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EMU AND ACCESSION COUNTRIES: FUZZY CLUSTER ANALYSIS OF MEMBERSHIP

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EMU AND ACCESSION COUNTRIES: FUZZY CLUSTER ANALYSIS OF MEMBERSHIP

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Abstract
This paper estimates the readiness of the Accession Countries of Central and East Europe for EMU or for unilateral euroisation using a fuzzy clustering algorithm. The variables to which the algorithm is applied are suggested alternately by the criteria in the Maastricht Treaty (nominal convergence) and by Optimum Currency Area theory (real convergence). The algorithm reveals that Estonia and Slovenia are the leaders in both nominal and real convergence, whereas the other countries from the 1998 Accession Wave have achieved substantial results only in real convergence. Moreover, Poland is excluded from the leading group in the most recent years due to its worsened economic performance.

This paper was presented at the conference on "Monetary Union: Theory, EMU Experience, and Prospects for Latin America" held at the University of Vienna and jointly organized by the Central Bank of Chile and the Oesterreichische Nationalbank on April 14-16, 2002. Hard copies of this paper must be ordered by e-mail from Oesterreichische Nationalbank (as working paper 71). Further information, see www.oenb.co.at/workpaper/pubwork.htm.

The dataset and programming code is available from the author upon request. I should thank Mike Artis and Anindya Banerjee for suggestions and useful comments.
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1 Introduction

The successful accession to membership in the European Union (EU) by the transition-economy applicants from the Central and Eastern Europe Countries (CEECs) will throw up many challenges. One of the main ones will be the eastward expansion of the euro area because the would-be members of the EU will not be able to stay outside the European Monetary Union[1], as has been the case with the several countries of Western and Northern Europe. Nevertheless, entry into the EU, which will occur only in 2004 at the earliest, does not guarantee immediate acceptance into the monetary union because the candidates will have to demonstrate for two years their ability to satisfy the convergence criteria of Maastricht Treaty. Therefore, according to the most optimistic estimates, the countries of Central and Eastern Europe could only join the EMU in 2007. However, many economists and especially politicians have even been arguing that the Accession countries should fix their currencies or enter into currency board arrangements based on the European currency or even introduce the euro unilaterally as a means of speeding up the accession and convergence processes (e.g. Nuti (2001) and Coricelli (2001)). They put forward several reasons why the CEE countries should join the EMU at an early date.

First, if the CEECs join the EMU they will enjoy lower risk premiums and interest rates, as well as lower transaction costs. They will, moreover, have a say in shaping the ECB's monetary policy, whereas if they decide to stay out they will lose this privilege, although the independence from the ECB will become more imaginary than real once a small country has integrated into the economy of the euro zone. Second, it is often argued that they satisfy the Optimum Currency Area (OCA) criteria and therefore it is beneficial for them to join. Next, given the likely insistence of the EU members on adopting measures to limit the exchange rate variability of the new members there will be no alternatives for them but to fix the exchange rates within some band (an arrangement which could prove fragile and prone to crisis) or to enter the Estonian- or Bulgarian-style currency board (which is the second-best solution in respect to forming a monetary union). Moreover, the incumbent EU members might not be able to do much to keep the aspirants out (Eichengreen and Ghironi, 2001).

In the light of these arguments, the question of the CEECs' readiness to join the EMU becomes even more important. Two main issues have to

[1] It was one of the EU-accession criteria specified in Copenhagen in 1993 which explicitly stated that new EU members will have to "... take on the obligations of membership, including (...) the Economic and Monetary Union" meaning that no 'opt-out' provision exists for these countries.

be addressed. First, there is the necessity of meeting the Maastricht Treaty criteria in order to qualify. These criteria limit the ability of the candidates to exercise monetary and fiscal policies at their discretion, which clearly represents a cost to be incurred by the countries on their way to the euro. Second, abdication of sovereign monetary policy has its own costs and benefits, which have usually been assessed in the framework of the OCA theory (see Mundell, 1961 and McKinnon, 1963), which advocated forming a monetary union if the adjustment of the bilateral exchange rate is either ineffective or unnecessary to stabilise output.

