Business cycle synchronization between EMU and CEE countries: An empirical study

April 19, 2011

Abstract

This paper analyzes the existence of common movements among real macroeconomic aggregates across EMU-8 and CEE-5 countries by using the multi-factor model. It then examines the convergence hypothesis by employing Markov-Switching models. It founds that the evolution of the global European factor is consistent with the main economic events between 1995 and 2008. This factor plays a central role in explaining output variability in EMU-8 countries and a minor role in CEE-5 countries. Furthermore, the results show evidence in favour of the business cycle synchronization, with the degree of concordance between country-specific and European business cycles being high.

JEL classification: E32, F44

Keywords: European business cycle; convergence; CEE economies

1 Introduction

The analysis of common economic movements among macroeconomic aggregates across countries, so-called "co-movements", has attracted the attention of economic research in last decades. Most of these studies have shown the existence of an international business cycle (see, for instance, Backus and Kehoe, 1992; Backus, Kehoe and Kydland, 1995; Baxter, 1995; Gregory, Head and Raynauld, 1997; Canova and Marrinan, 1998; Kose, Otrok and Whiteman, 2003; and Kose, Otrok and Whiteman, 2008; Kose, Otrok and Prasad, 2008; among others). However, there have been only few researchers who have focused on the existence of a European business cycle, and no consensus has emerged among them. Whereas researchers such as Artis, Kontolemis and Osborn (1997), Lumsdaine and Prasad (1997), and Artis, Krolzig and Toro (2004) have shown evidence in favour of a European business cycle, authors such as Dikerson, Heather and Tsakalatos (1998), Kose, Otrok and Whiteman (2003), and Camacho, Pérez-Quirós and Saiz (2005) have not supported such existence.

Recently, there has been a growing research interest in the existence of a common business cycle between European Union (EU) and Central and Eastern European (CEE) countries. Artis, Marcellino and Proietti (2004) find that the degree of concordance within the group of accession countries studied (the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia) is in general lower than that between the existing EU countries, with the Baltic countries being an exception. Moreover, their concordance measure shows a generous view of cyclical sympathy between a number of accession countries (all except Latvia and Lithuania) and the Eurozone, with the cyclical sympathy between some of these countries (Poland, Slovenia, Estonia, Hungary and the Czech Republic) and Germany being especially marked. In a survey paper, Fidrmuc and Korhonen (2006) report 35 studies on business cycle correlation between the CEE countries and the EU.[1] Their meta-analysis confirms that the business cycles in several CEE countries are highly correlated with the Eurozone business cycle. Moreover, their results indicate that some new EU member states like Hungary, Poland and Slovenia have achieved a relatively high degree of business cycle correlation with the Eurozone, while other countries did not. In this line, Artis, Fidrmuc and Scharler (2008) analyze potential sources of business cycle synchronization for a set of OECD and CEE countries. Their results confirm the endogeneity hypothesis of the optimal currency area criteria:[2] countries characterized by large bilateral trade and financial flows tend to have more correlated business cycles. However, labour market rigidities and divergent fiscal policies lower the correlation of business cycles between countries.

Boone and Maurel (1998) find that business cycles in CEE countries are similar to those in Germany and the Eurozone, suggesting that full European Monetary Union membership for CEE countries would be fruitful. Brada and Kutan (2001), on the other hand, examine monetary policy convergence between the candidate economies and the EU, proxied by Germany, and find no convergence between base money in Germany and the transition-economy candidates for EU membership. Kutan and Yigit (2005) show strong evidence of real stochastic convergence to EU standards for all CEE economies, now new EU members, although the degree of nominal convergence is idiosyncratic. The Baltic states exhibit the strongest monetary policy and price-level convergence, suggesting that they are ready to adopt the euro.

The contribution of this paper to the existing literature is twofold. First, we examine the existence of common movements among real macroeconomic aggregates across eight euro area countries, namely Austria, Belgium, Finland, France, Germany, Italy,

[1] According to Fidrmuc and Korhonen (2006), the structural vector autoregression methodology accounts for 18 empirical studies out of 35 (see, for example, Korhonen, 2003; Horvath and Rátfai, 2004; Karmann and Weimann, 2004; and Frenkel and Nickel, 2005) aiming to assess the degree of business cycles synchronization between CEE countries and the euro area.

[2] See Mongelli (2005) for a comprehensive review of the optimal currency area literature.

the Netherlands and Spain (EMU-8), and five Central and Eastern European countries, including the Czech Republic, Hungary, Poland, Slovakia and Slovenia (CEE-5), with the aim of contributing to the controversial debate as to whether there is a European business cycle. To do so, we employ the *multi-factor* model in the spirit of Kose, Otrok and Whiteman (2003, 2008) and Kose, Otrok and Prasad (2008). Second, we examine the convergence hypothesis (which suggests that the closer economic integration the more synchronization should exist across countries over time) for the EMU-8 and CEE-5 countries in order to shed more light on the level of business cycle synchronization. For that aim, we use the Markov-Switching methodology and we construct a measure of degree of concordance between the recessions and expansions.

The conclusions derived from this paper provide valuable information for policy-makers given that if the macroeconomic aggregates from the EMU and CEE countries do not show evidence of common movements and there is no convergence in their business cycles, the adoption of a common currency too early would be too costly since this fact would give rise to conflicts about the appropriate monetary policy to be adopted.[3,4]

The paper is structured as follows. Section 2 describes the data and methodology. Section 3 reports our empirical findings, and Section 4 draws some concluding remarks.

2 Data and Methodology

2.1 Data

The macroeconomic time series are from the *OECD Main Economic Indicators* and *IMF's International Financial Statistics*. We use quarterly output, consumption and investment data of the EMU-8 and CEE-5 countries for the common period 1995:2-

[3] Notice that the optimal currency area theory points out that the cost of adopting a common currency would be potentially high for economies that are considerably different.

[4] It is worth reminding that Slovenia and Slovakia adopted the euro in 2007 and 2009, respectively.

2008:4.[5] Consequently, we use 3 series per country for 13 countries, with 55 times series observations for each variable. Two regions, EMU-8 and CEE-5, are considered.[6] In the analysis of the common movements and the estimations of the *global*, regional and country-specific factors, each series was log first-differenced and demeaned. Nevertheless, we simply consider the first log-differences of output in the analysis of the business cycle synchronization, given that such a variable is the variable commonly used for characterizing the business cycle (see, *e.g.*, Krolzig, 1997; Artis, Krolzig and Toro, 2004; Artis, Marcellino and Proietti, 2004; Artis, Fidrmuc and Scharler, 2008; among others).

