}\Xi^{CF}_{jt-l} - \hat{u}_{i4jt} \ , \tag{B3}$$

where $\hat{A}_{i3jl}$ and $\hat{A}_{i4jl}$ are the third and the fourth rows of $\hat{A}_{jl}$. This is done recursively: ε_{i3jp_j} and ε_{i4jp_j} are computed according to (B3) and are then fed into (B2), yielding $\Xi^{CF}_{jp_j}$. $\Xi^{CF}_{jp_j}$ and (B3) serve to compute ε_{i3jp_j+1} and ε_{i4jp_j+1}, which are, again, fed into (B2), yielding $\Xi^{CF}_{jp_j+1}$ etc. We take $\hat{\Xi}_{j0},...,\hat{\Xi}_{jp_j-1}$ as starting values for $\Xi^{CF}_{j0},...,\Xi^{CF}_{jp_j-1}$.

Step 4. The counterfactual series are finally constructed as follows

$$Y^{CF}_{jt} = \hat{\Lambda}_j'\hat{F}_t + \Xi^{CF}_{jt} \ . \tag{B4}$$

Confidence bands were bootstrapped as described in Section 4 of the main text. Analogously, the uncertainty involved with the estimation of the idiosyncratic components is not taken into account, but the uncertainty involved with the estimation of the VAR model on the idiosyncratic components.

Some remarks and words of caution are in order. In this experiment, counterfactual changes in one country can affect output, inflation, interest rates and exchange rates of the same country. But variables of other countries and the common factors remain unaltered. Given that the CEECs are too small to have an impact on the euro area which is the most important trading partner of the CEECs, this is not an implausible assumption. The restriction is, however, more severe restriction for the EMU members. It should further be kept in mind that we ignore the contemporaneous covariances between the residuals of the VAR model on the idiosyncratic components. Alternatively, we could have estimated structural orthogonal idiosyncratic exchange and interest rate shocks. This would, however, have involved relying on questionable identifying restrictions, and we decided not to do so. Moreover and as already stressed in the main text, we are aware that this experiment is subject to the Lucas critique: changes of private sector expectations of the policy process that may result from policy changes and alter the parameters of the model are not accounted for. Also, possible beneficial consequences of an accession to EMU in terms of a more stable environment resulting, for example, from a reduction in transactions costs, from less uncertainty and from increased risk sharing[33] as a consequence of fiscal transfers and more integrated capital markets are also neglected. In addition, the main channels through which accession to a monetary union strengthens cyclical comovements are trade and financial integration. Trade linkages and linkages between financial markets will tighten gradually and it will take some time before they affect economic comovements. This effect cannot be captured by our model.

33 This has been investigated by Demyanyk and Volosovych (2005) who estimate potential welfare gains from risk sharing implied by the transition to a monetary union for the CEECs in a counterfactual experiment. The authors find that those gains would be relatively large for the Czech Republic, Slovakia and the Baltic countries.

References

Altissimo, F., A. Bassanetti, R. Cristadoro, M. Forni, M. Hallin, M. Lippi, L. Reichlin (2001), "EuroCOIN: a real time coincident indicator of the euro area business cycle", CEPR Working Paper 3108.

Artis, M. J., A. Banerjee, M. Marcellino (2004), "Factor forecasts for the UK", manuscript, www.iue.it/Personal/Banerjee/papers/abm2601.pdf.

Artis, M. J., M. Ehrmann (2000), "The exchange rate – a shack absorber or source of shocks? A study of four open economies", CEPR Discussion Paper 2550.

Artis, M. J., M. Marcellino, T. Proietti (2004), "Characterising the business cycle for accession countries", manuscript.

Backus, D. K., P. Kehoe, F. E. Kydland (1992), "International real business cycles", *Journal of Political Economy*, 100(4), 745-775.

Bai, J., S. Ng (2002), "Determining the number of factors in approximate factor models", *Econometrica*, 70(1), 191-221.

Banerjee, A., M. Marcellino, I. Masten (2003), "Leading indicators for euro-area inflation and GDP growth", CEPR Working Paper 3893.

Barrell, R., D. Holland (2004), "Modelling the accession countries: an analysis of symmetric and asymmetric structural shocks and spillover effects in relation to the EU", manuscript.

Bernanke, B. S., J. Boivin, P. Eliasz (2003), "Measuring the Effects of Monetary Policy: A Factor-Augmented Vector Autoregressive (FAVAR) Approach", NBER Working Paper 10220.

Bernanke, B., Gertler, M. Watson (1997), "Systematic monetary policy and the effects of oil price shocks", C.V. STARR CENTER FOR APPLIED ECONOMICS, New York University, RP# 97-25.

Boone, L., M. Maurel (1999), "An optimal currency area perspective of the EU enlargement to the CEECs", CEPR Discussion Paper 2119.

Breitung, J., U. Kretschmer (2004), "Identification and estimation of dynamic factors from large macroeconomic panels", Discussion Paper, http://www.ect.uni-bonn.de/discussion.htm.

Canova, F., G. de Nicoló (2003), "On the sources of business cycles in the G-7", *Journal of International Economics*, 59, 77-100.

Canzoneri, M. B., J. Vallés, J. Viñals (1996), "Do exchange rates move to address international macroeconomic imbalances? ", CEPR Discussion Paper 1498.

Cimadomo, J. (2003), "The effects of systematic monetary policy on sectors: a factor model analysis", manuscript.

Clarida, R., J. Galí (1994), "Sources of real exchange rate fluctuations: how important are nominal shocks?", NBER Working Paper 4658.

Clark, T. E., E. van Wincoop (2001), "Borders and business cycles", *Journal of International Economics*, 55, 59-85.

Croux, C., M. Forni, L. Reichlin (2001), "A measure for comovement for economic variables: theory and empirics", *The Review of Economics and Statistics*, 83(2), 231-241.

Dalsgaard, T., C. André, P. Richardson (2001), "Standard shocks in the OECD Interlink model", OECD Economics Department Working Paper 306.

Darvas, Z., G. Szapáry (2004), "Business cycle synchronization in the enlarged EU: comovements in the new and old members", Magyar Nemzeti Bank Working Paper 2004/1.

Deardorff, A. V. (1998), "Determinants of bilateral trade: does gravity work in a neoclassical world?" In: Frankel, J. A. (Ed.), *The regionalization of the world economy*, University of Chicago Press, Chicago, 7-22.

Dees, S., F. di Mauro, M. H. Pesaran, L. V. Smith (2004), "Exploring the international linkages of the euro area: a Global VAR analysis", CESIFO Working Paper 1425.

Demanyk, Y., V. Volosovych (2005), "Macroeconomic asymmetry in the European Union: the difference between new and old members", CEPR/EABCN Discussion Paper 15/2005.

Eickmeier, S. (2004), "Business cycle transmission from the US to Germany - a structural factor approach", Bundesbank Discussion Paper 12/2004.

Eickmeier, S. (2005), "Common stationary and non-stationary factors in the euro area analyzed in a large-scale factor model", revised version of Bundesbank Discussion Paper 2/2005.

Fagan, G., J. Henry, R. Mestre (2001), "An Area Wide Model (AWM) for the euro erea", ECB Working Paper 42.

Fidrmuc, J., I. Korhonen (2003), "The Euro goes east. Implications of the 2000-2002 economic slowdown for synchronization of business cycles between the euro area and CEECs", manuscript.

Fidrmuc, J., I. Korhonen (2004), "A meta-analysis of business cycle correlation between the euro area and CEECs: what do we know – and who cares? ", BOFIT Discussion Paper 20/2004.

Forni, M., M. Hallin, F. Lippi, L. Reichlin (2000), "The generalized dynamic factor model: identification and estimation", *The Review of Economics and Statistics*, 82(4), 540-554.

Frankel, J. A., A. K. Rose (1998), "The endogeneity of the optimum currency area criteria", *The Economic Journal*, 108 (July), 1009-1025.

Frenkel, M., C. Nickel (2002), "How symmetric are the shocks and the shock adjustment dynamics between the euro area and central and eastern European Countries? ", IMF Working Paper WP/02/222.

Giannone, D., L. Reichlin, L. Sala (2002), "Tracking Greenspan: systematic and unsystematic monetary policy revisited", manuscript, www.dynfactors.org.

