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Business Cycle Synchronization of the Euro Area with the New and Candidate Member Countries

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February 26, 2007

Abstract

We examine business cycle synchronizations between the euro area and the new and candidate countries of the EU. We utilize a bivariate VAR-GARCH specification with a smoothly time-varying correlation that allows for structural changes in the degree of co-movement between the cyclical components of monthly industrial production. After the application of a Lagrange Multiplier statistic that tests directly the constant correlation hypothesis, we find that all the new EU members and candidate countries (with the exception of Estonia) have *at least* doubled their business cycle synchronization with the euro area. The results point to great variety in timing and speed of the correlation shifts across the country sample.

JEL Classifications: C22; E32;

Keywords: Business Cycles, Conditional Correlations, Synchronization, Volatility.

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1. Introduction

On 1st of May 2004, 10 countries (Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovenia, and Slovakia) became members of the European Union (EU). In addition, two other countries (Bulgaria and Romania) joined the Union on 1st of January 2007, while three more countries (Croatia, Turkey, and FYROM) are at various stages of candidacy for membership. Once the new members and candidate countries meet the Maastricht convergence criteria, they will also join the Euro Area[1] (EMU), implying that their monetary policy will be determined by the European Central Bank (ECB).

Joining the EMU mandates a stabilization cost for each country since they lose the control of their exchange rate and the independence of their monetary policy. As shown by the New Keynesian monetary policy models of Rogoff (1985) and Clarida et al. (1999), among others, the ECB will respond more successfully to aggregate shocks and implement its policy with greater ease, if Euro area members have less volatile and more synchronized business cycles. In particular, theory predicts that the more synchronized the business cycles among the member states, the lower the probability of asymmetric shocks, and thus the less painful the loss of independent monetary policy. This implies that business cycle convergence represents a key characteristic for the success of the common monetary policy in Europe.

Intuitively, if the business cycle of a country is very highly correlated with the EMU-wide cyclical output, then monetary policy conducted by the ECB will be a very close substitute for the country's independent monetary policy. On the other hand, non-synchronization of cycles may yield a situation where ECB monetary policy amplifies the country's business cycle, thus aggravating the macroeconomic cost of EMU membership.

There is an extensive literature on business cycle synchronization in Europe that can be largely divided into two categories. The first category examines the co-movements of cycles of European countries with each other and/or with the US. For instance, Artis (2003) uses the Hodrick-Prescott (HP) filter to obtain the cyclical component of

[1] From the new members, Slovenia has joined EMU from the 1st of January 2007.

quarterly GDP series in 23 countries, of which 15 are European. He finds that during 1970-2001 whilst some European nations seem to exhibit high correlation with each other and with the US (Germany, Austria, Switzerland, and the Netherlands), another European group (France, Spain, Belgium, Italy, and Denmark) is highly correlated with Japan, and that there are other countries that show no tendency of synchronization (Ireland, Finland, Sweden, Portugal, the UK, and Norway). Angeloni and Debola (1999) limit their analysis between German and other European business cycles and recover fluctuations in industrial production indices, which show increasing correlations during 1993-1997. More recently, Koopman and Azevedo (2006) with the use of a technique that allows for time-varying association patterns in different cycles illustrate that French and German GDP fluctuations display a high degree of association with the Euro area over 1970-2001, while the Spanish and Italian cycles became more synchronized only after 1980.

The second category of studies focuses on the degree of business cycle synchronization between the Euro area and the new members of the EU and its candidate countries. In this context, Korhonen (2003) examines monthly indicators of industrial production in the euro area and nine central east-European countries (CEECs). He finds that some CEECs, especially Hungary, exhibit a high correlation with the euro-area business cycle. Correlation seems to be at least as high as in some smaller EMU members (e.g., Portugal and Greece). Fidrmuc (2004) also finds that the business cycle for Hungary, Slovenia, and (to a lesser extent) Poland correlates strongly with the German cycle.

In a similar way, Artis *et al*. (2004) compute business cycles as deviations from the HP band-pass cycles and find that Hungarian and Polish business cycles are the most similar to the euro area cycle. Furthermore, Darvas and Szapáry (2005) examine the synchronization of business cycles between new and old EU members with Hungary, Poland, and Slovenia and show strong improvement in cyclical correlations as moving from 1993-1997 to 1998-2002. In general these results seem to support the findings of Kočenda (2001) and Kutan and Yigit (2004), who report increasing convergence between the CEECs and the EU.

More recently, however, Furceri and Karras (2006) identify countries (such as Slovenia, Cyprus, and Hungary) whose business cycle is already well synchronized with the EMU, compared to countries (such as Latvia and Estonia) that exhibit low synchronization, and countries (such as Romania, Turkey and Croatia) with systematically negative correlations.

All these studies share one or two of the following features: they consider a uniform correlation coefficient for the period under investigation, or, in the best case, they exogenously determine time period sub-samples for which the potential change in the correlation is assessed. For the latter, this means that the empirical tests for changes in correlations among business cycles involve some sort of a two step approach, where in the first step correlations are calculated over either fixed or moving sub-samples, and in the second step the presence of level shifts or trends is assessed.

However, neither of the two methods is appropriate in establishing the magnitude of the business cycles synchronization. The estimation of a uniform correlation coefficient fails to consider potential regime switches, while the two step tests may suffer from two statistical deficiencies. Boyer et al. (1999) show that changes in correlations over time or across regimes cannot be detected reliably by splitting a sample according to the realized values of the data. As they argue, it is not possible to assess the presence of an upward trend in correlations by looking at the (trending) behavior of sub-sample estimates of correlations. Therefore, tests of changes in correlations are often severely biased. A second statistical deficiency is that such a test will lack power if the selected sub-samples do not closely match the true correlation regimes.

In our analysis, we take into account such considerations when examining the business cycles synchronization of the euro area with the new members of the EU and its candidate countries, with the use of monthly industrial production data over the period January 1980 (or the earliest date available) to June 2006. Our setup employs a bivariate VAR-GARCH specification that models the conditional volatility of the business cycle and allows for a smooth transition in the correlation specification (STC-GARCH) adopted by Berben and Jansen (2005). In addition, we utilize a Lagrange Multiplier (LM) test that discriminates between a constant correlation

GARCH model and the STC-GARCH model. In this way, we test whether a structural change in the time profile of business cycle synchronization has occurred. With this methodology we are able to endogenously identify the time period of such changes, if any, and also characterize the transition path to the new regime in terms of its smoothness.