2.2 The *Multi-factor* Model

This sub-section closely follows the description offered by Kose, Otrok and Whiteman (2008) to describe the *multi-factor* model proposed by Kose, Otrok and Whiteman (2003), which we use for the estimation of the *dynamic* factors.[7]

Suppose y_t is an $Q-$dimensional vector of covariance stationary time series at time t, and Σ_{yy} is its associated spectral density matrix. Then the time series $\{y_t\}$ is said to have *dynamic* factor structure if Σ_{yy} can be written in the form

$$\Sigma_{yy} = \Gamma\Gamma' + V$$

where Γ is $Q \times K$, $K \ll Q$, and V is diagonal with positive entries on the diagonal. This

[5] We do not consider Estonia and Slovenia within the EMU group given that these two countries have jointed the euro area only recently.

[6] One concern with procedures that extract measures of the *global* business cycle is that large countries drive the *global* component simply because of their size. In the procedure used here we are working in growth rates, so the size of the country can have no direct impact on the results. That is, the econometric procedure that extracts common components does not distinguish between a 1-percent growth rate in Germany and a 1-percent growth rate in Belgium. In other words, the procedure is a decomposition of the second moment properties of the data (*e.g.*, the spectral density matrix).

[7] It is worth noting that a *dynamic* factor model provides a description of the spectral density matrix of a set of time series, and so the factor(s) describe contemporaneous and temporal covariation among the variables.

structure means that all of the co-movement among the variables is controlled by the $M-$dimensional set of *dynamic* factors. The observable variables y_t can be represented as

$$y_t = a(L)f_t + u_t$$

where $a(L)$ is a $Q \times K$ matrix of polynomials in the lag operator, $\{f_t\}$ is a $K-$dimensional stochastic process of the factors, and the errors in u_t may be serially but not cross-sectionally correlated. The factors are in general serially correlated, and may be observed or unobserved.

In our implementation, there are K dynamic, unobserved factors thought to characterize the temporal co-movements in the cross-country panel of time series. Let N denote the number of countries, M the number of time series per country, R the number of regions, and T the length of the time series. Observable variables are denoted by $y_{i,t}$ for $i = 1, .., M \times N$, $t = 1, ..., T$. There are three types of factors: N country-specific factors ($f_n^{country}$, one per country), R regional factors (f_r^{region}, in this case, two regional factors: EMU-8 and CEE-5), and the single *global* European factor (f^{global}). Thus, the i^{th} observable variable evolves as:

$$y_{i,t} = a_i + b_i^{global} f_t^{global} + b_i^{region} f_{r,t}^{region} + b_i^{country} f_{n,t}^{country} + \varepsilon_{i,t} \quad (1)$$

$$E[\varepsilon_{i,t}\varepsilon_{j,t-s}] = 0 \text{ for } i \neq j$$

where r denotes the region number and n the country number. The coefficients b_i^j are the factor loadings, and reflect the degree to which variation in $y_{i,t}$ can be explained by each factor.[8] The *unexplained* idiosyncratic errors $\varepsilon_{i,t}$ are assumed to be normally distributed, but may be serially correlated. They follow $p_i - order$ autoregressions:

$$\varepsilon_{i,t} = \phi_{i,1}\varepsilon_{i,t-1} + \phi_{i,2}\varepsilon_{i,t-2} + ... + \phi_{i,p_i}\varepsilon_{i,t-p_i} + u_{i,t} \quad (2)$$

$$E[u_{i,t}u_{j,t-\tau}] = \begin{cases} \sigma_i^2 \text{ for } i = j, \tau = 0 \\ 0 \quad otherwise \end{cases}$$

[8] Notice that there are $M \times N$ time series to be "explained" by the $N + R + 1$ factors.

The evolution of the factors is likewise governed by an autoregression, of order q_k with normal errors:

$$f_{k,t} = \varepsilon_{f_k,t} \tag{3}$$

$$\varepsilon_{f_k,t} = \phi_{f_k,1}\varepsilon_{f_k,t-1} + \phi_{f_k,2}\varepsilon_{f_k,t-2} + ... + \phi_{f_k,q}\varepsilon_{f_k,t-q_k} + u_{f_k,t} \tag{4}$$

$$E[u_{f_k,t}u_{f_k,t}] = \sigma^2_{f_k};\ E[u_{f_k,t}u_{i,t-\tau}] = 0, \text{ for } \textit{all } k, i, \text{ and } \tau$$

Notice that all the innovations, $u_{i,t}$, $i = 0, ..., M \times N$ and $u_{f_k,t}$, $k = 1, ..., K$, are assumed to be zero mean, contemporaneously uncorrelated normal random variables. Thus all co-movement is mediated by the factors, which in turn all have autoregressive representations (of possibly different orders).

There are two related identification problems in the model $(1)-(4)$: neither the signs nor the scales of the factors and the factor loadings are separately identified. Signs are identified by requiring one of the factor loadings to be positive for each of the factors. In particular, we require that the factor loading for the *global* European factor be positive for German output; country factors are identified by positive factor loadings for output for each country, and the regional factors are identified by positive loadings for the output of the first country listed for each region (*i.e.*, Germany and the Czech Republic). Scales are identified following Sargent and Sims (1977) and Stock and Watson (1989, 1993) by assuming that each $\sigma^2_{f_k}$ is equal to a constant.

The model has to be estimated by special methods since the factors are unobservable. Following Stock and Watson (1989, 1993), Gregory, Head and Raynauld (1997) treat a related model as an observer system. They use classical statistical techniques employing the Kalman filter to estimate the model parameters, and the Kalman smoother to extract an estimate of the unobserved factor. Otrok and Whiteman (1998) used an alternative methodology based on the missing data problem (the data augmentation) developed in the Bayesian literature (Tanner and Wong, 1987).

In our context, data augmentation builds on the following key observation: if the factors were observable, under a conjugate prior the model (1) $-$ (4) would be a simple set of regressions with Gaussian autoregressive errors. This simple structure can in turn be used to determine the conditional (normal) distribution of the factors given the data and the parameters of the model. Then it is straightforward to generate random samples from this conditional distribution, and such samples can be employed as stand-ins for the unobserved factors. Because the full set of conditional distributions is known - parameters given data and factors, factors given data and parameters - it is possible to generate random samples from the joint posterior distribution for the unknown parameters and the unobserved factor using a Markov Chain Monte Carlo procedure. In particular, taking starting values of the parameters and factors as given, we first sample from the posterior distribution of the parameters conditional on the factors. Next, we sample from the distribution of the *global* European factor conditional on the parameters and the country and regional factors and then, we sample each regional factor conditional on the *global* European factor and the country factors in that region. Finally, we complete one step of the Markov chain by sampling each country factor conditioning on the *global* European factor and the appropriate regional factor.[9] This sequential sampling of the full set of conditional distributions is known as "Gibbs sampling" (see Chib and Greenberg, 1996; and Geweke, 1996, 1997).[10] Under regularity conditions satisfied here, the Markov chain this way produced converges, and yields a sample from the joint posterior distribution of the parameters and the unobserved factors, conditioned on the data. Additional details

[9] The sampling order within each step is irrelevant. All that matters is that samples are taken from each of the "blocks" of unknowns (parameters, *global* European factor, regional factors, country factors) conditional on the data and all the other blocks.