Giannone, D. L. Reichlin, L. Sala (2004), "Monetary policy in real time", forthcoming in Gertler, M., K. Rogoff (eds.), NBER Macroeconomics Annual, MIT Press.

von Hagen, J., I. Traistaru (2005), "Macroeconomic adjustment in the new EU member states", ZEI Working Paper B01 2005.

Hall, S.G., G. Hondroyiannis (2004), "Measuring the correlation of shocks between the European Union and the accession countries", manuscript.

Imbs, J. (2004), "Trade, finance, specialization and synchronization", *Review of Economics and Statistics*, forthcoming in August.

IMF (2001), "Monetary and exchange rate policies of the Euro Area", Country Report 01/60.

Jiménez-Rodríguez, R., M. Sánchez (2005), "Oil price shocks and real GDP growth: empirical evidence for some OECD countries", *Applied Economics*, 37(2), 201-228.

Kapetanios, G., M. Marcellino (2003), "A comparison of estimation methods for dynamic factor models of large dimensions", Queen Mary University of London, Working Paper 489.

Kenen, P. B. (1969), "The optimum currency area: an eclectic view", In R. A. Mundell and A. Swoboda (Eds.), *Monetary problems of the international economy*, Chicago: University of Chicago Press.

Kilian, L. (1998), "Small-Sample Confidence Intervals for Impulse Response Functions", *Review of Economics and Statistics*, 80(2), May 1998, 218-230.

Korhonen, I. (2003), "Some empirical tests on the integration of economic activity between the Euro area and the accession countries", *Economics of Transition*, 11(1), 177-196.

Kose, M. A., C. Otrok, C. H. Whiteman (2003a), "Understanding the evolution of world business cycles", manuscript, http://www.imf.org/external/np/res/seminars/2002/global/preconf.htm.

Kose, M. A., C. Otrok, C. H. Whiteman (2003b), "International business cycles: world, region and country-specific factors", *The American Economic Review*, September 2003, 93(4).

Krugman, P. (1991), "Geography and trade", MIT Press, Cambridge.

McKinnon, R. (1963), "Optimum currency areas", *The American Economic Review*, 53(4), 717-725.

Marcellino, M., J. H. Stock, M. W. Watson (2000), "A dynamic factor analysis of the EMU", manuscript, http://www.igier.uni-bocconi.it/whos.php?vedi=1139&tbn=albero&id_doc=177.

Mundell, R. A. (1961), "A Theory of Optimum Currency Areas", *American Economic Review* (November).

Otto G., G. Voss, L. Willard (2001), "Understanding OECD output correlations", Reserve Bank of Australia Research Discussion Paper 2001-05.

Peersman, G. (2005), "What caused the early millenium slowdown? Evidence based on vector autoregresssions", *Journal of Applied Econometrics*, 20(2), 185-207.

Peersman, G., F. Smets (2001), "Are the effects of monetary policy in the Euro Area greater in recessions than in booms?", ECB Working Paper 52.

Ramos, R., J. Suriñach (2004), "Shocking aspects of European enlargement", manuscript.

Sala, L. (2003), "Monetary transmission in the euro area: a factor model approach", manuscript, www.igier.uni-bocconi.it/whos.php?vedi=772&tbn=albero&id_doc=177.

Smets, F., R. Wouters (2002), "An estimated stochastic dynamic general equilibrium model of the Euro area", ECB Working Paper 171.

Stock, J. H., M. W. Watson (1998), "Diffusion indexes", NBER Working Paper 6702.

Stock, J. H., M. W. Watson (2002), "Macroeconomic forecasting using diffusion indexes", *Journal of Business & Economic Statistics*, 20(2), 147-162.

Uhlig, H. (2004), "What are the effects of monetary policy on output? Results from an agnostic identification procedure", manuscript.

Table 1: Data

Country/region	Variable
Euro area (aggregate variables)	Current account balance
	Effective exchange rate nominal
	Effective exchange rate real
	Total demand
	Public debt
	Government expenditure nominal
	HICP
	Gross investment deflator
	Real gross investment
	Whole-economy capital stock
	Employees (persons)
	Labour force
	Total employment (persons)
	Labour productivity
	Long-term interest rate
	Imports of goods and services deflator
	Imports of goods and services real
	Net foreign assets
	Net factor income from abroad
	Net factor income from abroad/GDP
	Consumption deflator
	Consumption real
	Household's disposable income nominal
	Household's disposable income real
	Variation of stocks deflator
	Variation of stocks real
	Short-term interest rate nominal
	Short-term quarterly interest rate real
	Trade balance nominal
	Trade balance real
	Unit labour costs
	Number of unemployed
	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

Table 1 cont.

Core EMU member countries (AUT, BEL, FRA, GER, ITA, NLD, ESP)	GDP, volume, market prices Private final consumption expenditure Private total fixed capital formation, volume[1)] Industrial production Capacity utilization rate manufacturing Total employment Unit labor costs (business sector) Productivity[2)] CPI, harmonized PPI[3)] GDP deflator, market prices Short-term interest rate nominal Long-term interest rate (gvt. bonds) nominal M1 M3 Main stock price index Imports (goods and services), volume Exports (goods and services), volume Bilateral exchange rate with US Dollar nominal Current account balance
Remaining EMU countries (FIN, GRC, IRE, LUX, PRT) and CEECs (CZ, ES, HUN, LT, LV, PL, SI, SK)	GDP, volume, market prices CPI, harmonized Short-term interest rate nominal Bilateral exchange rate with US Dollar nominal[4)]
World	US CPI US GDP, volume Energy prices World trade Euro/US Dollar nominal

[1)] Total fixed investment for Spain.
[2)] Not included for Belgium, Italy and Spain.
[3)] WPI for Austria.
[4)] Bilateral exchange rate with the Euro for Lithuania.

Table 2: Similarities in industry specialization and trade and FDI integration – some descriptive statistics[5)]

	Struct. similarities[6)]	Trade integration[3)]				FDI integration[2)]			
		TR^1, EA	TR^2, EA	TR^1, total	TR^2, total	FDI^1, EA	FDI^2, EA	FDI^1, total	FDI^2, total
AUT	17.0	1.42	0.65	0.43	0.19	0.52	0.24	0.27	0.12
BEL	9.4	3.70	1.43	1.06	0.40	-	-	1.50	0.58
FIN	18.4	0.41	0.29	0.21	0.14	0.36	0.26	0.31	0.22
FRA	14.4	5.28	0.43	1.71	0.11	5.97	0.50	3.04	0.21
GER	16.0	7.30	0.48	2.93	0.15	7.90	0.53	3.60	0.18
GRC	43.7	0.33	0.22	0.13	0.08	0.17	0.12	0.08	0.05
IRE[4)]	41.7	0.62	0.47	0.32	0.24	1.38	1.09	0.73	0.56
ITA	6.6	3.51	0.33	1.29	0.10	2.41	0.23	1.00	0.08
LUX	52.6	0.26	1.10	0.06	0.27	4.82	21.57	3.18	14.19
NLD	9.6	3.65	0.86	1.21	0.27	4.22	1.01	2.34	0.53
PRT	22.9	0.67	0.52	0.17	0.13	0.62	0.49	0.23	0.18
ESP	26.8	2.63	0.39	0.79	0.11	-	-	1.44	0.21
CZ	41.5	0.71	0.89	0.22	0.27	0.42	0.55	0.13	0.16
ES	24.8	0.06	0.71	0.02	0.30	0.02	0.30	0.02	0.22
HU	19.7	0.63	0.87	0.20	0.27	-	-	0.12	0.17
LT	48.2	0.06	0.39	0.04	0.22	0.01	0.08	0.01	0.09
LV	37.8	0.04	0.36	0.02	0.18	0.01	0.12	0.01	0.10
PL	28.0	0.80	0.44	0.29	0.16	0.47	0.24	0.15	0.08
SI	27.9	0.19	0.78	0.06	0.23	0.05	0.20	0.02	0.08
SK	28.8	0.28	0.98	0.10	0.33	0.09	0.33	0.03	0.11
Mean[1)] all countries	26.8	1.63	0.63	0.56	0.21	1.73	1.64	0.91	0.91
Mean[1)] EMU	23.3	2.48	0.60	0.86	0.18	2.84	2.61	1.48	1.43
Mean[1)] EMU \ GRC, PRT, IRE	19.0	3.13	0.66	1.08	0.19	3.74	3.48	1.85	1.82
Mean[1)] CEECs	32.1	0.35	0.68	0.12	0.25	0.15	0.26	0.06	0.13
Std. all countries	13.5	2.04	0.32	0.75	0.09	2.46	5.14	1.20	3.13
Std. EMU	15.0	2.27	0.36	0.85	0.09	2.73	6.67	1.27	4.02
Std. EMU \ GRC, PRT, IRE	14.0	2.28	0.39	0.88	0.10	2.81	7.98	1.24	4.65
Std. CEECs	9.5	0.32	0.25	0.10	0.06	0.20	0.16	0.06	0.05