As concerns the process of joining the EU three groups of transition countries may be identified. The Czech Republic, Estonia, Hungary, Poland and Slovenia started negotiations first, and constitute what is called the 1998 Accession Group, which is argued to have made substantial progress towards satisfying the entry requirements[2]. The other group, called the 2000 Accession Group, consists of Bulgaria, Latvia, Lithuania, Romania and the Slovak Republic, which have not yet advanced as far as the first group in the negotiation process. The rest are countries such as Croatia, which for various reasons are not yet part of the negotiation process. Given this segregation, a natural question to ask is whether a similar division applies to the issue of joining the EMU. The subsequent analysis of this paper thus endeavours to identify a group of countries which are "more EMU-ready" or better suited to enter into a currency board with the Euro and whether these countries are from the 1998 Accession Group or have already implemented a currency board arrangement.

In order to check for the existence of homogeneous groups in the CEECs the technique of cluster analysis is employed. This technique is used to examine the similarities and dissimilarities of economic structure in the data and to group the countries according to various sets of criteria. Given the problem of incomplete and noisy data, the more powerful technique of fuzzy clustering is employed. This method splits the data into groups by assigning membership coefficients indicating the degree of "belongingness" of each object to each of the groups, so that the highest coefficient would then indicate the group to which this country is most likely to belong. The accompanying statistics indicate the existence of the clear-cut structure in the data.

The first section briefly describes the algorithm of fuzzy clustering, clarifying its use for the problem at hand as well as the associated diagnostic statistics used in the paper. In the second section we look at the readiness of the applicants for the EMU from an institutional point of view according

[2]As the paper focuses on the countries in transition, Malta and Cyprus are omitted from the analysis that follows.

to their performance with respect to the Maastricht criteria. This section attempts to answer the question of the countries's *ability* to adopt the euro. The following section looks at the real convergence of the CEECs to the EU and to Germany in particular. This section therefore looks at the question of the *desirability* of their joining the EMU. The penultimate section compares the results of nominal vs. real convergence. The last section concludes.

2 Fuzzy clustering analysis

Cluster analysis is a well-known technique in the science of pattern recognition and is frequently applied in disciplines such as medicine, archeology etc., although its use in applied economic analysis is rather rare. In this paper fuzzy clustering analysis is used, which, unlike the hard clustering algorithms that assign each object to only one subgroup, much better equipped to analyze the data where some ambiguity is present. The method is applied to uncover the similarities of economic structure in the data across countries and to identify homogeneous subgroups of countries with regard to sets of economic criteria.

The algorithm of fuzzy clustering is taken from Kaufman and Rousseuw (1990) and can briefly be described as follows. The dataset consists of n objects (countries) with p variables (various criteria used in our analysis) for each object and is denoted by $X_{np} = \{x_1, x_2, ..., x_n\}$, where each $x_i = \{x_{i1}, ..., x_{ip}\}$. Each variable is standardised with mean zero and standard deviation one in order to treat them as having equal importance in determining the structure[3]. The dissimilarity coefficient between two objects is defined as a Euclidean distance[4]:

$$d(i,j) = \sqrt{\sum_{k=1}^{p}(x_{ki} - x_{kj})^2}$$

The algorithm minimizes the objective function C:

[3]In some cases, the standardisation of the variables is important to keep a variable with high variance from dominating the cluster analysis. It is also needed in cases where the variables are of different magnitude and not directly comparable (e.g. budget deficit and government debt level, the latter always being much higher).