[10] Technically, our procedure is "Metropolis within Gibbs", as one of the conditional distributions - for the autoregressive parameters given everything else - cannot be sampled from directly. As in Otrok and Whiteman (1998), we follow Chib and Greenberg (1996) in employing a "Metropolis-Hastings" procedure for that block.

can be found in Otrok and Whiteman (1998).

In our implementation, the length of both the idiosyncratic and factor autoregressive polynomials is 3. The prior on all the factor loading coefficients is $N(0,1)$. For the autoregressive polynomials parameters the prior was $N(0,\Omega)$, where $\Omega = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0.5 & 0 \\ 0 & 0 & 0.25 \end{bmatrix}$. Because the data are growth rates, this prior embodies the notion that growth is not serially correlated; also, the certainty that lags are zero grows with the length of the lag. As in Otrok and Whiteman (1998), the prior on the innovation variances in the observable equations is Inverted Gamma (6, 0.001), which is quite diffuse.

2.3 Markov-Switching Models

This sub-section briefly describes the methodology used to analyze the individual business cycles of EMU-8 and CEE-5 countries. In particular, we consider the model proposed by Engel and Hamilton (1990).[11] Thus, we model any given quarter's change in the output growth rate as deriving from one of two regimes, which correspond to expansion and recession, respectively.

The model postulates the existence of an unobserved variable (denoted s_t) that takes of the value one or two (*i.e.*, expansion and recession, respectively). This variable characterizes the regime (or state) that the process was in at date t. When $s_t = 1$, the observed change in the output growth rate in each country considered x_t is presumed to have been drawn from a $N(\mu_1, \sigma_1^2)$ distribution, whereas when $s_t = 2$, x_t is distributed $N(\mu_2, \sigma_2^2)$.

The stochastic process generating the unobservable regimes is an ergodic Markov chain defined by the transition probabilities:[12]

$$p_{i,j} = \Pr\left(s_t = j \,|s_{t-1} = i\,\right), \quad \sum_{j=1}^{2} p_{i,j} = 1 \;\; \forall i,j \in \{1,2\}$$

[11] This model is a special case of the model developed by Hamilton (1989).

[12] Notice that $p_{12} = \Pr(s_t = 2|s_{t-1} = 1) = 1 - p_{11}$ and $p_{21} = \Pr(s_t = 1|s_{t-1} = 2) = 1 - p_{22}$.

Maximum likelihood (ML) estimation of the model is based on an implementation of the Expectation-Maximization (EM) algorithm proposed by Hamilton (1990).[13] Filtered and smoothed probabilities are calculated. The filtered probability can be understood as an optimal inference on the state variable at time t, s_t, using only the information up to time t (Z_t), i.e. $\Pr^I(s_t = m\,|Z_t)$, where m stands for a given regime. The smoothed probability corresponds to the optimal inference on the regime m at time t using full sample information (Z_T), $\Pr^I(s_t = m\,|Z_T)$.

The Engel-Hamilton (1990) model can be also applied for analyzing the multi-country business cycle. In this case, the observed change in the vector of output growth rates of all countries considered X_t is assumed to be drawn from a $N(\mu_1, \Omega_1)$ distribution if $s_t = 1$, and from a $N(\mu_2, \Omega_2)$ if $s_t = 2$. It is obtained the ML estimates using the EM algoritm, and we calculate both filtered and smoothed probabilities (*i.e.*, $\Pr^E(s_t = m\,|Z_t)$ and $\Pr^E(s_t = m\,|Z_T)$, respectively).

We asses the synchronicity of the regime changes in each specific country with respect to the European business cycle (*i.e.*, multi-country business cycle) by analyzing the timing of the individual business cycle relative to the European business cycle. As a measure of the specific business cycle regime prevailing in each country, we follow Artis, Krolzig and Toro (2004) and we use the smoothed probability of being in each regime obtained from the univariate specification. We assign each observation of the sample to a given regime according to the highest smoothed probability. Thus, the rule reduces to assigning the observation to the first regime (expansion) if $\Pr^I(s_t = 2\,|Z_T) < 0.5$ and assigning it to the second regime (recession) if $\Pr^I(s_t = 2\,|Z_T) > 0.5$, with $\Pr^I(s_t = 2\,|Z_T)$ denoting the smoothed probability of being in a recessionary state obtained from the univariate specification in each country. A measure of the European business cycle is given by the

[13] The EM algorithm introduced by Dempster, Laird and Rubin (1977) is designed for a general class of models where the observed time series depends on some unobservable stochastic variables - for Markov-Switching models these are the regime variable s_t.

smoothed probability of being in each regime obtained from the multivariate specification. Then, we assign each observation of the sample to a expansion if $\Pr^E(s_t = 2\,|Z_T)$<0.5 and to a recession if $\Pr^E(s_t = 2\,|Z_T)$>0.5, with $\Pr^E(s_t = 2\,|Z_T)$ denoting the smoothed probability of being in a recessionary state obtained from the multivariate specification, that is, the inference on the recessionary state of the European business cycle. Moreover, we define S_{jt} and S_{rt} as binary variables that take the value 1 for recessions and 0 for expansions in the country j and the European region, respectively. As a measure of synchronicity, we have calculated the statistic suggested by Harding and Pagan (2002): the degree of concordance, defined as the fraction of time the reference cycle (S_{rt}) and the specific cycle (S_{jt}) are in the same state.

The degree of concordance is defined as follows

$$\begin{aligned} I_{jr} &= T^{-1}\left[\#\left\{S_{jt}=1,S_{rt}=1\right\}\right]+T^{-1}\left[\#\left\{S_{jt}=0,S_{rt}=0\right\}\right] \\ &= T^{-1}\left\{\sum_{t=1}^{T}S_{jt}S_{rt}+\sum_{t=1}^{T}\left(1-S_{jt}\right)\left(1-S_{rt}\right)\right\} \end{aligned}$$

where the symbol $\#\left\{S_{jt}=k,S_{rt}=k\right\}$ indicates the number of times in which both series, j and r, are in the same state. The index should be between 1 and 0, where 1 indicates maximum concordance.