The main results suggest that conditional correlation patterns between the Euro area and all the newly accessed member states and candidate countries have changed over the last two decades. More specifically, we find that correlations have more than doubled for the majority of the countries. These changes are generally abrupt and the dates of change vary widely across countries. One exception is Estonia for which an abrupt decrease has been observed. Additionally, some of the new EU members exhibit higher business cycle correlation with the Euro area compared to the EU peripheral states of Portugal and Ireland. Finally, the volatilities of the business cycles of new and candidate states are characterized by GARCH effects with statistically significant short and long term persistency coefficients while the business cycle of the Euro area is mainly characterized by short term persistency.

The rest of this paper is organized as follows. In the next section, we describe the data. Section 3 introduces the econometric methodology while section 4 presents the empirical results. Finally, section 5 offers some concluding remarks.

2. Data

We utilize monthly data on the seasonally adjusted industrial production index[2] for each country and an aggregate EU measure over the period January 1980 (or the earliest available) to June 2006. We exclude from our sample of new EU members and candidate countries Latvia, Malta, and Bulgaria due to data limitations.[3] As Artis et al. (2004) note, industrial production indexes display more cyclical sensitivity than GDP estimates. In this respect, they may prove more informative for monitoring

[2] Although quarterly GDP has been widely used to estimate the output gap, it is available for a very short time span, which is restrictive for the purpose of our study. Therefore, we prefer to base our analysis on industrial production index.

[3] We were not able to identify data for Malta, while for Latvia (since 2001:1) and Bulgaria (since 2000:1) the data coverage period produces insufficient observations for a reliable analysis to be undertaken.

business cycle fluctuations. To obtain a measure of the cyclical component for each country, we detrend each data series using the Hodrick and Prescott filter. We work throughout with the logarithms of the series because we are mainly interested in percentage deviations from trend. As Pallage and Robe (2001) indicate, this method is appropriate to assess the relative magnitude of fluctuations.

We concentrate our analysis on nine enlargement countries (Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Poland, Romania, Slovakia, and Slovenia) and on the countries which are in various stages of candidacy for membership (Croatia, FYROM, and Turkey). In the Appendix, Table A1 gives the exact time span of the country sample while Figure 1 depicts the time profile of the cyclical component of each country and of the EU. Although our primary target is to investigate the business cycle correlation of new members with the EU and identify potential structural changes over the period under investigation, we also include for comparison purposes in our sample some of the oldest ("core") members of the EU (Austria, Belgium, France, and the Netherlands) and its "periphery" countries (Greece, Ireland, Portugal, and Spain).[4]

Since we anticipate the implementation of monetary policy in the enlarged EU to be easier if the Euro area members have less volatile and more synchronized business cycles, we compare the compatibility of the new and candidate members' business cycles with the EU's.

3. Econometric Methodology

In this section we introduce a bivariate VAR-GARCH model proposed by Berben and Jansen (2005) that enables us to test the time-varying behavior of business cycle correlations.

[4] A set of diagnostic tests (available upon request) on the cyclical components, that includes a Ljung-Box test for up to twelve lags of serial correlation and its counterpart in the squared data, suggest strong presence of serial correlation and conditional heteroscedasticity. This implies that second moment nonlinear dependencies are significant, supporting the use of a GARCH specification that captures changes in volatility.

Consider a bivariate time series of cyclical components $\{y_t\}$, $t = 1, \ldots, n$, with two elements each, so that $y_t = (y_{1,t}, y_{2,t})'$, the stochastic properties of which are assumed to be described by the following model

$$y_t = c_0 + \phi y_{t-1} + \varepsilon_t, \quad (1)$$

where $\phi = \begin{bmatrix} \phi_{11} & \phi_{12} \\ \phi_{21} & \phi_{22} \end{bmatrix}$ captures any possible own past effects and cross effects from one business cycle to the other.[5] The error term is assumed to follow the process

$$\varepsilon_t \mid \Psi_{t-1} \sim N(0, H_t), \quad (2)$$

where Ψ_{t-1} is the information set consisting of all relevant information up to and including time $t-1$, and N denotes the bivariate normal distribution. The conditional covariance matrix of ε_t, H_t, is assumed to follow a time-varying structure given by

$$H_t = E[\varepsilon_t \varepsilon_t' \mid \Psi_{t-1}], \quad (3)$$

$$h_{11,t} = \omega_1 + \alpha_1 \varepsilon_{1,t-1}^2 + \beta_1 h_{11,t-1}, \quad (4)$$

$$h_{22,t} = \omega_2 + \alpha_2 \varepsilon_{2,t-1}^2 + \beta_2 h_{22,t-1}, \quad (5)$$

$$h_{12,t} = \rho_t (h_{11,t} h_{22,t})^{1/2}, \quad (6)$$

$$\rho_t = \rho_0 (1 - G(s_t;\gamma,c)) + \rho_1 G(s_t;\gamma,c), \quad (7)$$

where, in order to keep the analysis tractable, we have assumed that the conditional variances $h_{11,t}$ and $h_{22,t}$ both follow a GARCH(1,1) specification. Our choice is motivated by the heavy autocorrelation of the second moments, as indicated by the diagnostic tests, and by the empirical literature that has found that this specification adequately captures the persistence in second moments of industrial production indices (e.g., Fornari and Mele, 1997; Grier and Perry, 2000; Grier et al., 2004)

[5] To determine the appropriate order of equation (1) we use the Schwartz Infrormation Criterion for the maximum of 12 lags in (1).

To capture any changes in correlation we allow for a smooth transition functional form (Lin and Terasvirta, 1994) between two correlation regimes. Let $G(s_t; \gamma, c)$ be the logistic function

$$G(s_t; \gamma, c) = \frac{1}{1 + \exp(-\gamma(s_t - c))}, \qquad \gamma > 0, \tag{8}$$

where s_t is the transition variable, and γ and c determine the smoothness and location, respectively, of the transition between the two correlation regimes[6]. The transition variable is described as a function of time: $s_t = t/n$[7].

The Smooth Transition Correlation GARCH (STC-GARCH) model is able to capture a wide variety of patterns of change. If ρ_0 and ρ_1 differ, correlations move monotonically upward or downward, but the pace of change may vary strongly over time. The change between correlation regimes is abrupt for large values of γ, while the transition can be made arbitrarily gradual for small values of γ[8]. Obviously, for $\rho_0 < \rho_1$ an increase in correlation will be observed, whereas for $\rho_0 > \rho_1$ a decrease is obtained while the constant correlation model (Bollerslev, 1990) is a special case of the STC-GARCH model by setting either $\rho_0 = \rho_1$ or $\gamma = 0$.