[4]This is the special case of the Minkowski distance metric with argument equal to 2. There are several other distance measures for continuous data such as other Minkowski distance metrics, the Canberra distance measure, which is very sensitive to small changes near zero, the correlation coefficient similarity measure and some others.

$$C = \sum_{v=1}^{k} \frac{\sum_{i,j=1}^{n} u_{iv}^2 u_{jv}^2 d(i,j)}{2\sum_{j=1}^{n} u_{jv}^2}$$

subject to:

$$u_{iv} \geq 0 \ for\ i = 1, ..., n;\ v = 1, ..., n$$

$$\sum_{v} u_{iv} = 0\ for\ i = 1, ..., n$$

in which u_{iv} represents the unknown coefficient of membership of object i to cluster v, and k represents the number of clusters into which the data is partitioned. The algorithm produces the matrix of coefficients U_{nxk} with rows summing to one and showing the degree of belongingness of that object to each of the groups. If one of the coefficients is very high then it can be said that there is a high degree of certainty that this object belongs to that group, otherwise this object cannot be classified that easily.

In order to analyze how well the data is partitioned several statistics are used. One is the normalized Dunn's partition coefficient:

$$F_k = \frac{\frac{k}{n} * \sum_{i=1}^{n}\sum_{v=1}^{k} u_{iv}^2 - 1}{k-1}$$

which varies from 1 (indicating well-partitioned data) to 0 (indicating complete fuzzyness of the data). It reaches one only if for each object there is one coefficient equal to one and the others to zero and zero when all the coefficients of belongingness are $\frac{1}{k}$.

Another useful set of statistics is the silhouette width for each object, average silhouette width for each cluster and for total dataset. Silhouette width for each object is defined as:

$$s(i) = \frac{b(i) - a(i)}{\max(a(i), b(i))}$$

where $a(i)$ is defined as average dissimilarity of object i to all objects in the same cluster and $b(i)$ as the minimum across all other clusters of average

dissimilarity of object i to all objects in each cluster. When $s(i)$ is close to one it is implied that the object is well classified into an appropriate cluster. A value near zero indicates the ambiguity in deciding to which cluster the object might belong. Negative values indicate that the object is misclassified. The corresponding averages for each cluster and for the total dataset indicate how well each cluster's and the total dataset's partitioning has been done.

3 EMU and Maastricht Criteria

The Maastricht Treaty laid down a set of criteria to be fulfilled by countries aspiring to participate in the EMU. Their declared aim was convergence in both nominal and fiscal terms ensuring that monetary and fiscal policy converged in order not to disrupt functioning of the EMU in the future[5]. In formal terms, the criteria for nominal convergence are that a country must have an inflation rate within 1.5% of the average inflation rate of the three members with the lowest inflation rates and a long-run bond yield within 2% of the average of the bond yields of the same three countries. Furthermore, the Treaty required that the exchange rate must have been stable within the $\pm$ 15% ERM bounds for at least two years. As regards fiscal policy, the budget deficit should be no higher than 3% of GDP and public debt less than 60% of GDP.

The same set of qualifications will be applied to any future applicant. Although the earliest date for the candidates to enter the EMU is estimated to be the year 2006 and criteria are to be complied with only for a year before admission, it is nevertheless useful to see whether the Accession Countries represent a uniform group with respect to stability orientation. First, it might indicate how easy it will be for the applicants to comply in the future with the provisions of the Stability and Growth pact, and second, it might show whether the countries obey the criteria when conducting their macroeconomic policies in order to show their commitment to the accession process.

Given that the criteria were criticised for focusing on the short one-year period of assessment before qualification[6] data for longer time periods is used here[7]. Table 1 shows the corresponding values for accession countries and Croatia as well as an average for 12 EMU members. The casual inspection of

[5] When supplemented by the Growth and Stability Pact.

[6] Two years for the exchange rate stability criterion.

[7] We split the data into three overlapping time periods of 1993-2001, 1997-2001, and 2001 and used the averages over the corresponding periods. Thus, it might be argued, a clearer picture of true "stability orientation" of the economy might be obtained and any progress in the development towards stability might be more evident.