3 Empirical Results

This section reports all the empirical results. Subsection 3.1 presents the time pattern of the *global* European factor and its relationship with both the country-specific factor and the output growth rate for each country. Subsection 3.2 discusses the results of variance decomposition, which measures the contribution of the *global*, regional and country-specific factors to variations in macroeconomic variables in each country. Finally, Subsection 3.3 displays a further analysis about the business cycle synchronization, by discussing both the results from the univariate and multi-country Markov-Switching models and the degree of concordance between the recessions and expansions.

3.1 Evolution of the *Global* European Factor

Figure 1 illustrates the median of the posterior distribution of the *global* European factor, along with 5, 10, 90 and 95 percent quantile bands. The estimated evolution of the *global* European factor is consistent with the main economic events between 1995 and 2008: (i) the expansionary period in the late 1990s, usually associated with the technology boom; (ii) the downturn of the early 2000s, connected with both a weak euro and the burst of the "New Economy" bubble;[14] and (iii) the recession of the late 2000s, related to the recent global financial crisis.

[Insert Figure 1 about here]

Figures 2 and 3 display the *global* European factor, the country-specific factor and the output growth rate for each of the EMU-8 countries and each of the CEE-5 countries, respectively. For the EMU-8 countries, the evidence suggests that the *global* European and country-specific factors show a highly similar evolution in different periods of time (1995-1997, 2002-2005, and the end of the sample period) in most cases. This is evidence in favour of common movements over time. Yet some differences are detected between the two factors in 1997-2002, 2005-2007 and at the end of the sample in some countries, mainly in Austria and Italy. In the case of the CEE-5 countries, the *global* European factor and country-specific factor exhibit strong differences over the period studied (with very few exceptions). In addition, the country-specific factors seem to explain the evolution of output growth for some episodes, whereas the *global* European factor seems to be more strongly related to the country output evolution for other episodes, especially in Hungary and Slovenia after 2001.

[14] The euro was introduced on January 1, 1999, which was met much anticipation, had its value immediately plummet, and it continued to be a weak currency throughout 2000 and 2001. In 2002, the value of the euro recovered and began to rise rapidly.

[Insert Figures 2 and 3 about here]

The previous analysis provides two central messages: (i) the *global* and country-specific factors play different roles at different periods depending on the particular country. This result is in the line with previous empirical evidence shown by Kose, Otrok and Whiteman (2003, 2008) and Kose, Otrok and Prasad (2008) for a larger country sample and for yearly data; (ii) the *global* European and country-specific factors in the CEE-5 countries (particularly in the Czech Republic, Hungary and Slovenia) play a different role than in the EMU-8 countries.

3.2 Variance Decomposition Analysis

We now decompose the variance of each variable considered (namely, output, consumption and investment) for each country into the fraction that is due to the *global* European factor, the regional factor, the country-specific factor and the idiosyncratic component. Tables 1 and 2 show the variance decomposition for output, consumption and investment for each of the EMU-8 countries and each of the CEE-5 countries, respectively. Tables report the median of posterior quantiles, as well as 33% and 66% quantiles.

[Insert Tables 1 and 2 about here]

Results for EMU-8 countries reveal that the *global* European factor plays a central role in explaining output growth variability. Looking at the 50% quantiles, the *global* European factor accounts on average for 49% of the fluctuation in output growth, with a range from 42% (Belgium) to 57% (France and Spain). Moreover, the idiosyncratic component seems also to be relevant to explain the variations in output. Thus, the idiosyncratic factor explains on average around 38% of output volatility. Finally, the country-specific and regional factors play a minor role in explaining output volatility.[15]

[15] Kose, Otrok and Whiteman (2003, 2008) show that the country-specific factor for G-7 countries explains around 43% of the output variability during the globalization period (1986-2003), whereas we

Regarding the variance decomposition for the consumption, the *global* European factor accounts for a smaller share of the consumption variation (especially, in Germany, France, Austria and the Netherlands) than it does for output growth in all countries.[16] However, the idiosyncratic component explains around 65% of consumption variability. The country-specific factor plays, again, a minor role but the regional factor becomes important in several countries. Furthermore, the *global* European factor explains 14% of investment variation, while the idiosyncratic factor accounts for around 47% of investment variation. It is also worth noting that the county-specific and regional factors play some role in some countries.

In the case of CEE-5 countries (see Table 2), we could distinguish two groups of countries. In the first group, including the Czech Republic, Poland and Slovakia, the idiosyncratic component is important. For example, this factor accounts for 72% of output volatility in the Czech Republic, 67.7% in Poland and 68.5% in Slovakia. In these three countries the contribution of the *global* European factor is much smaller than in the EMU-8 countries (ranging from 3.3% to 16%) and the country-specific factor gains importance (between 1.8% and 10%). Countries in the second group (Hungary and Slovenia) behave similarly to the EMU-8 countries: the *global* European factor explains around 40% of output volatility, and the idiosyncratic component represents about 40%. Again, the role of the country-specific factors is larger than in the EMU-8 countries (specifically, the 3.9% and 8.3%, respectively). In addition, the *global* European factor does not account for the consumption variation in transition economies (except for Hungary, where the *global* European factor explains just the 3%) and the country-specific factor gains some role (especially, in Slovakia and Slovenia). Finally, the variance decomposition of investment shows that the idiosyncratic component explains around

find a very small percentage (around 0.7%, on average) of country-specific factor contribution to explain the output variability from 1995 to 2008.

[16] This result is consistent with previous empirical evidence, such as Backus, Kehoe and Kydland (1995), Imbs (2004) and Kose, Otrok and Whiteman (2003, 2008).

60% of investment variability, and that the country-specific factor explains about 20% of investment variation in the Czech Republic, Slovakia and Slovenia.

In sum, the variance decomposition of output for the EMU-8 countries over the last decades shows: a) an increase in the role of *global* European factor to explain output variability; b) a strong importance of the idiosyncratic component; and c) a negligible role of the regional and country-specific factors. It is worth mentioning that our results differ from the previous empirical research in terms of the role of country-specific factor. Such difference can be explained by the fact that our results are reflecting the effects of both the globalization and the recent financial crisis.[17] The variance decomposition in the EMU-8 countries also shows that the *global* European factor accounts for a smaller share of consumption and investment variation than it does for output in all countries. Also, there is a central role of the idiosyncratic factor and a larger importance of regional and/or country factors to explain the investment variability in several countries. The later results are reasonable because of consumption and investment are substantially determined by specific preferences and particular economic-productive structure, respectively, in each country. As such, the regional and specific-country factors gain importance. Furthermore, the variance decomposition of output for the CEE-5 countries indicates that a) a sizeable fraction of the output volatility has been explained by the idiosyncratic component, and b) the country-specific factors play some role for these countries. This is a natural outcome from the transition period experimented by these economies, in which each economy has been opened with a different speed depending on their own restructuring process. In addition, the *global* European factor plays a minor role in explaining the consumption and investment volatility, and the country-specific

[17] It is worth reminding that the *global* European factor plays a central role in detriment of the role of the country-specific factor in the recent strong European recession. The *global* European factor is perfectly able to explain the recent recession.

factor plays a more relevant role than in the EMU-8 countries.