[1)] Unweigted average.
[2)] Refers to stocks of FDI at the end of 2002. The FDI^1 measures are multiplied by 100, the FDI^2 measures by 1013. Sources: Eurostat and ECB for Belgium. World GDP is taken from the IMF.
[3)] Refers to trade flows in 2003. The TR^1 measures are multiplied by 100, the TR^2 measures by 10^{13}. Source: ECB. World GDP is taken from the IMF.
[4)] Irish FDI to the rest of the euro area refers to 2001.
[5)] See Clark and Wincoop (2001) for more details on the measures.
[6)] Structural similarities of industry specialization. Refers to 2003.

Table 3: Dynamic correlations between individual countries' and changes in euro-area output and inflation

	Y[2)]		Π[3)]	
	all frequ.[1)]	bc frequ.[1)]	all frequ.[1)]	bc frequ.[1)]
AUT	0.58	0.77	0.53	0.57
BEL	0.61	0.78	0.59	0.49
FIN	0.28	0.59	0.47	0.43
FRA	0.59	0.90	0.86	0.83
GER	0.77	0.86	0.82	0.73
GRC	-0.11	-0.13	0.54	0.47
IRE	0.53	0.61	0.48	0.37
ITA	0.47	0.74	0.54	0.43
LUX	0.33	0.59	0.58	0.52
NLD	0.64	0.82	0.13	0.16
PRT	0.15	0.35	0.00	0.10
ESP	0.39	0.64	0.61	0.53
CZ	-0.04	-0.09	0.25	0.19
ES	0.14	0.15	0.16	0.12
HU	0.21	0.40	0.22	0.26
LT	0.08	-0.04	0.35	0.33
LV	-0.06	0.12	0.21	0.18
PL	0.19	0.27	0.34	0.31
SI	0.21	0.54	0.27	0.26
SK	0.08	-0.02	-0.01	-0.05
Mean[4)] all countries	0.30	0.44	0.40	0.36
Mean[4)] EMU	0.44	0.63	0.51	0.47
Mean[4)] EMU \ GRC, PRT, IRE	0.52	0.74	0.57	0.52
Mean[4)] CEECs	0.10	0.17	0.22	0.20
Std. all countries	0.26	0.34	0.24	0.22
Std. EMU	0.24	0.28	0.24	0.20
Std. EMU \ GRC, PRT, IRE	0.16	0.11	0.21	0.19
Std. CEECs	0.11	0.22	0.11	0.12

[1)] On average over all/business cycle frequencies. The latter correspond to 6 to 32 quarters.

[2)] Real GDP growth.

[3)] CPI inflation growth.

[4)] Unweighted.

Table 4: Lead/lag associated with the maximum cross-correlation with the euro-area aggregate

	Y[2]			Π[3]		
	Lead/lag	Max. correl.	Contemp. correl.	Lead/lag	Max. correl.	Contemp. correl.
AUT	0	0.61	0.61	0	0.52	0.52
BEL	0	0.67	0.67	0	0.63	0.63
FIN	-1	0.31	0.29	0	0.51	0.51
FRA	0	0.72	0.72	0	0.88	0.88
GER	0	0.76	0.76	0	0.88	0.88
GRC	-4	0.19	-0.09	0	0.61	0.61
IRE	0	0.51	0.51	0	0.50	0.50
ITA	0	0.53	0.53	0	0.60	0.60
LUX	1	0.66	0.55	0	0.58	0.58
NLD	0	0.71	0.71	4	0.26	0.10
PRT	-3	0.36	0.23	1	0.33	-0.07
ESP	0	0.45	0.45	0	0.63	0.63
CZ	-2	0.09	-0.04	0	0.28	0.28
ES	0	0.12	0.12	-3	0.19	0.16
HU	0	0.25	0.25	0	0.24	0.24
LT	0	0.04	0.04	0	0.35	0.35
LV	-1	0.09	-0.04	-3	0.30	0.22
PL	1	0.32	0.19	0	0.40	0.40
SI	-1	0.35	0.24	0	0.26	0.26
SK	0	0.06	0.06	2	0.18	0.02
Mean[4] all countries	-0.4	0.41	0.36	0.1	0.47	0.42
Mean[4] EMU	-0.6	0.54	0.49	0.4	0.58	0.53
Mean[4] EMU \ GRC, PRT, IRE	0.0	0.60	0.59	0.4	0.61	0.59
Mean[4] CEECs	-0.1	0.18	0.12	-0.6	0.28	0.24
Std. all countries	1.2	0.24	0.27	1.5	0.21	0.27
Std. EMU	1.4	0.18	0.25	1.2	0.18	0.27
Std. EMU \ GRC, PRT, IRE	0.5	0.15	0.15	1.3	0.19	0.23
Std. CEECs	0.7	0.13	0.11	1.8	0.08	0.13

[1] Positive values indicate by how many quarters the euro-area aggregate leads.
[2] Real GDP growth.
[3] CPI inflation growth.
[4] Unweighted.

Table 5: Bai and Ng (2002) criteria to select *r*[1]

	IC_{p1}	IC_{p2}	IC_{p3}
1	-0.102	-0.098	-0.113
2	-0.128 *	-0.118 *	-0.150
3	-0.120	-0.106	-0.154
4	-0.111	-0.093	-0.156
5	-0.101	-0.078	-0.157 *
6	-0.074	-0.046	-0.141
7	-0.049	-0.016	-0.127
8	-0.023	0.014	-0.112
9	0.004	0.046	-0.096
10	0.033	0.079	-0.080

[1] Based on r_{max}=10. Asterisks indicate the minima.

Table 6: 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 7: Breitung and Kretschmer (2004) criteria to select *q*[1)]

	Akaike		Schwartz	
1	0.819		1.488	
2	0.597	*	0.974	
3	0.674		0.842	*
4	1.633		1.675	
5	3.148		3.148	

1) Based on canonical correlation analysis. Conditional on r=5. Asterisks indicate the minima.

Table 8: Variance shares of selected aggregate euro-area variables explained by the common factors[1)]

GDP	0.88
Investment	0.65
Consumption	0.38
Employment	0.34
Productivity	0.78
CPI inflation	0.73
Short-term interest rate	0.72
Long-term interest rate	0.67
Effect. exchange rate real	0.85
Current account	0.53

1) First difference of these variables.

Table 9: Variance decompositions of selected aggregate euro-area variables[1)]

	Supply shock		Demand shock		Monetary pol. shock	
GDP	0.19	(0.11 0.24)	0.40	(0.35 0.42)	0.39	(0.36 0.54)
Investment	0.26	(0.19 0.27)	0.55	(0.42 0.71)	0.19	(0.03 0.32)
Consumption	0.10	(0.01 0.25)	0.70	(0.49 0.91)	0.20	(0.07 0.31)
Employment	0.64	(0.20 0.89)	0.25	(0.05 0.29)	0.13	(0.01 0.45)
Productivity	0.45	(0.05 0.55)	0.17	(0.07 0.87)	0.39	(0.07 0.40)
CPI inflation	0.76	(0.05 0.99)	0.16	(0.00 0.53)	0.07	(0.00 0.42)
Short-term interest rate	0.04	(0.00 0.57)	0.76	(0.39 0.85)	0.18	(0.02 0.29)
Long-term interest rate	0.13	(0.01 0.71)	0.61	(0.06 0.83)	0.22	(0.02 0.37)
Effect. exchange rate real	0.09	(0.00 0.57)	0.26	(0.03 0.39)	0.64	(0.18 0.91)
Current account	0.25	(0.02 0.26)	0.63	(0.06 0.82)	0.14	(0.01 0.86)

[1)] Median and 90% confidence bands. Horizons 0 to 5 years. Separate variance decompositions for the short run (0 to 1 year) and the medium run (3 to 5 years) are not reported here, but available upon request.