Table 1: Maastricht Treaty Criteria and Transition Countries

	Deficit[1)]		Debt[1)]		Volatility of ER[2)]		Inflation[3)]		Interest rate[4)]	
	1993-2001	2001	1993-2001	2001	1993-2001	2001	1993-2001	2001	1993-2001	2001
Bulgaria	-3.6	-1.7	113.1	97.5	5.7	0.0	161.5	7.9	49.6	11.1
Czech R.	-2.2	-5.2	25.8	29	0.9	0.5	8.7	4.7	11.3	7.0
Estonia	-0.7	-0.8	8.0	6.1	0.2	0.1	24.6	5.9	15.6	7.7
Hungary	-5.8	-3.7	88.7	64.4	0.9	0.6	17.2	9.6	21.7	12.3
Latvia	-2.5	-2.2	9.3	10.2	1	1.0	23.2	3.0	30.0	11.5
Lithuania	-4.4	-1.4	22.5	25	1.7	1.4	62.6	1.2	29.4	10
Poland	-3.3	-4.3	49.1	42.8	1.2	1.4	18.7	6.0	25.9	19.3
Romania	-4.3	-4	22.6	32.2	2.4	1.3	89.2	34.4	57.7	45.8
Slovak R.	-4.3	-5	31.8	42.7	0.7	0.7	10.6	7.5	16.4	12.2
Slovenia	-1.2	-1.1	21.7	25.5	0.4	0.4	13.1	8.5	23.7	15.2
EU-12	-2.9	-1	71.2	67.4	0.4	0.0	2.4	2.0	9.0	7.9
Croatia	-2.6	-5.3	27.1	38	2.8	0.9	182.1	3.3	175.2	9.6

Source: see Appendix for data description[5)].

Notes:

1) Deficit and debt as % of GDP.

2) Volatility in exchange rate is measured by the standard deviation(x10^2) of monthly differences.
of the log difference in bilaterial monthly average exchange rate against DM.

3) CPI index.

4) Lending rates of longest maturity are taken for accession countries and the average of the lending rate of France, Italy and Germany for EU-12

5) Data for 1998-2001 are not reported in the table but are available upon request from the author

the data reveals several things. First, most of the countries tried to keep their budget deficits low, which proved to be a hard task. During the last eight years five out of eleven countries in the sample had an average budget deficit lower than the three per cent requirement. In recent years the budget deficit has diminished for Bulgaria and Hungary but has increased for Croatia, the Czech Republic, Poland and Slovakia. Second, the debt levels are comfortably below the 60% criterion except in Bulgaria and Hungary (and the EU average itself). Third, volatility of exchange rates (as measured by the standard deviation of the log difference in bilateral exchange rates against the German mark, (which is preferred to the volatility of exchange rates against the ECU) is low for countries which fixed their currencies against DM. By the year 2001 it had reduced substantially for almost all countries with the notable exception of Poland. Next, inflation rates have dropped below ten per cent except for Romania. This has had an effect on the lending rates[8] although the difference between Polish lending rates and inflation is above ten per cent, indicating the commitment of the Central Bank of Poland to reduce inflationary expectations brought about by the recent inflation increase.

I run the algorithm for three subsamples and in each case the optimal number of clusters was chosen by maximising the average silhouette width of the dataset (Table 2 reports only the best partition for each period). Dunn's coefficient is above 0.5, indicating the presence of some fuzzyness in the data, and the average silhouette widths, showing the extent to which the groups formed are different from each other, are higher than 0.5 which is a sign that the structure is present in the data (Kaufman and Rousseuw, 1990).