3.3 Convergence Analysis

The convergence hypothesis suggests that an increase in economic integration goes hand in hand with more synchronization across countries over time. We here test this hypothesis by using the information obtained from both the univariate and the multi-country Markov-Switching models, as well as that obtained from the measure of degree of concordance between the recessions and expansions.

[Insert Figure 4 about here]

Figure 4 shows the smoothed probability of being in a recessionary state obtained from the multivariate specification (Panel A)[18] and from the univariate specification (Panels B and C). The results from the univariate specification suggest several regularities. For the EMU-8 countries, the recession probabilities are highly similar in Germany, Belgium, Italy, France, Spain and Finland, and show a remarkable resemblance for Austria and the Netherlands. Moreover, the probability of being in recession is observed to be one at the end of the sample for all countries. In the case of the CEE-5 countries, the recession probabilities generally differ across countries. The multivariate specification indicates that the recession probability is observed to be one at the end of the sample.

[Insert Table 3 about here]

Finally, Table 3 presents the results for the degree of concordance that allows one to assess the synchronicity of the regime changes in each specific country with respect to the European business cycle. In general, we observe a high degree of synchronisation for all EMU-8 countries and for all CEE-5 countries, with Poland showing the lowest value (0.60).

[18] It is worth reminding that a measure of the European business cycle is given by the smoothed probability of being in each regime obtained from the multivariate specification.

4 Concluding Remarks

In this paper we analyzed the existence of common movements among real macroeconomic aggregates (output, consumption and investment) across EMU-8 and CEE-5 countries, using quarterly data from 1995:2 to 2008:4, to see whether there is a European business cycle. We also examined the convergence hypothesis by employing the Markov-Switching methodology and a measure of degree of concordance.

Results suggest several empirical regularities: (i) the *global* European and country-specific factors play different roles in different periods depending on the particular country, although their evolution over time in the EMU-8 countries is more similar than in the CEE-5 countries; (ii) the *global* European factor plays a central role in explaining the output variability in the EMU-8, while the regional and country-specific factors play a minor role and the idiosyncratic components show a strong importance; (iii) a large fraction of the output variability is explained by the idiosyncratic components, with the country-specific factors playing some role in CEE-5 countries; (iv) there is evidence in favour of synchronicity in all EMU-8, with the recession probabilities showing, in generally, similar patterns, whereas in CEE-5 countries the evolution of the recession probability is different across countries; and (v) the probability of being in recession is equal to one at the end of the sample in all countries studied except for Slovakia.

We could extract several important economic implications from the previous empirical regularities. The existence of a larger distance between the evolution of *global* European factor and the country-specific factors in the CEE-5 than in the EMU-8 and the fact that the country-specific factors play some role in explaining the output variability in CEE-5 countries indicate that country-specific shocks seem to have relevant effects on these economies. This result could be explained by the fact that each CEE-5 economy has opened with a different velocity, the transformation process is still ongoing, and each of these economies is nowadays in a different stage of its restructuring process.

Finally, the evidence found in favour of synchronization in all EMU-8 and their high degree of concordance show evidence of business cycle convergence in EMU-8, as was to be expected in a monetary union. For CEE-5 countries, the one probability of being in recession observed at the end of the sample and the central role of idiosyncratic components could be reflecting both the greater CEE-5 countries openness (greater product market linkages, greater internalization of enterprises, etc.) and the accelerated process toward liberalization and integration of global financial markets. Since the CEE-5 countries have opened to world product and financial markets, these economies have been substantially affected by the recent global financial crisis. That is, a greater openness has increased the vulnerability of these economies to external shocks. Furthermore, the degree of concordance found in the CEE-5 countries is, without any doubt, encouraging for the full economic integration of those countries that have already joined to the euro area (Slovenia and Slovakia) and for the suitability of those countries that adopt the euro at a later stage.

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Table 1. Variance Decomposition EMU-8 countries

Output

	ger			fra			aut			bel			esp			fin			ita			nld		
	33	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***
global	0.536	0.490	0.579	0.601	0.571	0.627	0.458	0.434	0.480	0.444	0.423	0.464	0.601	0.570	0.629	0.520	0.496	0.545	0.540	0.511	0.568	0.471	0.438	0.501
country	0.011	0.005	0.020	0.023	0.012	0.039	0.008	0.003	0.019	0.007	0.003	0.015	0.015	0.007	0.028	0.011	0.005	0.022	0.017	0.008	0.028	0.029	0.014	0.052
region	0.114	0.075	0.160	0.034	0.015	0.062	0.016	0.007	0.034	0.007	0.003	0.016	0.034	0.014	0.058	0.010	0.004	0.020	0.029	0.015	0.051	0.053	0.026	0.088
idiosyn	0.338	0.431	0.241	0.343	0.402	0.272	0.518	0.556	0.467	0.541	0.571	0.506	0.350	0.409	0.285	0.459	0.495	0.413	0.414	0.466	0.352	0.447	0.523	0.359

Consumption

	ger			fra			aut			bel			esp			fin			ita			nld		
	33	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***
global	0.058	0.045	0.071	0.066	0.050	0.082	0.120	0.102	0.141	0.373	0.352	0.394	0.511	0.467	0.547	0.289	0.268	0.308	0.269	0.247	0.294	0.061	0.048	0.074
country	0.020	0.008	0.041	0.066	0.033	0.107	0.009	0.003	0.023	0.006	0.003	0.014	0.012	0.005	0.023	0.013	0.006	0.028	0.009	0.004	0.019	0.049	0.021	0.091
region	0.046	0.028	0.069	0.095	0.061	0.133	0.090	0.062	0.123	0.010	0.004	0.018	0.079	0.045	0.123	0.010	0.004	0.019	0.058	0.033	0.085	0.050	0.026	0.077
idiosyn	0.876	0.918	0.820	0.773	0.856	0.678	0.781	0.833	0.713	0.611	0.641	0.573	0.399	0.482	0.307	0.689	0.722	0.644	0.663	0.716	0.601	0.841	0.904	0.757