Table 10: Historical decomposition of selected aggregate euro-area variables[1)]

	Total forecast error		Forecast error explained by the supply shock		demand shock		monetary policy shock	
Phase of expansion (1994Q4-2000Q4)								
GDP[2)]	3.10	(1.25 5.24)	-0.01	(-0.14 0.13)	2.29	(0.52 4.35)	0.79	(0.20 1.61)
Investment[2)]	7.55	(3.15 12.63)	-0.06	(-0.40 0.27)	6.37	(1.87 10.98)	1.22	(-0.08 3.17)
Consumption[2)]	1.79	(0.75 2.84)	0.04	(-0.05 0.14)	1.40	(0.39 2.44)	0.30	(-0.04 0.78)
Employment[2)]	0.27	(-0.02 0.52)	-0.01	(-0.04 0.01)	0.24	(-0.08 0.47)	0.04	(-0.04 0.16)
Productivity[2)]	1.26	(-0.33 2.80)	-0.03	(-0.17 0.06)	0.82	(-0.79 2.34)	0.46	(-0.08 1.15)
CPI inflation[2)]	0.71	(0.11 1.44)	0.03	(-0.04 0.09)	0.55	(0.05 1.32)	0.08	(-0.06 0.33)
Short-term interest rate[3)]	3.24	(1.80 4.93)	0.11	(-0.03 0.25)	2.68	(1.24 4.20)	0.47	(-0.06 1.13)
Long-term interest rate[3)]	2.05	(0.46 3.68)	0.07	(-0.12 0.20)	1.80	(0.05 3.18)	0.23	(-0.40 0.99)
Effect. exchange rate real[2)]	-30.89	(-50.97 -3.29)	0.72	(-0.76 2.32)	-21.26	(-44.06 11.41)	-12.87	(-21.37 -2.45)
Current account balance[4)]	-2.98	(-5.10 -0.79)	0.05	(-0.10 0.19)	-2.82	(-4.82 -0.34)	-0.25	(-1.12 0.50)
Phase of slowdown/stabilization (2001Q1-2003Q4)								
GDP[2)]	-2.82	(-4.35 -1.56)	-0.36	(-0.77 -0.13)	-1.10	(-2.42 -0.14)	-1.25	(-2.44 -0.36)
Investment[2)]	-5.49	(-8.85 -2.78)	-1.06	(-2.08 -0.25)	-2.30	(-4.92 -0.39)	-1.94	(-4.73 -0.14)
Consumption[2)]	-1.70	(-2.64 -0.82)	-0.17	(-0.35 0.01)	-0.93	(-1.68 -0.30)	-0.54	(-1.26 0.01)
Employment[2)]	-0.24	(-0.46 -0.05)	-0.10	(-0.15 -0.04)	-0.06	(-0.20 0.07)	-0.07	(-0.25 0.04)
Productivity[2)]	-1.39	(-2.56 -0.20)	-0.32	(-0.72 -0.02)	-0.28	(-1.19 0.58)	-0.73	(-1.81 0.09)
CPI inflation[2)]	0.22	(-0.29 0.74)	0.36	(0.11 0.52)	-0.04	(-0.40 0.22)	-0.03	(-0.36 0.20)
Short-term interest rate[3)]	-2.33	(-3.88 -1.15)	0.07	(-0.27 0.32)	-1.47	(-2.68 -0.62)	-0.84	(-1.94 -0.02)
Long-term interest rate[3)]	-0.91	(-2.37 0.49)	0.17	(-0.26 0.53)	-0.57	(-1.54 0.45)	-0.43	(-1.63 0.53)
Effect. exchange rate real[2)]	32.90	(6.18 68.17)	1.86	(-4.61 9.22)	9.83	(-6.89 33.83)	19.68	(1.17 38.22)
Current account balance[4)]	1.86	(0.35 3.60)	0.48	(-0.04 1.10)	0.95	(-0.01 2.03)	0.38	(-0.61 1.54)

[1)] Median and 90% confidence intervals. Refers 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. It is referred to the 8-quarters ahead forecast error, since 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.

[2)] Percent.

[3)] Percentage points.

[4)] Levels, divided by 1000.

Table 11: Variance shares of output and inflation growth in individual countries explained by the common factors

	Y[1)]	Π[2)]
AUT	0.42	0.24
BEL	0.62	0.36
FIN	0.40	0.44
FRA	0.63	0.77
GER	0.69	0.68
GRC	0.14	0.55
IRE	0.29	0.22
ITA	0.47	0.23
LUX	0.58	0.53
NLD	0.59	0.02
PRT	0.16	0.19
ESP	0.26	0.23
CZ	0.24	0.10
ES	0.24	0.16
HU	0.28	0.33
LT	0.40	0.36
LV	0.06	0.31
PL	0.43	0.42
SI	0.23	0.27
SK	0.30	0.06
Mean[3)] all countries	0.37	0.32
Mean[3)] EMU	0.44	0.37
Mean[3)] EMU \ GRC, PRT, IRE	0.52	0.39
Mean[3)] CEECs	0.27	0.25
Std. all countries	0.18	0.20
Std. EMU	0.19	0.23
Std. EMU \ GRC, PRT, IRE	0.14	0.24
Std. CEECs	0.11	0.13

1) Real GDP growth.
2) CPI inflation growth.
3) Unweighted.

Table 12: Variance decompositions of output and inflation of individual countries[1)]

	Supply shock	Demand shock	Monetary pol. shock
Y[2)]			
AUT	0.36 (0.27 0.44)	0.20 (0.01 0.36)	0.44 (0.36 0.55)
BEL	0.19 (0.05 0.23)	0.38 (0.27 0.39)	0.43 (0.38 0.67)
FIN	0.23 (0.02 0.30)	0.16 (0.04 0.78)	0.60 (0.12 0.84)
FRA	0.11 (0.00 0.19)	0.37 (0.06 0.41)	0.53 (0.40 0.85)
GER	0.45 (0.32 0.74)	0.39 (0.10 0.41)	0.16 (0.03 0.33)
GRC	0.55 (0.02 0.61)	0.14 (0.00 0.95)	0.30 (0.01 0.41)
IRE	0.20 (0.15 0.23)	0.40 (0.18 0.42)	0.39 (0.36 0.63)
ITA	0.15 (0.01 0.23)	0.21 (0.02 0.48)	0.64 (0.31 0.97)
LUX	0.11 (0.00 0.22)	0.37 (0.05 0.41)	0.51 (0.38 0.88)
NLD	0.24 (0.23 0.27)	0.39 (0.28 0.41)	0.37 (0.35 0.46)
PRT	0.08 (0.00 0.78)	0.48 (0.05 0.50)	0.45 (0.17 0.50)
ESP	0.10 (0.01 0.65)	0.52 (0.13 0.62)	0.38 (0.21 0.40)
CZ	0.10 (0.00 0.81)	0.71 (0.02 0.79)	0.16 (0.02 0.31)
ES	0.33 (0.01 0.36)	0.13 (0.03 0.89)	0.53 (0.08 0.65)
HU	0.19 (0.01 0.28)	0.11 (0.01 0.74)	0.69 (0.16 0.89)
LT	0.23 (0.00 0.62)	0.71 (0.01 0.97)	0.12 (0.01 0.36)
LV	0.26 (0.01 0.95)	0.48 (0.03 0.63)	0.25 (0.01 0.38)
PL	0.52 (0.01 0.68)	0.35 (0.01 0.92)	0.15 (0.02 0.36)
SI	0.19 (0.01 0.26)	0.10 (0.00 0.62)	0.70 (0.29 0.90)
SK	0.41 (0.01 0.68)	0.53 (0.01 0.94)	0.07 (0.01 0.31)
Π[3)]			
AUT	0.34 (0.01 0.93)	0.16 (0.00 0.44)	0.50 (0.04 0.59)
BEL	0.38 (0.00 0.97)	0.39 (0.01 0.59)	0.24 (0.00 0.42)
FIN	0.67 (0.03 0.92)	0.07 (0.01 0.37)	0.31 (0.01 0.61)
FRA	0.75 (0.04 0.99)	0.17 (0.00 0.53)	0.08 (0.00 0.42)
GER	0.69 (0.02 0.97)	0.08 (0.01 0.46)	0.23 (0.00 0.52)
GRC	0.67 (0.03 0.95)	0.06 (0.00 0.42)	0.28 (0.01 0.56)
IRE	0.52 (0.01 0.99)	0.28 (0.01 0.55)	0.20 (0.00 0.42)
ITA	0.51 (0.01 0.77)	0.47 (0.01 0.87)	0.07 (0.00 0.23)
LUX	0.21 (0.00 0.92)	0.35 (0.01 0.52)	0.44 (0.07 0.52)
NLD	0.29 (0.01 0.87)	0.16 (0.03 0.46)	0.53 (0.03 0.67)
PRT	0.07 (0.00 0.77)	0.70 (0.04 0.80)	0.18 (0.05 0.30)
ESP	0.62 (0.02 0.98)	0.29 (0.01 0.60)	0.09 (0.00 0.38)
CZ	0.62 (0.05 0.80)	0.19 (0.10 0.57)	0.19 (0.08 0.37)
ES	0.20 (0.01 0.29)	0.13 (0.01 0.85)	0.64 (0.03 0.79)
HU	0.43 (0.01 0.68)	0.50 (0.01 0.94)	0.09 (0.00 0.32)
LT	0.76 (0.03 0.91)	0.24 (0.00 0.72)	0.06 (0.00 0.24)
LV	0.74 (0.02 0.91)	0.21 (0.02 0.71)	0.09 (0.01 0.26)
PL	0.42 (0.00 0.68)	0.49 (0.01 0.94)	0.12 (0.01 0.32)
SI	0.21 (0.00 0.91)	0.53 (0.03 0.63)	0.27 (0.02 0.40)
SK	0.16 (0.01 0.26)	0.17 (0.06 0.71)	0.67 (0.05 0.85)