The likelihood function at time t (ignoring the constant term and assuming normality) is given by

$$l_t(\theta) = -\frac{1}{2}\ln | H_t | - \frac{1}{2}\varepsilon_t' H_t \varepsilon_t, \tag{9}$$

where θ is the vector of all the parameters to be estimated. The log-likelihood for the whole sample from time 1 to n, $L(\theta)$, is given by

$$L(\theta) = \sum_{t=1}^{n} l_t(\theta). \tag{11}$$

[6] As the transition function $G(s_t; \gamma, c)$ is bounded between zero and one, and assuming that ρ_0 and ρ_1 are between −1 and +1, the correlation ρ_t will be between −1 and +1 as well.

[7] In practice, we scale $(t/n - c)$ by $\sigma_{t/n}$, the standard deviation of the transition function t/n, to make estimates of γ comparable across different sample sizes. In principle, any variable can act as a transition variable.

[8] Note that if $\gamma \rightarrow \infty$, the transition between ρ_0 and ρ_1 becomes a step at $t = cn$.

This log-likelihood is maximized with respect to all parameters simultaneously, employing numerical derivatives of the log-likelihood. To allow for non-normality of $\varepsilon_t \left| \Psi_{t-1} \right.$, robust "sandwich" standard errors (Bollerslev and Wooldridge, 1992) are used for the estimated coefficients.

4. Empirical Results

In this section, we first look at the correlations of the full sample assuming that there is no regime switch within the covered time period. This also allows us to compare our results with those of the existing literature. Then, we apply a LM test to investigate whether a structural change has actually occurred in the correlations between the business cycles of new, candidate, "core", and "periphery" countries with the Euro area members. Finally, we estimate the STC-GARCH model to determine the time and the pattern of the shifts.

4.1. Full-sample correlations

Table 1 shows the correlations of the new and candidate countries with the euro area for three different time periods: the full coverage period, a period that ends in 2002, and a period that begins in 1995. Although the most relevant results come from the full sample period, we also report the other two sub-samples for the following reasons. First, we limit the end period to 2002 in order to conform to the data coverage of some studies, and because this date highlighted the end of the admission negotiation period of the 10 countries that eventually joined the EU in 2004. Second, the starting date of 1995 has been identified by many studies as important because official EU membership applications started at that time, but most significantly because the post-1995 period excludes the turbulent years of transition in the early 1990s for the CEECs.[9]

A number of observations deserve attention. First, the correlation estimates of the full sample and of the sample ending in 2002 appear to be materially unaltered. However, these similarities may mask endogenous changes in business cycle synchronization at a date after 2002 that are smoothed out when considering the entire sample. Second, for most CEECs the change in the sample to the post-1995 period shows an increase

[9] Time series tests of convergence that rely on periods where countries are far away from their steady state are criticized as not being reliable (see, for example, Bernard and Durlauf, 1996).

in their correlation coefficients giving support to the claims that prior to 1995 the data may be biased due to transitional recessions. Third, the degrees of co-movements appear to be consistent with the findings in the literature. For instance, Berger et al. (2002) consider a similar detrending technique for industrial production during 1990-2001, and find comparable correlations to our end-of-2002 sample estimates for Cyprus, Hungary, Poland, Romania, and Slovenia. Their correlations for the remaining countries are somewhat smaller in magnitude. Similarly, Firdmuc (2004) for the 1996-2001 period reports identical results with our last column.

Fourth, the basic findings in the related literature of high EU area synchronization with Hungary, Poland, Slovenia, and Cyprus and the very low, and even negative, correlation with Romania, Turkey, and Croatia (e.g., Firdmuc and Kohonen, 2004; Artis et al., 2004; Darvas and Szapáry, 2005; Furceri and Karras, 2006) are not fully and consistently verified from the results in Table 1. Although the first two columns of results depict the high correlation of Slovenia and the negative correlations of Romania, Turkey, and Croatia, they only show moderate to low correlations for Poland and Slovenia. These two latter inconsistencies are corrected in the last column of the post-1995 sample.

Overall, the above results suggest that the findings in the literature depend heavily on the period under investigation. This, in turn, implies that there may be two dominant trends in business cycle synchronization that highlight a change in correlation regimes. Whether this change occurred after 1995, or after the end of the EU admission negotiations in 2002, however, needs to be tested rather than assumed in an ad-hoc manner. This is the way we proceed in the next sections where we endogenously determine the date and the speed of change in regime shifts.

4.2. Evaluation of structural changes

To assess whether the proposed time-varying GARCH specification really improves the model's ability to track the time-series properties of the data over a fixed parameter version, we employ a Lagrange Multiplier (LM) test developed by Berben and Jansen (2005).[10] This test is designed to discriminate between the constant correlation GARCH model and the STC-GARCH model.

Under the null hypothesis, the LM statistic is asymptotically χ^2 distributed with one degree of freedom. The LM test does not discriminate between an increase and a decrease in correlation. It simply tests the null hypothesis H_0: $\gamma = 0$ against the alternative of H_a: $\gamma > 0$, which implies a time-varying conditional correlation. To determine whether the correlation has gone up or down, the STC-GARCH model has to be estimated. As stated earlier, we assume that business cycles have time-varying variances that follow a GARCH(1,1) specification.[11]

Table 2 reports the LM statistics. The test reveals that the null hypothesis of no structural change in the business cycle co-movements of each country with the euro area is rejected at least at the 5% marginal level of significance. The only exception is Slovakia where the null is rejected at the 10% level. These results strongly support the notion of a regime switch in the cycles not only for the older members of the EU ("core" and "periphery"), but also for the most recent members and the candidate nations. To examine the direction and the pattern of change, we turn next to the estimation of the STC-GARCH model.

4.3. Time-varying shifts in business cycle synchronization

Based on the evidence provided by the LM test, Tables 3 and 4 report the estimated parameters of the STC-GARCH model described in equations (1)-(8) for all the countries. Table 3 presents the VAR and GARCH parameters, while Table 4 describes the estimated parameter values of the transition function (8) and the correlations that characterize the old and the new regimes.

Starting with Table 3, the VAR parameters ϕ_{ij}^{k}, where $i, j = 1,2$ and $k = 1,2,3,$ represent the past own country and EU effects of business cycles on each country's

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[10] We refer to Berben and Jansen (2005) for an excellent description of the development and the details of this test.