Investment

	ger			fra			aut			bel			esp			fin			ita			nld		
	33	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***
global	0.326	0.296	0.357	0.515	0.486	0.539	0.365	0.339	0.390	0.061	0.051	0.071	0.291	0.250	0.333	0.099	0.084	0.113	0.276	0.253	0.299	0.145	0.108	0.187
country	0.056	0.025	0.106	0.048	0.024	0.079	0.011	0.004	0.026	0.135	0.067	0.225	0.053	0.025	0.088	0.145	0.066	0.243	0.142	0.062	0.238	0.066	0.031	0.111
region	0.068	0.034	0.111	0.023	0.010	0.046	0.021	0.009	0.041	0.006	0.002	0.012	0.190	0.143	0.242	0.013	0.005	0.027	0.026	0.013	0.045	0.372	0.313	0.434
idiosyn	0.550	0.646	0.427	0.413	0.479	0.336	0.604	0.648	0.544	0.799	0.880	0.692	0.466	0.583	0.337	0.743	0.845	0.617	0.556	0.673	0.417	0.417	0.548	0.267

Note: This Table presents the variance decomposition of output, consumption and investment for the EMU-8 countries. We report the median of posterior quantiles, as well as 33% and 66% quantiles.

Table 2. Variance Decomposition CEE-5

Output

	cz			hu			po			svk			slv		
	33	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***
global	0.041	0.033	0.051	0.407	0.377	0.433	0.181	0.160	0.204	0.056	0.040	0.073	0.496	0.472	0.520
country	0.155	0.100	0.214	0.070	0.039	0.107	0.047	0.018	0.095	0.124	0.084	0.166	0.107	0.083	0.132
region	0.008	0.003	0.015	0.018	0.008	0.031	0.018	0.009	0.033	0.063	0.039	0.091	0.005	0.002	0.010
idiosyn	0.796	0.864	0.720	0.506	0.576	0.429	0.753	0.813	0.669	0.757	0.837	0.670	0.392	0.443	0.338

Consumption

	cz			hu			po			svk			slv		
	33	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***
global	0.002	0.001	0.003	0.042	0.030	0.056	0.004	0.002	0.008	0.004	0.002	0.007	0.005	0.002	0.008
country	0.103	0.064	0.158	0.156	0.082	0.248	0.103	0.047	0.177	0.267	0.198	0.346	0.230	0.181	0.283
region	0.007	0.003	0.013	0.047	0.026	0.072	0.098	0.068	0.129	0.010	0.004	0.019	0.008	0.003	0.017
idiosyn	0.889	0.933	0.826	0.755	0.862	0.624	0.795	0.883	0.686	0.719	0.796	0.627	0.758	0.814	0.692

Investment

	cz			hu			po			svk			slv		
	33	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***	***33***	***50***	***66***
global	0.002	0.001	0.004	0.034	0.026	0.043	0.043	0.035	0.053	0.004	0.002	0.007	0.256	0.238	0.279
country	0.273	0.187	0.376	0.075	0.041	0.123	0.055	0.024	0.116	0.255	0.166	0.334	0.307	0.253	0.353
region	0.028	0.014	0.047	0.021	0.010	0.036	0.009	0.004	0.018	0.009	0.003	0.017	0.012	0.005	0.022
idiosyn	0.697	0.798	0.574	0.870	0.923	0.798	0.893	0.938	0.813	0.732	0.828	0.642	0.425	0.504	0.346

Note: This Table presents the variance decomposition of output, consumption and investment for the CEE-5 countries. We report the median of posterior quantiles, as well as 33% and 66% quantiles.

Table 3. Degree of Concordance

EMU-8

ger	fra	aut	bel	esp	fin	ita	nld
0.964	0.964	0.727	1.000	0.945	0.964	0.964	0.782

CEE-5

cz	hu	po	svk	slv
0.782	0.745	0.600	0.927	1.000

Note: This Table presents the degree of concordance as a measure of the synchronicity of the business cycle in each specific country with respect to the European business cycle. The degree of concordance is calculated as $I_{jr} = T^{-1}\left\{\sum_{t=1}^{T} S_{jt}S_{rt} + \sum_{t=1}^{T}(1-S_{jt})(1-S_{rt})\right\}$, where $S_{jt} = \Pr^{I}(s_t = 2|Z_T)$ and $S_{rt} = \Pr^{E}(s_t = 2|Z_T)$ are the smoothed probabilities of being in a recessionary state obtained from the univariate and multivariate specifications, respectively.

Figure 1. Evolution of the *global* European factor

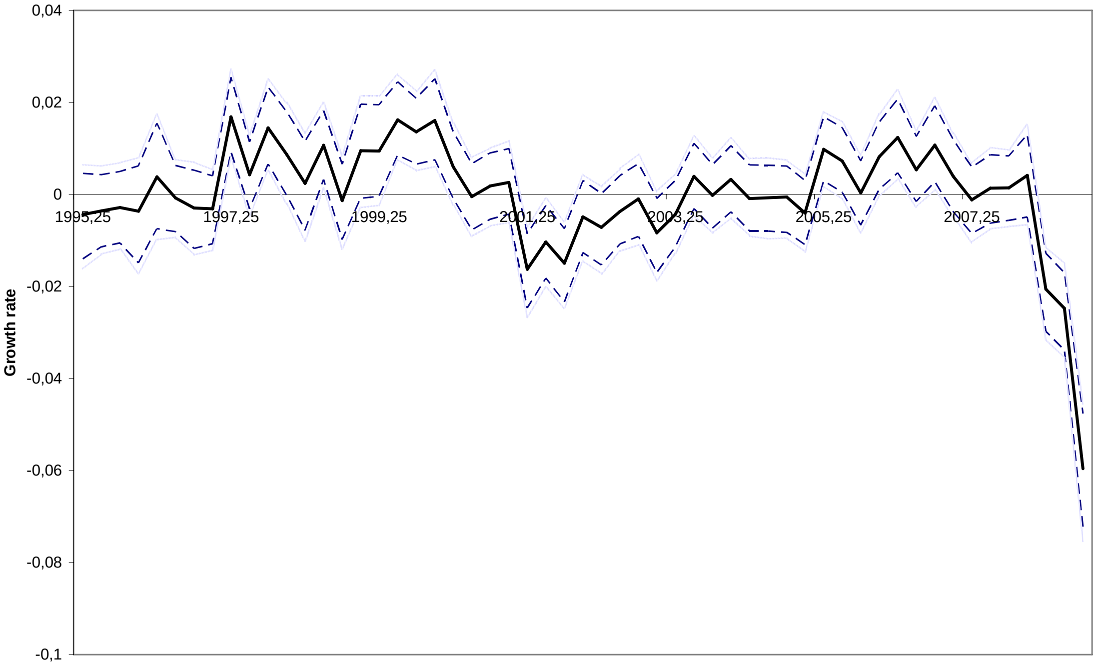


Figure 2. Evolution of real GDP growth, and the *global* European and country-specific factors for EMU-8