[1)] Variance shares explained by the shocks of the common components at horizons 0 to 5 years. Median and 90% confidence bands.

[2)] Real GDP.

[3)] CPI inflation.

Table 13: Economic volatility in the counterfactual case compared to the baseline case[3)]

	Y[2)]						Π[2)]					
AUT	0.80	(	0.50	1.31	)		0.94	(	0.47	2.11	)	
BEL	1.06	(	0.62	1.65	)		1.82	(	0.70	13.10	)	
FIN	0.81	(	0.48	1.46	)		0.65	(	0.35	1.08	)	
FRA	0.87	(	0.51	1.30	)		1.05	(	0.63	1.54	)	
GER	0.89	(	0.59	1.26	)		1.12	(	0.67	1.88	)	
GRC	0.89	(	0.49	1.52	)		0.87	(	0.48	1.58	)	
IRE	1.17	(	0.58	2.16	)		1.77	(	0.91	3.59	)	
ITA	0.65	(	0.36	1.09	)		1.46	(	0.71	3.00	)	
LUX	0.90	(	0.44	1.48	)		1.79	(	0.88	3.42	)	
NLD	1.50	(	0.92	2.20	)		0.96	(	0.47	2.02	)	
PRT	1.52	(	0.73	2.60	)		0.81	(	0.47	1.32	)	
ESP	0.68	(	0.36	1.16	)		1.82	(	0.86	3.65	)	
CZ	1.05	(	0.68	1.64	)		1.02	(	0.55	1.62	)	
ES	0.96	(	0.57	1.45	)		1.02	(	0.70	1.49	)	
HU	1.10	(	0.69	1.68	)		1.02	(	0.67	1.57	)	
LT	1.05	(	0.66	1.49	)		0.98	(	0.67	1.53	)	
LV	0.98	(	0.62	1.66	)		1.21	(	0.82	1.83	)	
PL	0.98	(	0.69	1.39	)		0.95	(	0.64	1.37	)	
SI	1.02	(	0.61	1.70	)		0.92	(	0.57	1.52	)	
SK	1.02	(	0.64	1.63	)		0.82	(	0.46	1.60	)	

[1)] Variance of the series in the counterfactual case divided by the variance of the series under the baseline scenario. Median and 90% confidence bands.

[2)] First differences of real GDP and CPI inflation.

Table 14: Dynamic correlations with the euro-area aggregates in the counterfactual case compared to the baseline case[4)]

	Baseline case				Counterfactual case			
	Y[2)]		Π[3)]		Y[2)]		Π[3)]	
	all frequ.[1)]	bc frequ.[1)]	all frequ.[1)]	bc frequ.[1)]	all frequ.[1)]	bc frequ.[1)]	all frequ.	bc frequ.[1)]
AUT	0.57	0.77	0.53	0.57	0.83	0.89	0.69	0.67
BEL	0.65	0.77	0.60	0.52	0.86	0.93	0.54	0.51
FIN	0.30	0.60	0.48	0.43	0.52	0.77	0.74	0.61
FRA	0.59	0.90	0.86	0.82	0.65	0.88	0.79	0.68
GER	0.78	0.87	0.82	0.71	0.76	0.86	0.72	0.62
GRC	-0.12	-0.17	0.60	0.52	-0.38	-0.40	0.71	0.59
IRE	0.53	0.59	0.49	0.39	0.85	0.89	0.68	0.57
ITA	0.50	0.74	0.53	0.41	0.51	0.84	0.71	0.61
LUX	0.05	0.17	0.40	0.33	0.52	0.58	0.52	0.43
NLD	0.49	0.68	0.06	0.09	0.70	0.80	0.33	0.31
PRT	0.05	0.02	0.28	0.25	0.24	0.36	-0.02	-0.05
ESP	0.25	0.42	0.42	0.38	0.43	0.45	0.42	0.27
CZ	-0.01	-0.23	0.26	0.32	0.27	0.09	0.46	0.27
ES	0.17	0.14	-0.15	0.05	0.07	0.14	0.22	0.12
HU	0.35	0.28	0.02	0.07	0.34	0.68	-0.02	-0.05
LT	0.34	0.27	0.31	0.35	0.16	0.26	0.46	0.30
LV	0.00	0.24	0.19	0.10	-0.08	0.34	0.17	0.06
PL	0.33	0.34	0.14	0.09	0.39	0.29	-0.14	-0.16
SI	0.30	0.31	0.00	0.09	0.28	0.65	0.10	0.05
SK	0.22	0.22	-0.19	-0.26	0.24	0.06	-0.24	-0.16

[1)] On average over all/business cycle frequencies. The latter correspond to 6 to 32 quarters.

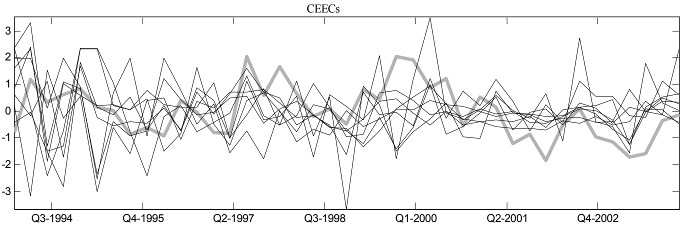
[2)] Real GDP growth.

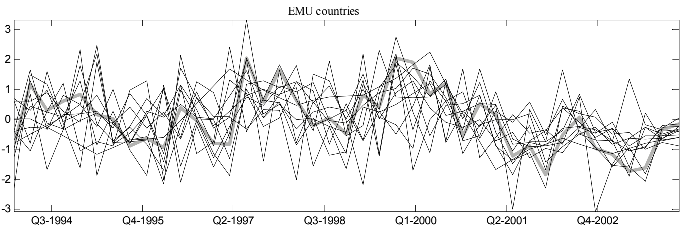
[3)] CPI inflation growth.

[4)] 1993-1998 for EMU countries except for GRC, 1993-2000 for GRC, 1993-2003 for CEECs. Estimation is based on the median estimate of the counterfactual time series.