[11] We establish the adequacy of the model specification by performing standardized residual diagnostic tests. The mean and variance of the standardized residuals are found to have values of zero and one respectively for all the economies. In addition, the Ljung-Box statistics in the standardized and squared standardized residuals show no evidence of linear dependence, suggesting that the model is well specified. These results are available upon request.

and the EU's current business cycle. The order of lags (k) is determined by the Schwartz Information Criterion and appears for each country under the VAR order. Although we have allowed up to 12 lags of effects, the table shows the identified lag order for each country.[12] It is clear from the table that the own business cycle lagged effects are significant both for each country (ϕ_{11}^{k}) and for the EU (ϕ_{22}^{k}). Unsurprisingly, this indicates the importance of the lag structure since past own business cycles exert a significant impact on the determination of subsequent business cycles.

In a similar way, the EU business cycle seems to substantially affect the business cycle of each country, as illustrated by the significance of the parameters ϕ_{12}^{k}. This could be due to the higher trade, financial, and economic integration that EU offers to its members, thus influencing the profile of their domestic business cycles. This has been also supported by Firdmuc (2004), who finds that since the mid-1990s the business cycle of the EU has greatly determined the developments in the CEECs' economies. Finally, note that the past cyclical effects of each new member country do not affect the cyclical behavior of the EU industrial production index (Hungary constitutes an exception) as indicated by the parameter ϕ_{21}^{k}. This is not surprising since the weight of these new countries' business cycles in the overall EU business cycle is small compared to that of the "core countries", as highlighted by the significance of their coefficient estimates.

As far as the coefficients of the conditional covariance matrix of ε_t are concerned, the significance of the estimates of α_i and β_i suggest that the GARCH(1,1) specification we have utilized captures the changing conditional volatility of the business cycle in these countries. More specifically, the volatilities of business cycles of new and candidate states are characterized by short and/or long term persistency. However, the behavior of the volatility of business cycle of the Euro area is mainly influenced by short term persistency in most of the combinations.

[12] For example, ϕ_{12}^{2} describes the two period lagged effect of the EU business cycle on the current business cycle of each country.

Turning our attention to the examination of the transition function, Table 4 reports the correlations in the old (ρ_0) and the new (ρ_1) regime, the location of the transition (*c*), the shape of the transition (γ), and, finally, the central date of the implied structural change for our full sample period. Note that the inflection point represented by *c* is expressed as a fraction of the sample size, so that the reported month of structural change corresponds to *c*.

The main finding that emerges from Table 4 is that all the countries – new EU members, candidates, core, and periphery states – experienced an increase in their business cycle synchronization with the euro area. The only exception is Estonia for which the degree of correlation declined by about half its size at the middle of 1998. The increase in correlation for all the other countries has been quite substantial, in particular for the new EU and candidate nations. For all but two (Poland and FYROM) the correlations quadrupled, whereas for the remaining two it approximately doubled.[13]

It is interesting that for some countries (Cyprus, the Czech Rep., Hungary, Lithuania, Slovakia, and Croatia) the regime switch has been so large that they attained correlation patterns similar not only to periphery EU members, but also to some core states (Austria, Belgium, and Netherlands).[14] A similar picture is obtained for the periphery EU states that have been "catching-up" with the core members for a number of years. Their synchronization with the euro area cycle more than doubled and reached levels equivalent to some core countries, for which co-movements have also increased.

As it regards the length of the transition periods indicated by the value of γ, it seems that for the majority of the countries the transition has been quite swift. Apart from a few countries (Cyprus, the Czech Rep., Slovakia, Croatia, Austria, France, Portugal, and Spain) the large values of γ suggest the abrupt changes in correlation regimes. In addition, the dates of the structural change for five of the new EU members (Cyprus,

[13] Notice, in particular, the switch in correlations from negative to positive for Romania, Turkey, and FYROM.

[14] Lithuania deserves special reference since the majority of the studies have found that it exhibits very low or even negative correlation. That appears to also be the case in our analysis, but it restricts itself only in the first regime. Thereafter, Lithuania's synchronization is comparable to that of Germany's.

the Czech Rep., Lithuania, Romania, and Slovakia) occurred around or after the completion of their admission negotiations at the end of 2002. The remaining states (Estonia, Hungary, Poland, and Slovenia) showed a change in correlations at the second half of the 1990s.

These findings can be justified on the grounds of higher trade and financial integration between the EU and its associated states (e.g., Firdmuc, 2004; Furceri and Karras, 2006). They are also in line with the related literature, which shows a higher level of business cycle compatibility between the EU, on the one hand, and Hungary, Poland, and Slovenia, on the other. These countries appear to have been ready to join the EU sooner than their counterparts which eventually entered the EU in 2004. These results can be also viewed in Figure 2, which presents graphical illustrations of the shape and smoothness of the transition function.[15]

To examine the robustness of our results for the new EU and candidate states, we consider the transitional element of their experience in the first half of the 1990s and repeat our analysis for the post-1995 period. Table 5 shows the results. The limitation of the sample period does not alter the main outcomes of our regime-switching technique, therefore providing support to our findings. We still obtain similar changes in correlations in terms of their magnitude, smoothness, and timing of the switch. The only exceptions are Hungary for which now the correlation drops from the old to the new regime, but the size of the correlation in the new regime is comparable to the one found for the full sample. In addition, the date of change for Hungary and Poland has moved forward for about 2.5 and 8 years respectively. These could be taken as an indication of more than two correlation regimes implying the presence of hump-shaped patterns in business cycle co-movements. This is an interesting issue that we plan to address in future research.

5. Conclusions

This paper examines business cycle synchronizations between the euro area and the new and candidate countries of the EU. The issue itself is by no means novel, nor the examination of the countries under consideration. The benefits and costs of a currency

[15] For space considerations, we do not report in Figure 2 the old members of the EU (core and periphery states). Plots are available upon request.

union have been extensively analyzed in the literature in the pioneering works of Mundell (1961), McKinnon (1963), and Kenen (1969), and more recently by Bayoumi and Eichengreen (1996), Frankel and Rose (1998), and Rose (2000). Moreover, a number of recent papers examined the above issue for newly accepted EU states, among them, Berger et al. (2002), Artis et al. (2004), Firdmuc (2004), Darvas and Szapáry (2005), Furceri and Karras (2006), and Firdmuc and Korhonen (2006).

The main innovation of our paper lies in the methodological technique we utilize that allows for structural changes in the degree of co-movement between the cyclical components of industrial production. This novel technique allows us to identify the time period at which the change occurs and at the same time describes the length of the transition phase. The advantage with this procedure is that we endogenously determine the date of the regime switch instead of setting it in an ad-hoc manner. In this way, we manage to avoid the statistical deficiencies associated with the exogenous setting of date of change that biases other approaches in the literature.