For the sample of 1993-2001 the optimal number of groups is two - one comprising Bulgaria and Croatia whilst the other countries form the other group. This should come as no surprise because it has been quite a turbulent period for the transition countries and most of them have had to stabilise and restructure their economies which has had an effect on their economic and monetary performance. During that period Bulgaria and Croatia are characterised by extremely high levels of exchange rate volatility, inflation and interest rates compared to the other countries in the sample; therefore they were identified as a distinct group. For the rest of the countries no further conclusions can be made for this sample and, therefore, it is instructive to look at more recent periods.

During the period of 1998-2001 we observe several noticeable changes. The statistics indicate that the data is best partitioned into four groups. The

[8]This assumption is made because of the data unavailability for the CEECs. The European Commission in its regular reports on countries' progress towards accession look at the lending rates of over one year when assessing the countries' performance, therefore we are using these rates as proxies of the yields on the long-term government bonds.

Table 2. Partitioning by Maastricht Criteria

	1993 - 2001				1998 - 2001						2001						
	Coefficients[1]		Silhouette width[2]	Cluster	Coefficients				Silhouette width	Cluster	Coefficients					Silhouette width	Cluster
Bulgaria	.19	**.81**	0.18	2	.03	**.92**	.01	.04	0.85	2	.03	**.90**	.01	.03	.02	0.81	2
Croatia	.22	**.78**	0.12	2	.09	.04	.02	**.86**	0.66	4	.02	.05	.01	**.92**	.04	0.70	4
Czech Republic	**.98**	.02	0.88	1	.08	.03	.01	**.88**	0.56	4	.07	.05	.02	**.78**	.08	0.62	4
Estonia	**.86**	.14	0.79	1	**.89**	.05	.01	.06	0.77	1	**.85**	.04	.01	.04	.07	0.74	1
Hungary	**.64**	.36	0.58	1	.18	.20	.06	**.56**	0.57	4	.13	.22	.04	**.47**	.14	0.40	4
Latvia	**.95**	.05	0.86	1	**.53**	.07	.03	.37	0.29	1	.08	.02	.01	.05	**.84**	0.71	5
Lithuania	**.84**	.16	0.80	1	.08	.03	.02	**.86**	0.68	4	.05	.02	.01	.04	**.89**	0.82	5
Poland	**.97**	.03	0.87	1	.15	.08	.05	**.72**	0.59	4	.11	.08	.06	**.44**	.31	0.21	4
Romania	**.55**	.45	0.54	1	.00	.00	.00	**1.0**	0.00	3	.00	.00	**1.0**	.00	.00	0.00	3
Slovak Republic	**.97**	.03	0.89	1	.07	.03	.01	**.88**	0.67	4	.01	.01	.00	**.96**	.02	0.79	4
Slovenia	**.88**	.12	0.80	1	**.91**	.04	.01	.04	0.72	1	**.83**	.01	.04	.04	.07	0.62	1
EU-12 Average	**.89**	.11	0.83	1	.08	**.87**	.01	.04	0.71	2	.12	**.75**	.01	.06	.06	0.59	2
Number of clusters			2					4							5		
Silhouettes width[3]			0.78 0.15					0.68 0.78 0.00 0.62							0.68 0.70 0.00 0.54 0.77		
Average silhouette width			0.68					0.64							0.64		
Dunn`s coefficient			0.54					0.63							0.62		

Source: author's calculations

Notes:

1) The coefficients of belonginness of the country to each cluster with the highest in bold.

2) Individual silhouette width

3) Silhouettes widths for each cluster in ascending order

first group is comprised of Estonia, Slovenia and Latvia and is characterised by low values for all criteria except for exchange rate volatility which varies from low (Estonia) to high level (Latvia). Apart from the later criterion and high inflation rates, this group performs in line with the EU average in respect of the Maastricht criteria. The second group consists of the EU average and Bulgaria which have been put together primarily due to the very low exchange rate volatility, low budget deficit and high level of public debt, which is above the 60 per cent limit. Disregarding the public debt criterion these two groups can be treated as one group, that is those Accession Countries which have performed in line with the EMU members according to stability orientation criteria. Interestingly, two of the three CEECs (Bulgaria and Estonia) that officially entered into currency board arrangements are in this group. On the other hand, Romania is a distinct outlier with very high values for all criteria except for the public debt and therefore it has been classified as a singleton (i.e. a group consisting only of one member). The rest of the countries were grouped together because they have a high level of budget deficits, an average level of public debt, average to high exchange rate volatility but mixed results for inflation and interest rates.