Figure 1: Economic comovements in the euro area and CEECs

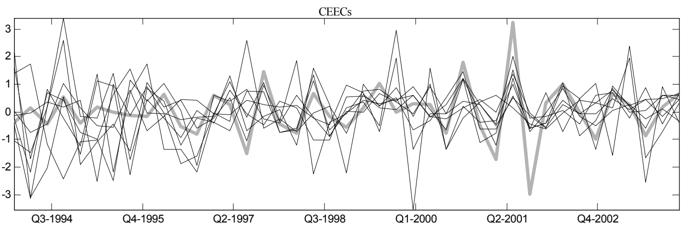
Output growth

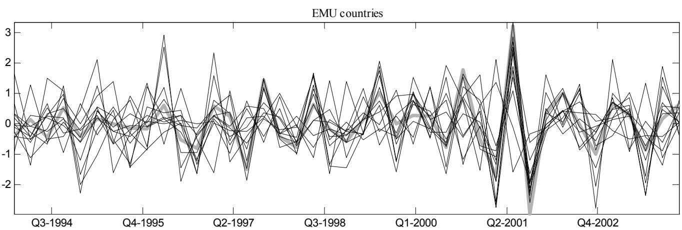




Euro-area aggregate (gray), individual countries (black)

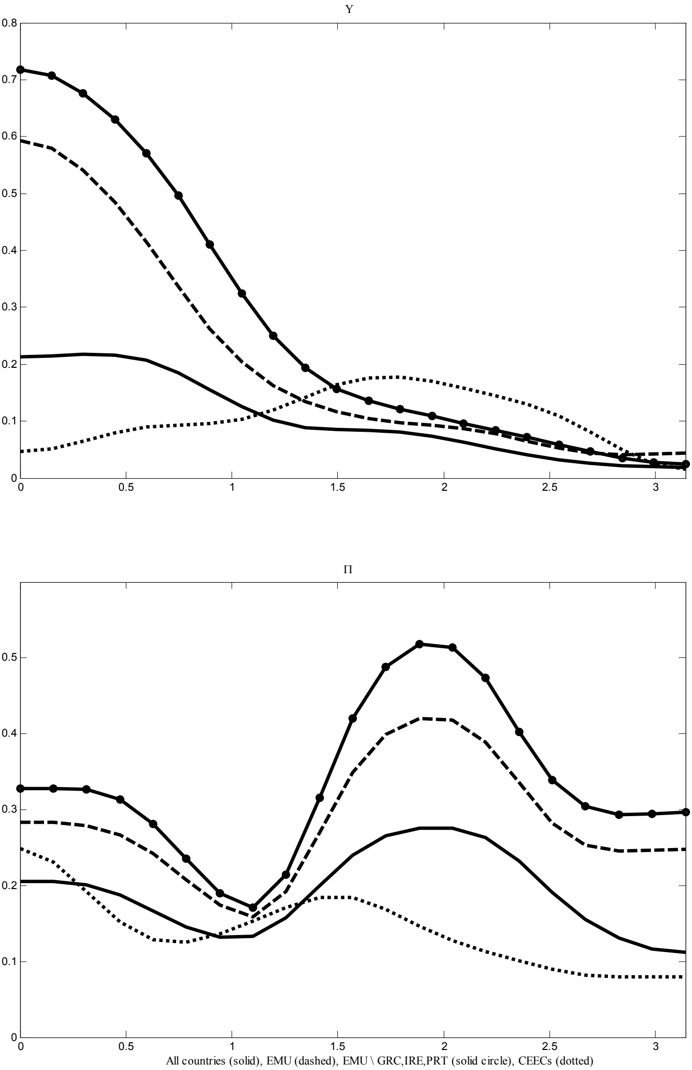
Changes in inflation





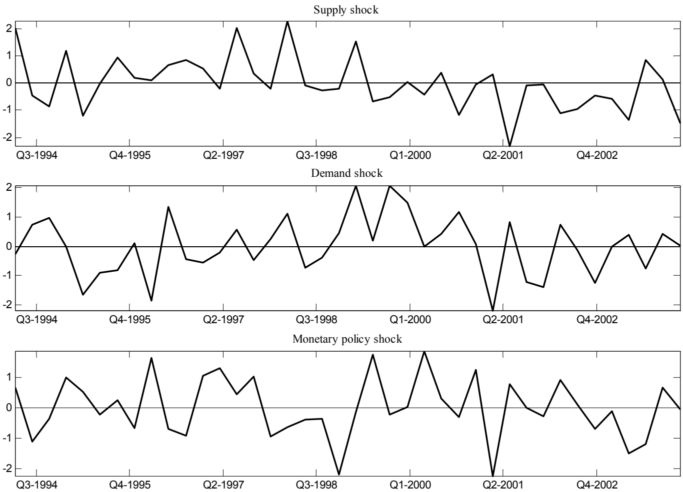
Euro-area aggregate (gray), individual countries (black)

Figure 2: Cohesion[1)]



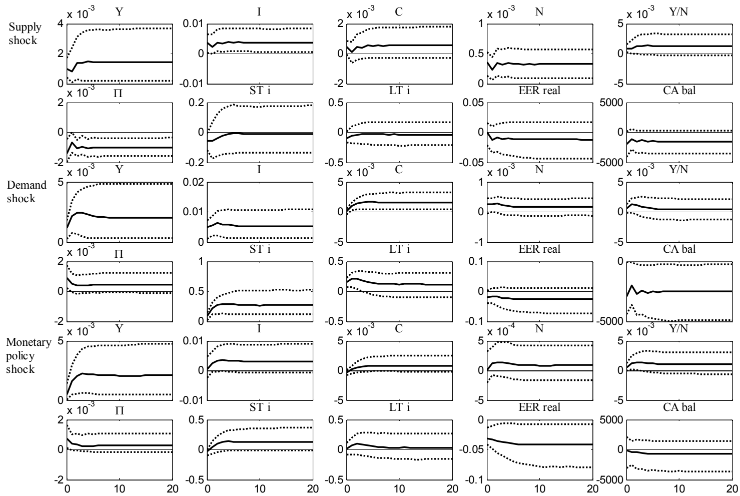
[1)] Y refers to real GDP growth and Π to CPI inflation growth.

Figure 3: Euro-area shock series[1)]



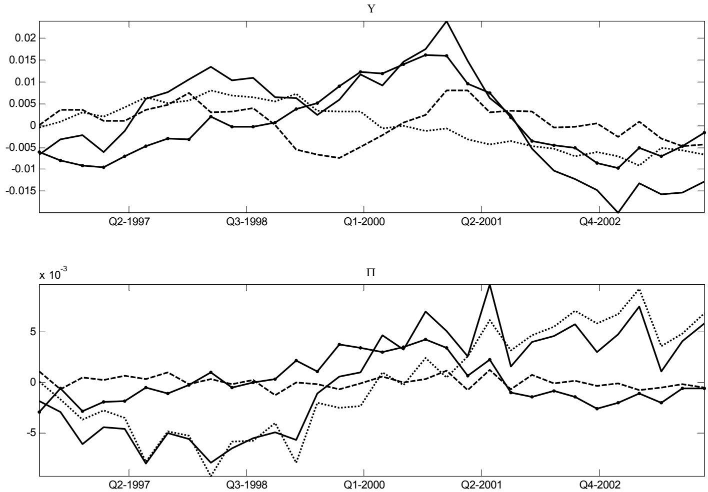
1) The size of the shocks is one standard deviation. Median point estimates.