The formulation of our model is based on a bivariate VAR-GARCH specification with a smoothly time-varying correlation (STC-GARCH). To examine the presence of a structural break, we first use a Lagrange Multiplier (LM) statistic that tests directly the constant correlation hypothesis in the business cycles of the euro area and eight of the recent EU members (except for Latvia and Malta) and three of its candidates. Once we establish the occurrence of such breaks, we then use our GARCH model to investigate in more detail the characteristics of the regime shifts.

We find that all the countries – new EU members, candidates, core, and periphery states – experienced a sizeable increase in their business cycle synchronization with the euro area (with the exception of Estonia). For some countries the regime switch has been so large that they attained correlation patterns similar not only to periphery EU members, but also to some core states.

Our results point to great variety in timing and speed of the correlation shifts across our country sample. For the majority of the countries we identify an abrupt transition to the new regime. The dates of the structural change also seem to differ with half of the new EU members experiencing a change around or after the completion of their admission negotiations at the end of 2002. However, some countries (Hungary, Poland, and Slovenia) have been better prepared in joining the EU sooner than 2004 since their regime shifts took place well before 2002.

Our findings, on the one hand, provide a critical view in past works that do not consider a flexible approach to modeling structural changes. On the other hand, however, provides support to the general conclusions in the literature. Therefore, we consider our modeling strategy as a step forward in the examination of business cycle co-movements. However, our methodology is not free of restrictive elements. This refers in particular to the strict monotonicity assumption of the correlation change we impose. A more flexible technique that would allow for more than two correlation regimes would be more appropriate. The development of such a non-monotonic specification represents part of our future research agenda.

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Table 1: Uniform Sample Correlations

Country	Sample period	Full period	Ending 2002:12	Starting 1995:1
Cyprus	1988:1-2006:6	0.31	0.34	0.07
Czech Republic	1993:1-2006:6	0.48	0.45	0.50
Estonia	1994:1-2005:12	0.36	0.37	0.48
Hungary	1985:1-2006:6	0.26	0.26	0.68
Lithuania	1997-1:2006:6	0.22	0.17	0.22
Poland	1985:1-2006:6	0.15	0.12	0.49
Romania	1990:5-2006:6	-0.009	-0.019	-0.11
Slovakia	1993:1-2006:6	0.41	0.42	0.38
Slovenia	1993:1-2006:6	0.66	0.66	0.54
Croatia	1991:1-2006:6	-0.06	-0.06	0.18
FYROM	1993:1-2005:12	0.05	0.11	0.10
Turkey	1985:1-2006:6	-0.001	-0.031	0.36

Note: full-sample correlation estimates are based on a bivariate constant correlation AR-GARCH model.

Table 2: LM Statistics for Smooth Transition Conditional Correlations

Country	LM-test
Cyprus	14.913***
Czech Republic	16.415***
Estonia	31.562***
Hungary	8.454***
Lithuania	32.01***
Poland	48.644***
Romania	9.534***
Slovakia	3.412*
Slovenia	13.647***
Croatia	4.408**
FYROM	4.759**
Turkey	11.595***
CORE COUNTRIES	27.737***
Austria	5.232**
Belgium	20.656***
France	5.910**
Germany	7.454***
Netherlands	21.166***
PERIPHERY	7.998***
Greece	6.315**
Ireland	45.746***
Portugal	21.463***
Spain	18.442***