Given that the Maastricht criteria are to be applied to assess the performance of would-be members one year before entry, it is, therefore, useful to look at the latest data and to see what the current economic and financial situation is in the CEECs. With that in mind I ran the algorithm for the data of year 2001 alone[9]. This time the best partition consists of five groups, although many regularities from the previous subsample are still present. Estonia and Slovenia again form the group with low values for all criteria except for the interest rates. Considering the fact that we use lending rates instead of government bond yields as specified by the Maastricht Treaty, this group may be regarded as the best performing one. Latvia and Lithuania form the other group, which follows it closely, although they have higher exchange rate volatility. As in the previous period, Bulgaria and the average EU member form the third group because of the high debt level, although the inflation rate in Bulgaria is too high by EMU standards. Allowing for some flexibility in interpreting the Maastricht criteria it may be argued that the countries from these three groups are the best performers and by now have managed to bring the government finances and domestic monetary situation under control. Again, the interesting fact is that this time all three countries which implemented the currency board arrangements are included[10]. Roma-

[9]Subsample of 2000 - 2001 is used to calculate the exchange rate volatility.

[10]High level of exchange rate volatility of the Lithuanian Lit against the DM may be explained by the fact that it is fixed against the basket of the currencies, with the US dollar in sizeable proportion. As for Bulgaria, its public debt declines constantly each

nia on its own forms another group again because of grossly breaching all the criteria and the rest of the countries constitute the last group, which is characterised by high budget deficit and average to high values for the other criteria.

Looking across all the subsamples the following conclusions can be reached (Table 3 summarises the findings). During the whole sample period of the last eight years the countries have shown mixed performance, so that no detailed partitioning can be made except for separating the countries which have undergone some serious crisis during that period. Nevertheless, looking separately at the recent period there appears to be a clear-cut segmentation among the CEECs. All three Baltic states, Bulgaria and Slovenia seem to make a group of countries, which is well ahead as concerns the stability orientation of the economy and expressed by the Maastricht criteria. An interesting correlation is observed that all three CEECs who implemented the currency board arrangement against the Euro are in this group.

4 OCA Criteria and Economic Convergence

4.1 OCA Criteria Explained

It is often argued in the literature that although in the nineties the EU countries were converging in nominal terms as was manifested in general compliance with the Maastricht Criteria, real convergence was far from being achieved and one could even have pointed out real divergence between some countries. As a consequence, the countries whose initial conditions are unfavourable and which are unable to use a national monetary policy to adjust to specific shocks will find themselves on low growth and high unemployment paths. As pointed out by Bayoumi and Eichengreen (1997b) and others, the Maastricht criteria do not ensure the real convergence which is required for the successful functioning of a monetary union. This idea of real convergence was first put forward by Mundell (1961) and later revived by Krugman (1990). Krugman developed the foundations of the OCA theory, which stated that two countries should form a monetary union in the case of prevalence of a high degree of intra-trade among the members and the absence of any profound asymmetry in the pattern of shocks impacting their economies.

As OCA theory states, there are certain benefits and costs associated with adopting a single currency that depend on the degree of convergence of the

year, which may be regarded as a sign of convergence to the debt criterion limit.