Figure 4: Responses of selected aggregate euro-area variables to euro-area shocks[1)]



1) To shocks of size one standard deviation. Median: solid, 90% confidence bands: dotted. 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 5: Historical decomposition of selected aggregate euro-area variables[1)]

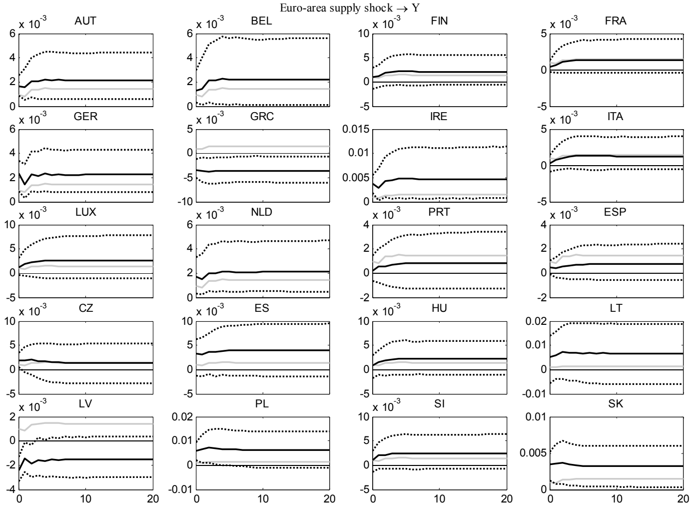


Total forecast error (solid), Forecast error expl. by the supply shock (dotted), the demand shock (solid circle), the monetary policy shock (dashed)

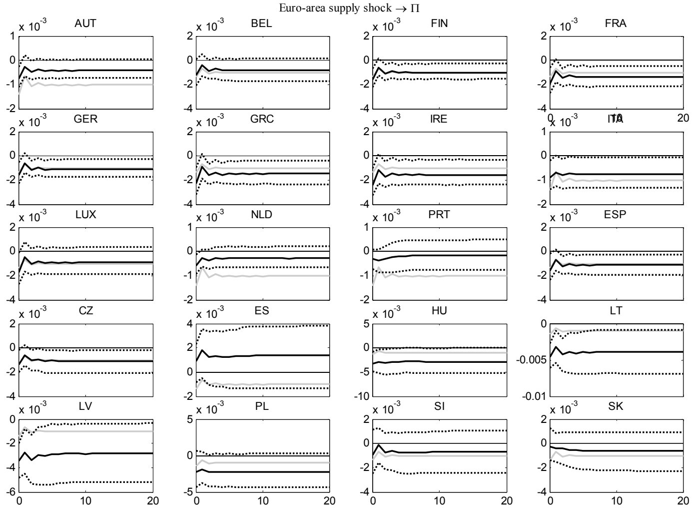
1) Median estimates. It is referred to the 8-quarters-ahead forecast error of the common component.

Figure 6: Impulse responses of output and inflation of individual countries (black) and euro-area aggregates (gray) to euro-area shocks[1)]

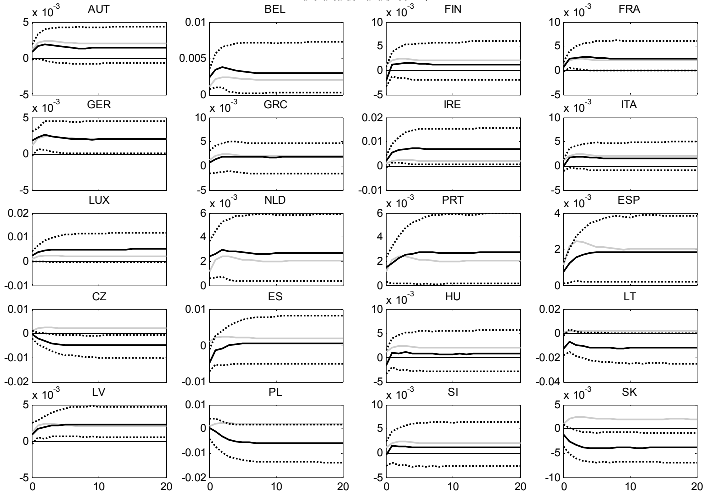
Euro-area supply shock → Y



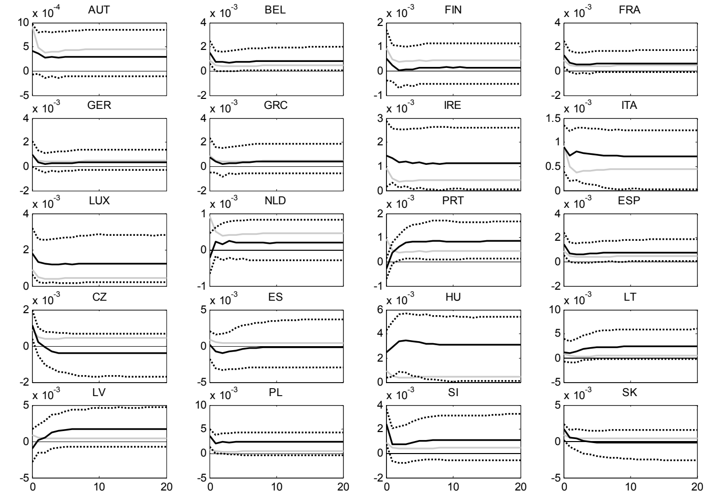
Euro-area supply shock → Π



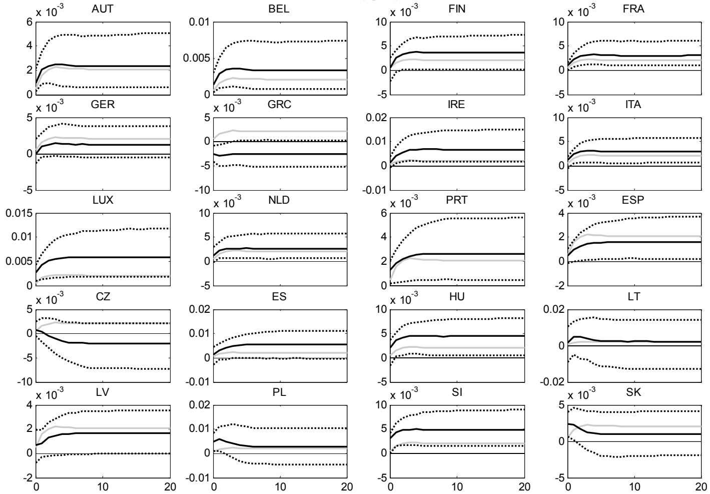
Euro-area demand shock → Y



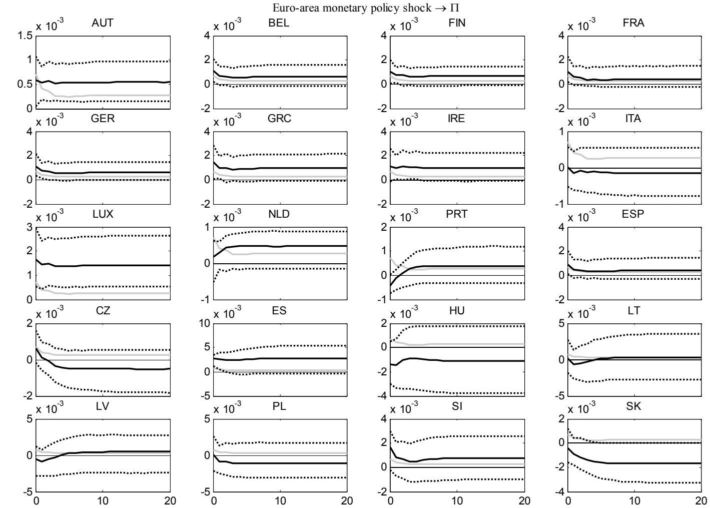
Euro-area demand shock → Π



Euro-area monetary policy shock → Y

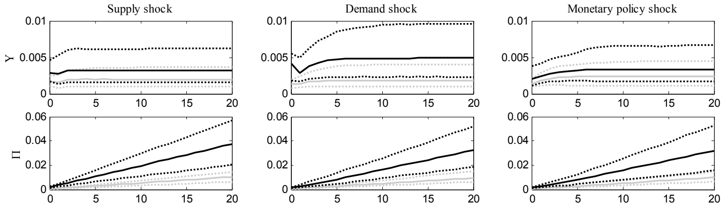


Euro-area monetary policy shock → Π

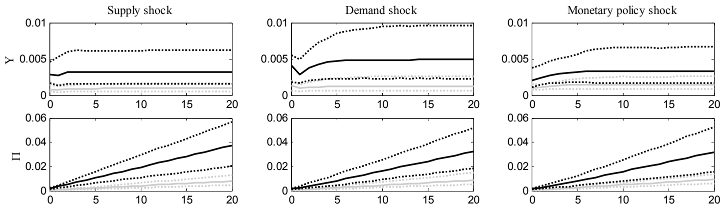


[1] To shocks of size one standard deviation. Median: solid, 90% confidence bands: dotted. Y refers to real GDP and Π to CPI inflation.