*, **, *** denote significance at 10%, 5% and 1%, respectively

Table 3: Estimates of the VAR/STC-GARCH Model

Country with Euro Area	VAR order	Country's Coefficients										EU's Coefficients									
		c_{01}	$\phi_{11}^{(1)}$	$\phi_{11}^{(2)}$	$\phi_{11}^{(3)}$	$\phi_{12}^{(1)}$	$\phi_{12}^{(2)}$	$\phi_{12}^{(3)}$	ω_1	α_1	β_1	c_{02}	$\phi_{21}^{(1)}$	$\phi_{21}^{(2)}$	$\phi_{21}^{(3)}$	$\phi_{22}^{(1)}$	$\phi_{22}^{(2)}$	$\phi_{22}^{(3)}$	ω_2	α_2	β_2
Cyprus	2	-0.062	**0.138**	**0.223**	-	**-0.417**	**0.670**	-	0.285	**0.104**	**0.862**	0.017	-0.006	-0.009	-	**0.676**	**0.229**	-	0.415	**0.093**	0.001
Czech Rep.	1	-0.004	**0.408**	-	-	**0.605**	-	-	**3.909**	**0.102**	0.001	-0.006	-0.009	-	-	**0.833**	-	-	0.003	0.001	**0.995**
Estonia	3	-0.127	**0.149**	0.026	**0.415**	**0.274**	**0.807**	**-0.761**	0.001	**0.036**	**0.957**	0.024	0.003	-0.004	**0.024**	**0.586**	**0.179**	0.075	0.028	0.008	**0.920**
Hungary	0	0.132	-	-	-	-	-	-	**0.878**	**0.173**	**0.726**	**0.165**	-	-	-	-	-	-	0.588	**0.578**	0.001
Lithuania	1	-0.238	**0.404**	-	-	**0.314**	-	-	0.559	**0.040**	**0.938**	0.033	-0.015	-	-	**0.787**	-	-	0.417	**0.262**	0.001
Poland	2	-0.053	**0.346**	**0.285**	-	-0.182	**0.319**	-	1.258	**0.196**	**0.694**	-0.003	-0.002	-0.002	-	**0.669**	**0.212**	-	0.447	**0.148**	0.001
Romania	1	0.096	**0.720**	-	-	0.145	-	-	0.214	**0.089**	**0.888**	0.012	0.013	-	-	**0.839**	-	-	0.069	0.001	**0.881**
Slovakia	1	-0.058	**0.443**	-	-	**0.407**	-	-	0.258	0.009	**0.934**	0.001	-0.008	-	-	**0.768**	-	-	0.007	0.001	**0.988**
Slovenia	1	-0.006	**0.393**	-	-	**0.570**	-	-	0.001	**0.018**	**0.978**	0.001	**0.082**	-	-	**0.761**	-	-	0.007	0.001	**0.988**
Croatia	1	-0.029	**0.392**	-	-	0.113	-	-	0.842	**0.141**	**0.777**	0.008	-0.026	-	-	**0.879**	-	-	0.443	0.011	0.003
FYROM	0	-0.246	-	-	-	-	-	-	**23.658**	**0.358**	0.001	0.013	-	-	-	-	-	-	0.321	**0.740**	0.069
Turkey	2	0.054	**0.236**	**0.312**	-	**-0.307**	0.123	-	**9.840**	**0.194**	0.132	0.012	**0.022**	-0.015	-	**0.450**	**0.414**	-	0.194	**0.120**	**0.559**
CORE	2	0.003	**0.243**	**0.285**	-	**0.374**	-0.121	-	0.745	0.084	0.001	-0.006	**-0.112**	**0.153**	-	**0.735**	0.070	-	0.423	**0.144**	**0.146**
Austria	1	0.007	**0.189**	-	-	**0.670**	-	-	0.085	0.001	**0.966**	-0.001	**0.075**	-	-	**0.721**	-	-	0.513	**0.331**	**0.091**
Belgium	1	-0.019	**0.182**	-	-	**0.541**	-	-	0.356	**0.084**	**0.821**	-0.007	-0.025	-	-	**0.848**	-	-	0.475	**0.286**	0.001
France	1	-0.032	**0.395**	-	-	**0.296**	-	-	0.217	**0.151**	**0.686**	-0.033	**-0.048**	-	-	**0.867**	-	-	0.414	**0.290**	**0.097**
Germany	2	-0.024	**0.365**	**0.101**	-	**0.209**	**0.278**	-	**1.548**	**0.077**	0.001	-0.015	**0.163**	-0.048	-	**0.300**	**0.410**	-	0.310	**0.095**	**0.501**
Netherlands	2	-0.019	**0.127**	**0.083**	-	**0.566**	**-0.258**	-	0.048	**0.032**	**0.955**	-0.014	**-0.044**	0.007	-	**0.671**	**0.198**	-	0.465	**0.198**	0.049
PERIPHERY	1	0.019	**0.262**	-	-	**0.344**	-	-	1.510	**0.153**	**0.167**	-0.001	-0.050	-	-	**0.881**	-	-	0.348	**0.167**	0.001
Greece	1	-0.021	**0.417**	-	-	**0.314**	-	-	0.139	0.001	**0.955**	0.006	0.045	-	-	**0.726**	-	-	0.532	0.075	0.001
Ireland	2	-0.043	**0.211**	**0.202**	-	**0.353**	-0.059	-	4.802	**0.165**	**0.437**	-0.009	-0.012	-0.001	-	**0.664**	**0.193**	-	0.429	**0.246**	0.067
Portugal	2	-0.055	**0.250**	**0.269**	-	-0.097	0.187	-	1.001	**0.075**	**0.738**	-0.010	-0.016	-0.022	-	**0.639**	**0.218**	-	0.400	**0.225**	0.124
Spain	2	-0.002	**0.306**	**0.318**	-	**0.177**	-0.095	-	1.504	**0.277**	**0.139**	0.004	**0.070**	0.012	-	**0.541**	**0.202**	-	0.526	**0.154**	0.009

Notes: statistically significant coefficients (for 1%, 5% and 10%) appear in bold type.

Table 4: Estimates of the Transition Function on Correlation Regimes (Full Sample)

Country with Euro Area	ρ_0	ρ_1	c	γ	Date of Change
Cyprus	0.109	0.553	0.882	12.931	2004-2
Czech Rep.	0.171	0.656	0.787	11.474	2003-6
Estonia	0.343	0.153	0.389	146.967	1998-6
Hungary	0.090	0.654	0.442	140.456	1994-7
Lithuania	0.182	0.890	0.941	865.677	2005-9
Poland	0.181	0.477	0.569	2138.211	1997-3
Romania	-0.043	0.272	0.707	1117.584	2001-10
Slovakia	0.190	0.757	0.848	7.168	2004-6
Slovenia	0.143	0.472	0.353	676.831	1998-2
Croatia	0.068	0.987	0.915	3.715	2005-2
FYROM	-0.258	0.136	0.304	840.996	1996-12
Turkey	-0.123	0.329	0.485	849.309	1995-5
CORE	0.726	0.866	0.650	2444.610	1997-3
Austria	0.264	0.631	0.633	17.211	1996-9
Belgium	0.219	0.694	0.643	1305.950	1997-1
France	0.544	0.783	0.712	5.139	1998-10
Germany	0.658	0.834	0.672	332.223	1997-9
Netherlands	0.274	0.433	0.337	3001.350	1988-11
PERIPHERY	0.341	0.723	0.474	166.988	2000-4
Greece	0.100	0.659	0.815	3156.270	2004-4
Ireland	-0.068	0.378	0.182	2727.801	1984-5
Portugal	0.155	0.567	0.873	38.002	2003-1
Spain	0.383	0.745	0.425	22.462	1991-3

Table 5: Estimates of the Transition Function on Correlation Regimes (Post-1995 Sample)

Country with Euro Area	ρ_0	ρ_1	c	γ	**Date of Change**
Cyprus	0.025	0.455	0.759	1219.62	2003-8
Czech Rep.	0.107	0.616	0.675	1053.41	2002-9
Estonia	0.545	0.171	0.481	1069.30	2000-3
Hungary	0.871	0.541	0.181	175.53	1997-2
Lithuania	0.182	0.890	0.941	865.68	2005-9
Poland	0.335	0.880	0.972	5.55	2005-6
Romania	-0.149	0.229	0.469	3.14	2000-5
Slovakia	0.256	0.734	0.839	6.95	2004-6
Slovenia	-0.177	0.471	0.175	2780.94	1997-1
Croatia	0.106	0.831	0.857	3.48	2004-11
FYROM	-0.544	0.130	0.178	1008.57	1997-1
Turkey	-0.835	0.302	0.037	761.35	1995-4

Appendix

Table A1: Data Coverage

New Members	Sample Period
Cyprus	1988:1-2006:6
Czech Republic	1993:1-2006:6
Estonia	1994:1-2005:12
Hungary	1985:1-2006:6
Lithuania	1997-1:2006:6
Poland	1985:1-2006:6
Romania	1990:5-2006:6
Slovakia	1993:1-2006:6
Slovenia	1993:1-2006:6
Candidate Countries	
Croatia	1991:1-2006:6
FYROM	1993:1-2005:12
Turkey	1985:1-2006:6
CORE COUNTRIES	1980:1-2006:6
Austria	1980:1-2006:6
Belgium	1980:1-2006:6
France	1980:1-2006:6
Germany	1980:1-2006:6
Netherlands	1980:1-2006:6
PERIPHERY	1995:1-2006:5
Greece	1995:1-2006:6
Ireland	1980:1-2006:6
Portugal	1980:1-2006:6
Spain	1980:1-2006:5