Table 3. Classification of the countries by nominal convergence[1)]

	ER volatility	Budget deficit	Public debt	Inflation	Interest rates
1993 - 2001					
{Bulgaria, Croatia}	High	Ave	Mixed	High	High
{Other countries}	Mixed	Mixed	Mixed	Mixed	Mixed
1998 - 2001					
{Estonia, Latvia,Slovenia}	Mixed	Low	Low	Low	Low
{Bulgaria, EU-12}	Low	Low	High	Mixed	Low - Ave
{Croatia, Czech R.,Hungary, Lithuania, Poland, Slovakia }	Ave - High	High	Ave	Mixed	Mixed
{Romania}	High	High	Ave	High	High
2001					
{Latvia, Lithuania}	Ave - High	Low	Low	Low	Low
{Estonia, Slovenia}	Low	Low	Low	Low	Mixed
{Bulgaria, EU-12}	Low	Low	High	Mixed	Mixed
{Croatia, Czech R., Hungary, Poland, Slovak R.}	Ave - High	High	Ave - High	Ave	Ave
{Romania}	High	High	Ave	High	High

Source: author's calculations

Notes:

1) Table shows groups' classification according to whether the countries in each group have low (Low), average (Ave) or high (High) values for each criteria. If the countries in a group have a large dispersion of values for a criterion, then Mixed is reported

economies. The benefits are associated with economising on exchange costs and with importing the credibility of the union's central bank, thus reducing the inflationary expectations and level of inflation. This point is illustrated by the example of Bulgaria, which entered the currency board arrangement in order to combat inflation and stabilise its economy. Another clear case is Estonia, whose level of inflation was substantially lower than that of the other CEECs. As for the associated costs they are essentially the negative of the benefits of having an independent monetary policy and exchange rate, which are useful as a means of coping with shocks that are asymmetric between the potential monetary union partners. The less effective the monetary policy is in counteracting the idiosyncratic shocks by adjusting the nominal exchange rate, the lower the costs. Other domestic conditions such as sufficient labour mobility or fiscal federalism also reduce the need for independent monetary policy.

The OCA criteria are a useful benchmark for evaluating the costs and benefits of any exchange rate arrangement. First, the qualitative analysis of the costs and benefits and comparative studies can be conducted. One of the examples for European countries is by De Grauwe and Yunus (1999). On the sample of CEECs there are several papers by Boone and Maurel (1998 and 1999) and Habib (2000) as well as by Fidrmuc and Schardax (2000). Second, the OCA theory was rendered operational through cross-country estimations of the effect on the variability of the bilateral exchange rates by the asymmetry of the business cycles and other explanatory variables. This was first done by Bayoumi and Eichengreen (1997a) for industrialised countries and later adopted to CEECs by Bénassy-Quéré and Lahrèche-Révil (1998).

Notwithstanding the popularity of the approach, recently there has been growing criticism of the classical OCA literature. Two basic points have been made. First, the OCA literature has allegedly failed to consider the dynamic and endogenous nature of the criteria because economists have often applied OCA criteria as if they were taking a snapshot of a motionless object. However, these characteristics could react to the very policy decision to fix the exchange rate, adopt another country's currency or join a currency union. In other words, the OCA literature does not take into account the Lucas Critique and considers the several criteria as exogenous parameters. Frankel and Rose (1998) claimed that the OCA criteria are in fact endogenous and found that greater integration resulted in more highly synchronised business cycles. According to this result, a country that does not satisfy the OCA criteria could join a currency union eliminating exchange risk and transactions costs. Reduced costs would foster trade integration, which, in turn, would increase the correlation of business cycles. Hence, the endogeneity of OCA

criteria poses some limitations to a static application of the theory. Second, the OCA literature has not paid enough attention to the increasing role of international financial markets and capital mobility.

These limitations contribute even more to the already complicated cost-benefit analysis of a common currency. However, for the purpose of the paper they have little relevance. Here we are more concerned with identification of the homogeneous groups among CEECs, so the analysis will indicate if there is a group of countries whose current nominal and real convergence with the EMU is at a higher stage. If the criteria are endogenous then these countries will have some competitive advantage over the other applicants and the likely structural changes and catch-up processes will be less dramatic.