Figure 7: Average standard deviations of impulse responses to euro-area shocks[1)]



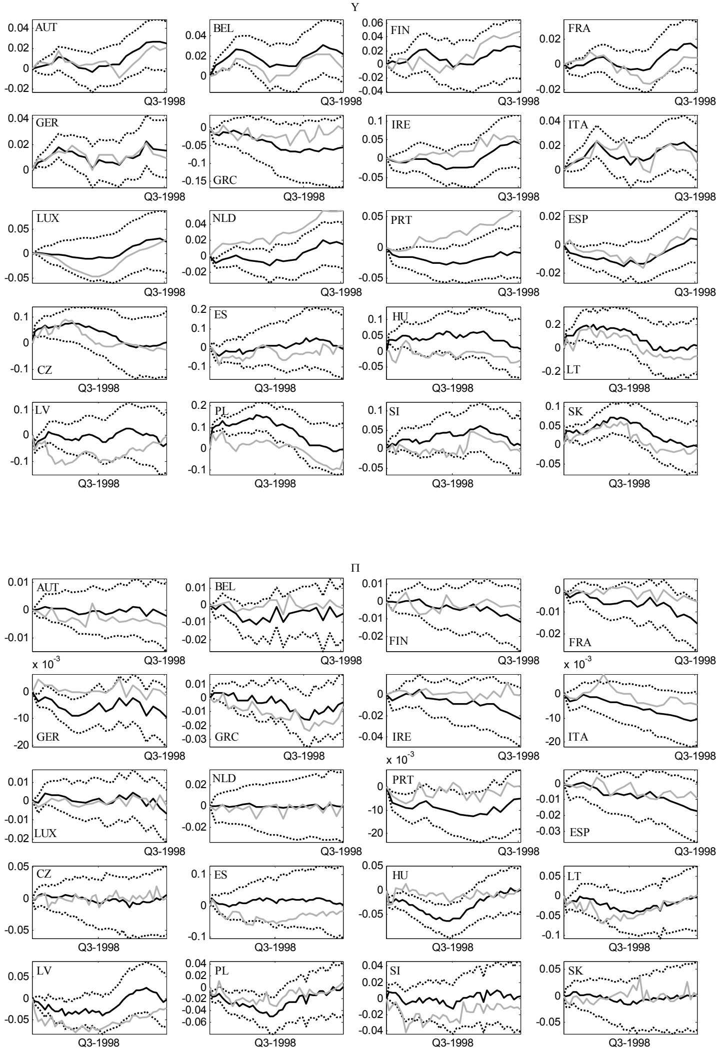
CEECs (black), EMU (gray)



CEECs (black), EMU without GRC,PRT,IRE (gray)

1) To shocks of size one standard deviation. Median: solid, 90% confidence bands: dotted. Y refers to real GDP and Π to CPI inflation.

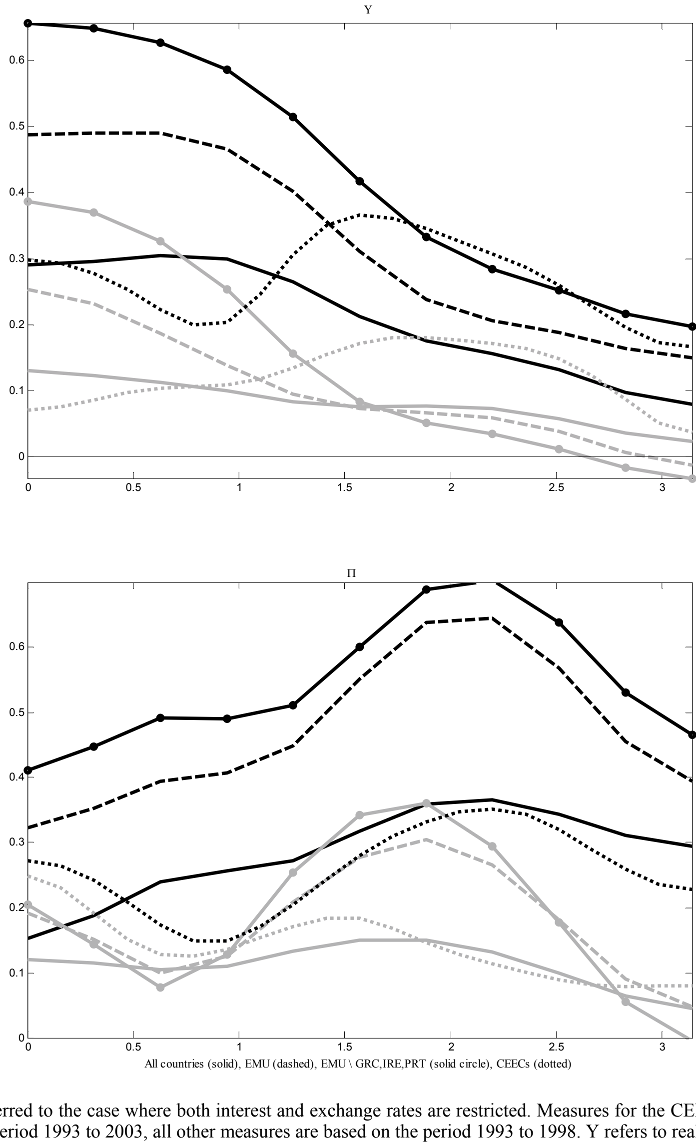
Figure 8: Output and inflation in the counterfactual case and the baseline case[1)]



Baseline scenario (gray), counterfactual scenario (black - median (solid), 90% confidence interval (dotted))

1) Y refers to real GDP and Π to CPI inflation. The graphs for the CEECs refer to 1993 to 2003, those for the EMU countries to 1993 to 1998 and those for Greece to 1993 to 2000.

Figure 9: Cohesion in the counterfactual case (black) and the baseline case (gray)[1)]



1) It is referred to the case where both interest and exchange rates are restricted. Measures for the CEECs based on the period 1993 to 2003, all other measures are based on the period 1993 to 1998. Y refers to real GDP and Π to CPI inflation growth. Estimation is based on the median estimates of the counterfactual times series.

Already published

No.	Title	Authors
1	IMF and Economic Growth: The Effects of Programs, Loans, and Compliance with Conditionality	Axel Dreher
2	Do gasoline prices converge in a unified Europe with non-harmonized tax rates?	Axel Dreher, Tim Krieger
3	Is There A Causal Link between Currency and Debt Crisis?	Axel Dreher, Bernhard Herz, Volker Karb
4	What Determines Differences in Foreign Bank Efficiency? Australien Evidence	Jan-Egbert Sturm, Barry Williams
5	Market oriented institutions and policies and economic growth: A critical survey	Jakob de Haan, Susanna Lundström, Jan-Egbert Sturm
6	Does Globalization Affect Growth? Evidence from a new Index of Globalization	Axel Dreher
7	Transformation nicht-gehandelter in handelbare Kreditrisiken	Günter Franke
8	Student Flows and Migration: An Empirical Analysis	Axel Dreher, Panu Poutvaara
9	Foreign Exchange Intervention and the Political Business Cycel: A Panel Data Analysis	Axel Dreher, Roland Vaubel
10	M&A-Transaktionen - Fluch oder Segen der Realoptionstheorie?	Günter Franke, Christian Hopp
11	Wie hat sich die universitäre volkswirtschaftliche Forschung in der Schweiz seit Beginn der 90er Jahre entwickelt?	Miriam Hein
12	Determinants of Long-term Growth: New Results Applying Robust Estimation and Extreme Bounds	Jan-Egbert Sturm, Jakob de Haan
13	Which Variables Explain Decisions on IMF Credit? An Extreme Bounds Analysis	Helge Berger, Jakob de Haan, Jan-Egbert Sturm

THURGAUER
WIRTSCHAFTSINSTITUT
an der Universität Konstanz

Hauptstr. 90
CH-8280 Kreuzlingen 2

Telefon: +41 (0)71 677 05 10
Telefax: +41 (0)71 677 05 11

info@twi-kreuzlingen.ch
www.twi-kreuzlingen.ch