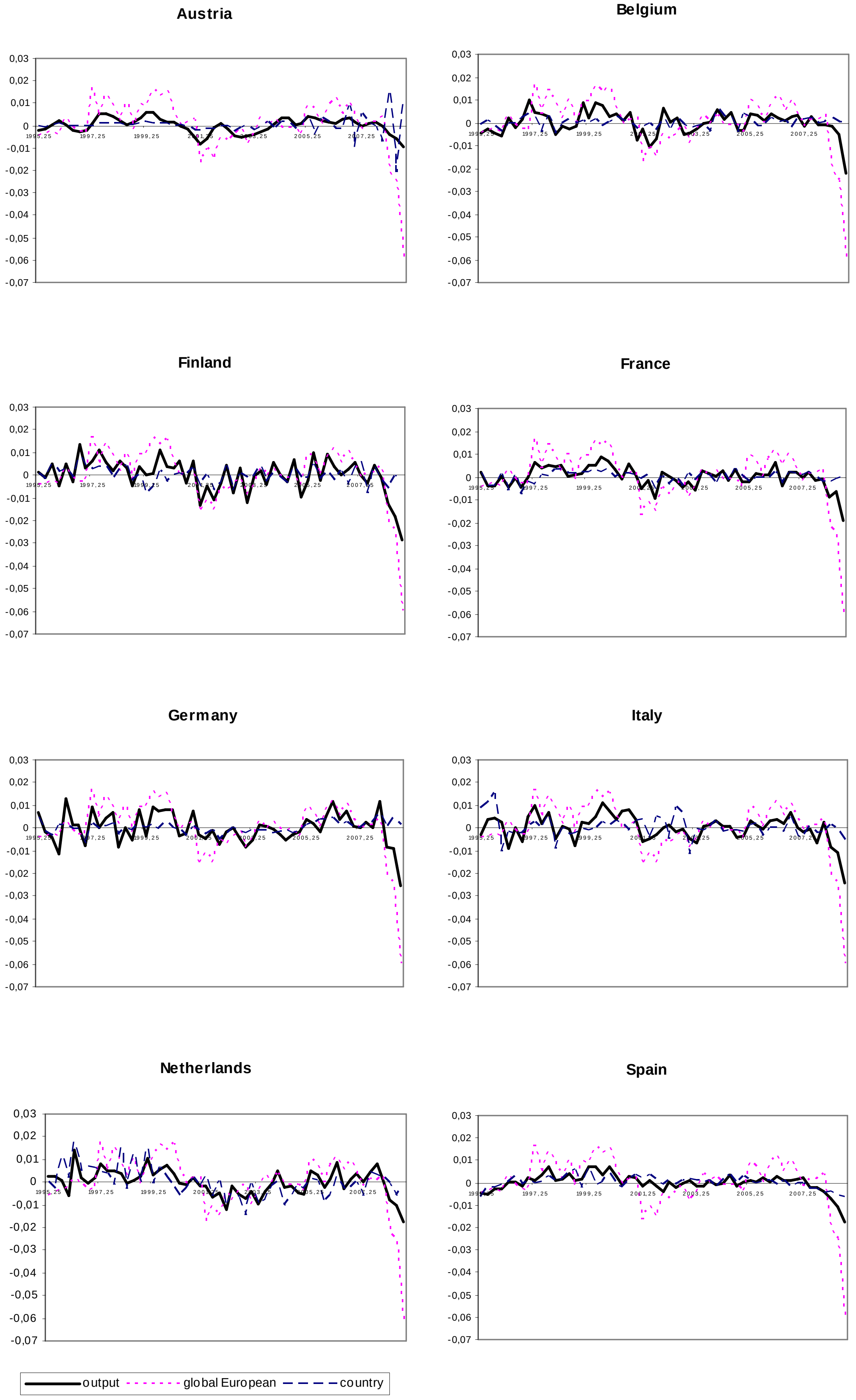


Figure 3. Evolution of real GDP growth, and the *global* European and country-specific factors for CEE-5