Figure 1: Time Profile of Business Cycles

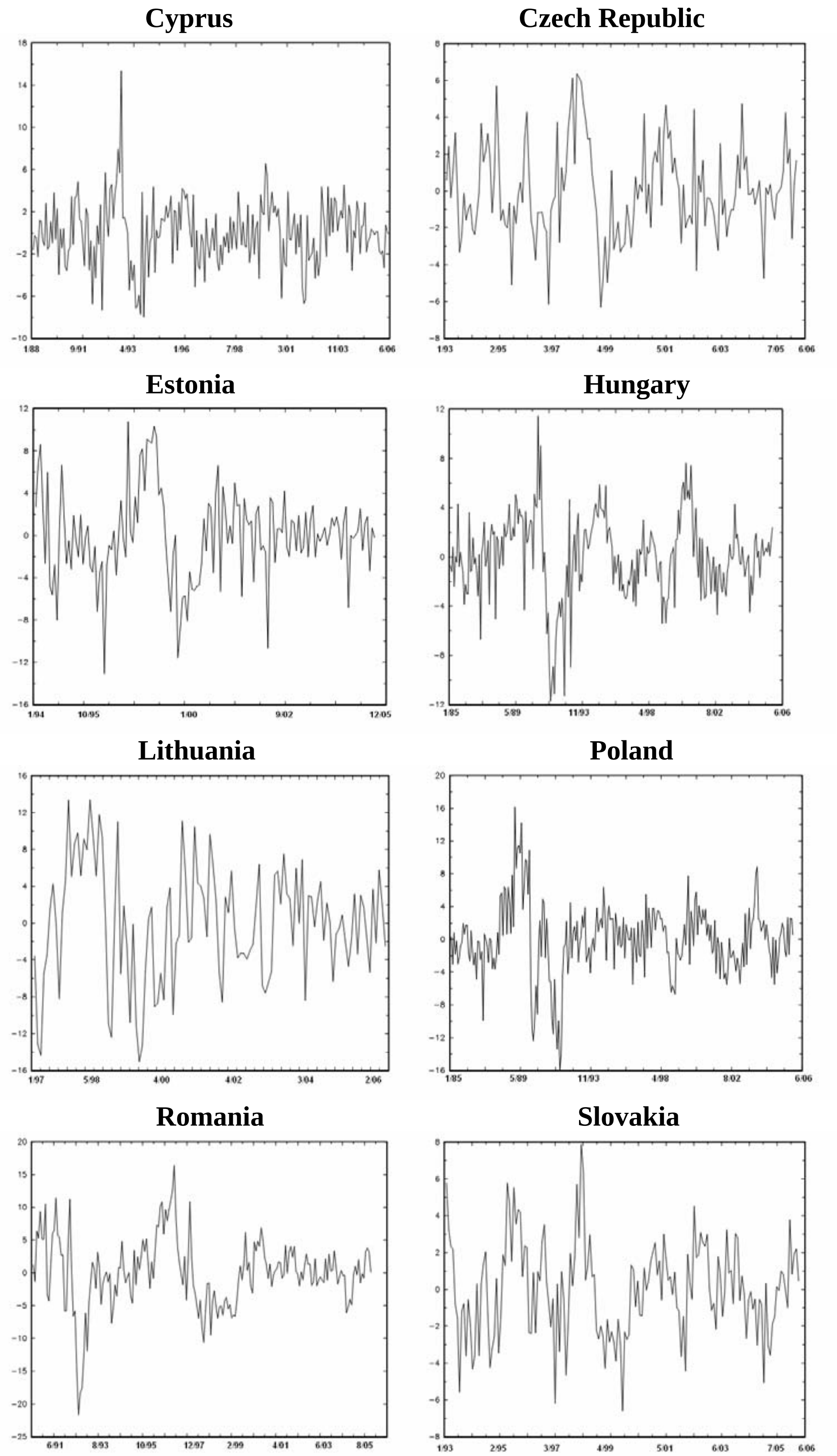
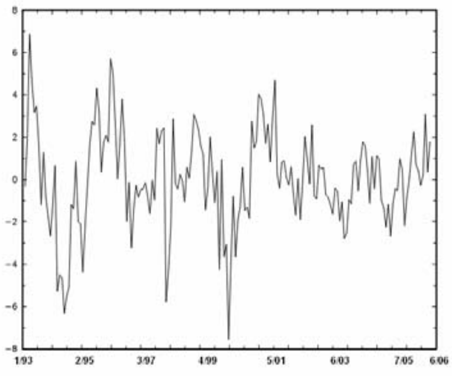
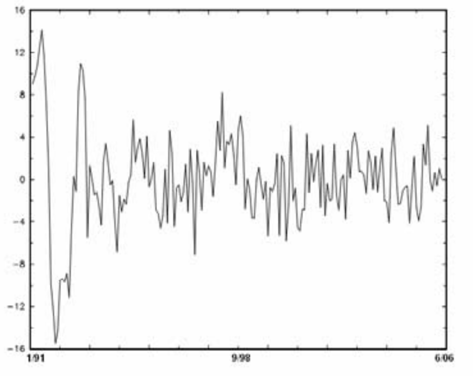


Figure 1 (Continues)

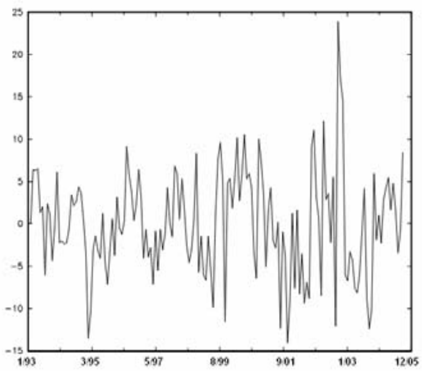
Slovenia



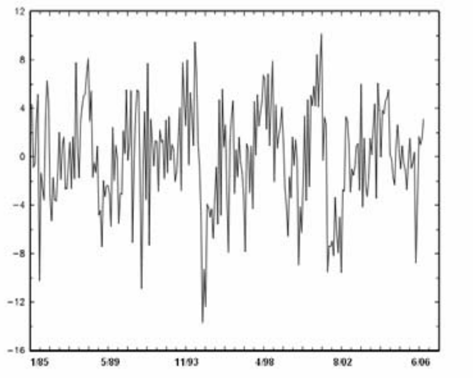
Croatia



FYROM



Turkey



Euro Area

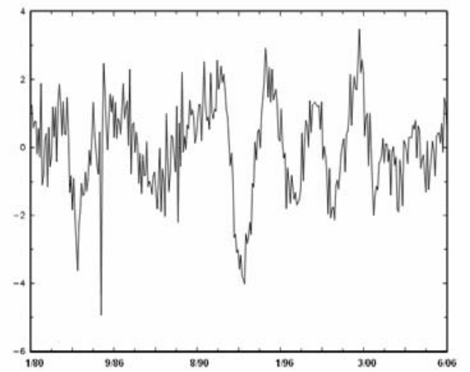


Figure 2: Transition of Business Cycle Correlations

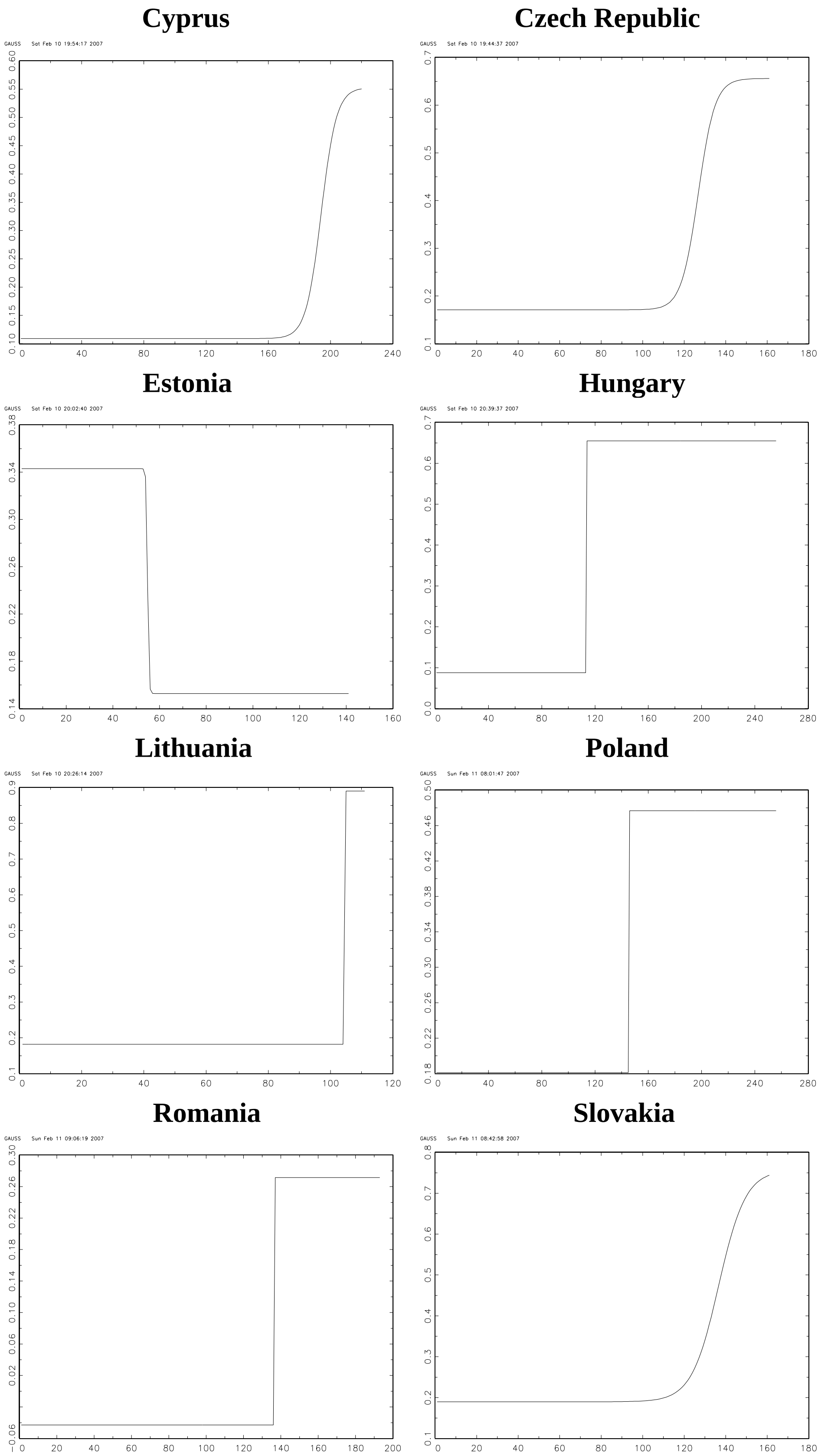
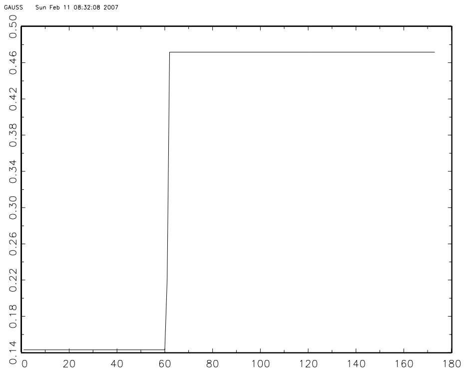
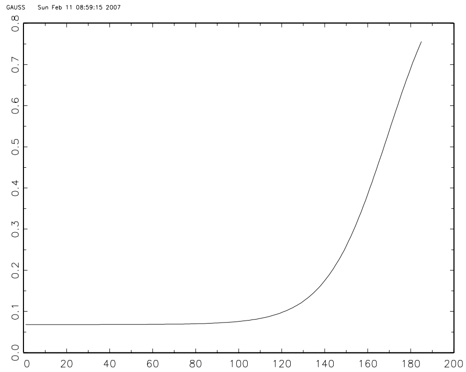


Figure 2 (Continues)

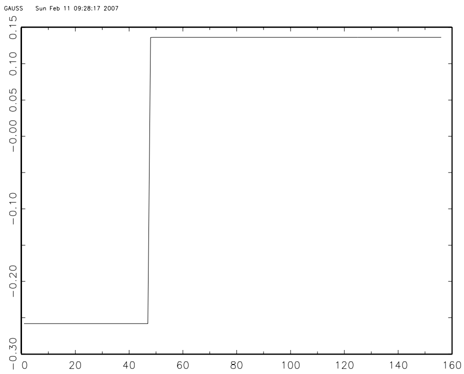
Slovenia



Croatia



FYROM



Turkey