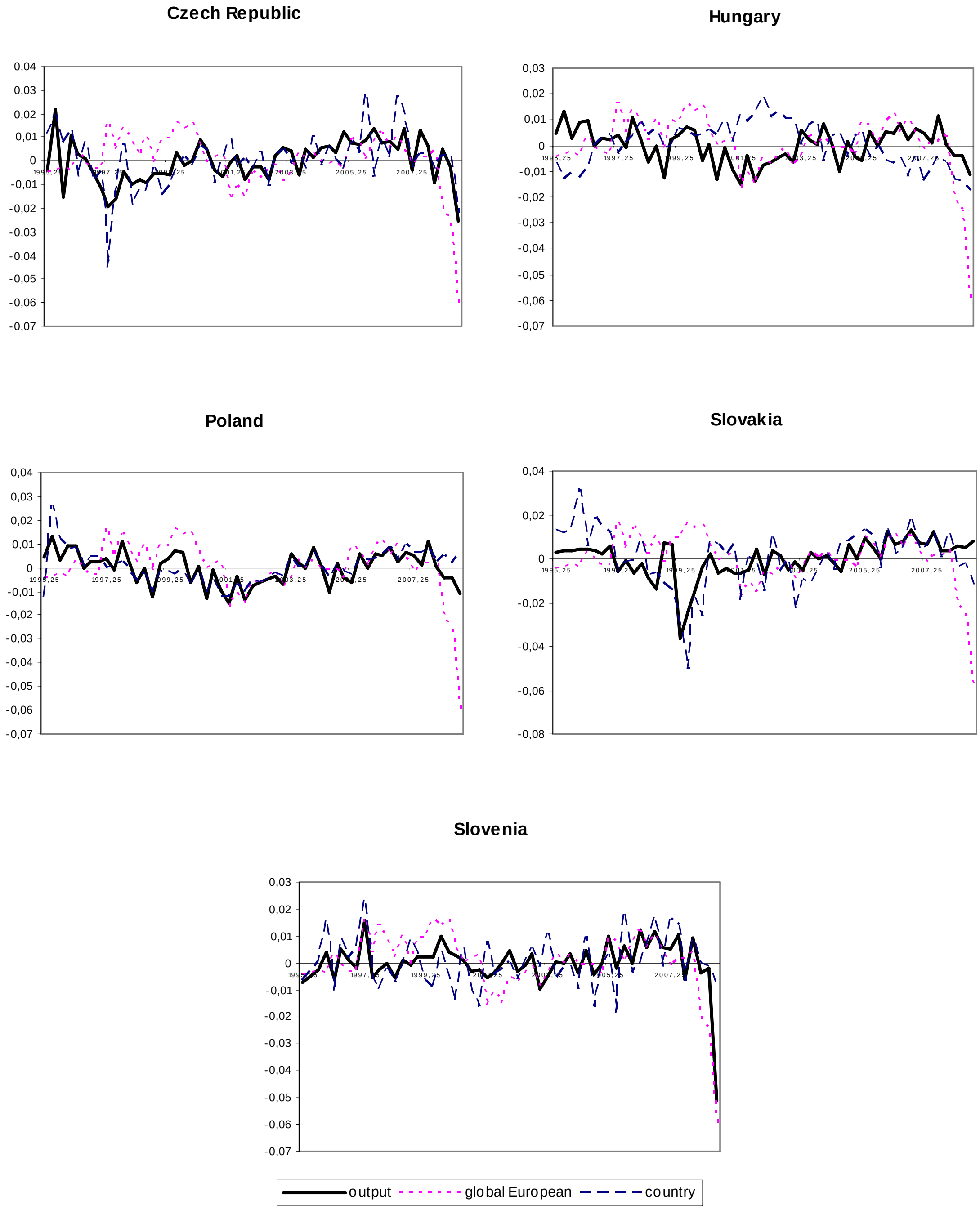
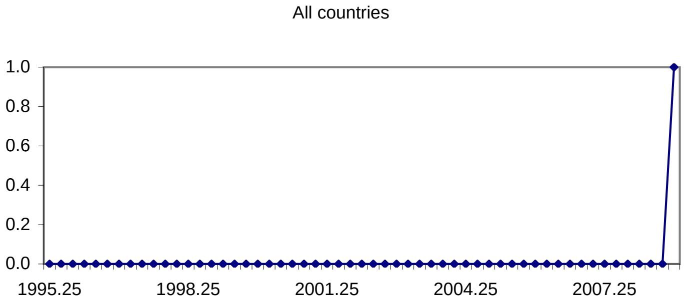


Figure 4. The smoothed probability of being in a recessionary state

Panel A. The smoothed probability of being in a recessionary state obtained from the multivariate specification.



Panel B. The smoothed probability of being in a recessionary state obtained from the univariate specification in each EMU-8 country

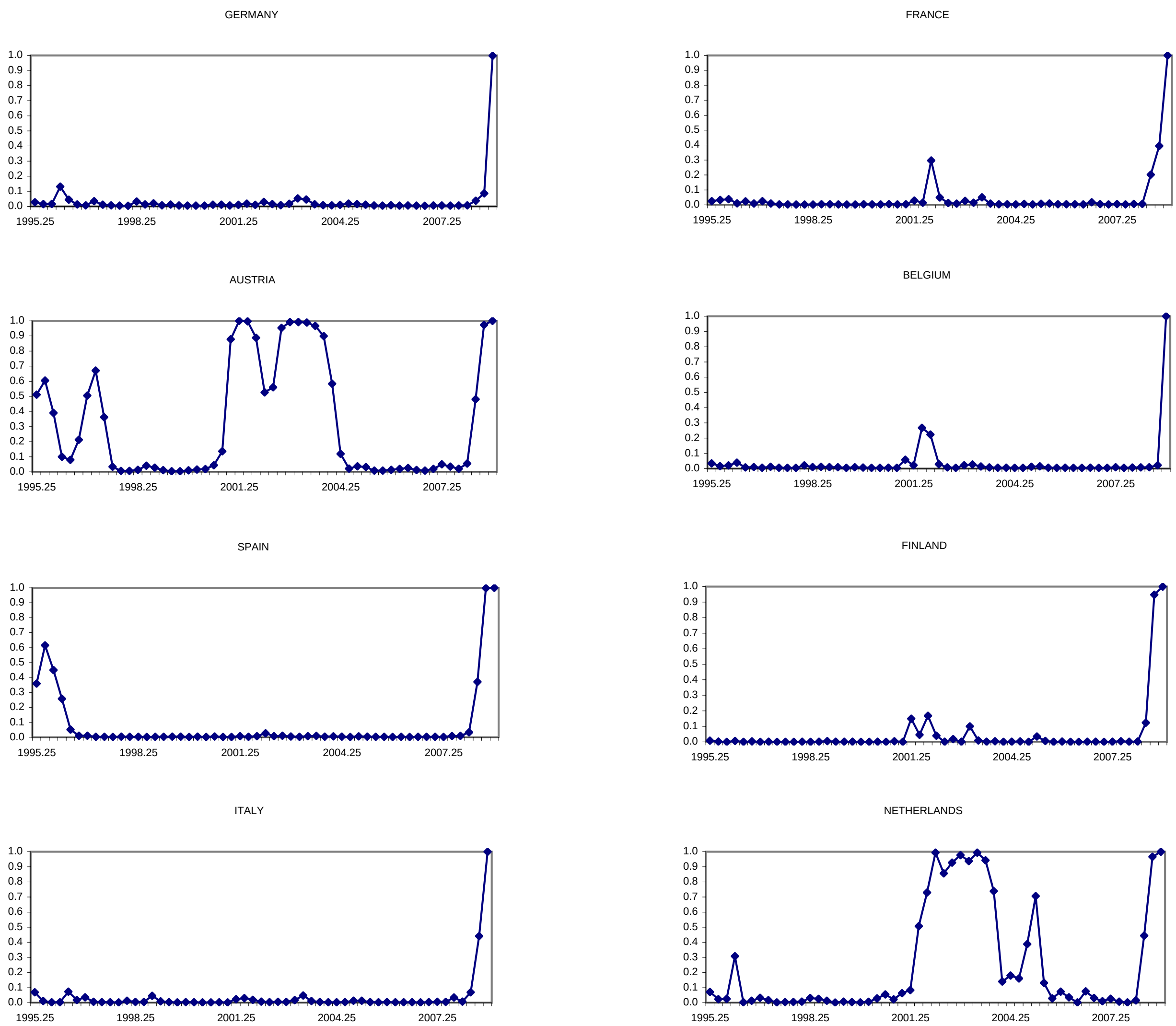


Figure 4. The smoothed probability of being in a recessionary state (*Cont.*)

Panel C. The smoothed probability of being in a recessionary state obtained from the univariate specification in each CEE-5 country