4.2 Empirical results for economic convergence

4.2.1 Choice of variables

The choice of variables to analyse the economic convergence of CEECs was inspired by the OCA criteria following the work of Artis and Zhang (1998). For the sample of ten accession countries I collected the monthly and annual data (see Table 4) starting from 1993 from various sources which are described in the Appendix.

1) Synchronisation of business cycles

The popular choice to implement the OCA criterion related to symmetry of output shocks is by studying the cross-correlation of the cyclical components of output (e.g. Artis and Zhang, 1998). Due to the data unavailability of quarterly GDP growth rates[11] I decided to follow the approach of Artis and Zhang (1998), who identified the symmetry of output shocks with the cross-correlation of the cyclical components of monthly industrial production series. Whereas the aggregate GDP estimates for the eurozone are available[12] this is not so for the industrial production data, and so for the purpose of the estimation the Germany monthly industrial production index was taken. The choice was justified on the grounds of the existence of what is called the "European business cycle" (see Artis and Zhang, 1995), and it is confirmed when we look at Figure 1, which shows the quarterly GDP and industrial production growth rates for the Eurozone, Germany and Estonia[13].

[11] Romanian National Statistical Office does not produce quarterly GDP estimates at all; Bulgaria has started to publish them only since 2000. For the other countries the qurterly data from 1993 would give only 30 observations up to Q3 2001.

[12] For example from Beyer and Hendry (2001)

[13] I was unable to locate the monthly industrial production index for Estonia at all and for Bulgaria after 1996 and therefore used monthly unemployment rate for Bulgaria

Table 4. OCA criteria and economic convergence

	Correlation in business cycles[1]			Exchange rate volatility[2], (x10^2)			Trade openness[3]			Inflation differential[4], %		
	1993-2001	1997-2001	1999-2001	1993-2001	1997-2001	1999-2001	1993-2000	1997-2000	1999-2000	1993-2001	1997-2001	1999-2001
Bulgaria	0.12	0.34	-0.32	4.45	3.53	0.48	0.45	0.48	0.50	159.1	218.2	5.0
Czech R.	0.20	0.50	0.52	0.97	1.16	0.71	0.59	0.63	0.66	6.3	4.0	1.7
Estonia	0.15	0.38	0.64	0.60	0.25	0.20	0.59	0.58	0.59	22.2	4.5	2.5
Hungary	0.52	0.60	0.84	0.85	0.68	0.62	0.64	0.69	0.70	14.8	10.4	7.9
Latvia	0.14	0.41	0.29	1.38	0.83	0.90	0.47	0.53	0.52	20.7	2.3	0.8
Lithuania	-0.32	0.04	0.05	2.00	1.42	1.53	0.40	0.44	0.46	60.2	1.5	-0.9
Poland	0.39	0.59	0.68	1.10	1.18	1.18	0.66	0.66	0.67	16.3	8.1	5.9
Romania	-0.12	0.06	0.33	3.04	3.54	1.48	0.55	0.60	0.63	86.8	66.0	40.0
Slovak R.	0.30	0.53	0.58	0.92	0.79	0.79	0.43	0.52	0.54	8.1	6.7	8.1
Slovenia	0.49	0.45	0.56	0.49	0.44	0.45	0.66	0.67	0.67	10.6	6.8	6.7

Source : see Appendix for data description[5]

Notes:

1) Measured as cross-correlation of differenced monthly industrial production indices with German one. For Bulgaria cross-correlation of differenced monthly unemployment rate with German unemployment is taken. For Estonia cross-correlation of quarterly GDP growth with German GDP growth is taken.

2) Standard deviation of log difference in bilateral real exchange rate against DM

3) Average for the period of the ratio of import and export to the EU over total imports and exports

4) Average for the period of the CPI indices less the EU-15 average inflation over the same period

5) Data for 1995 - 2001 is not reported in the table but available from the author upon request

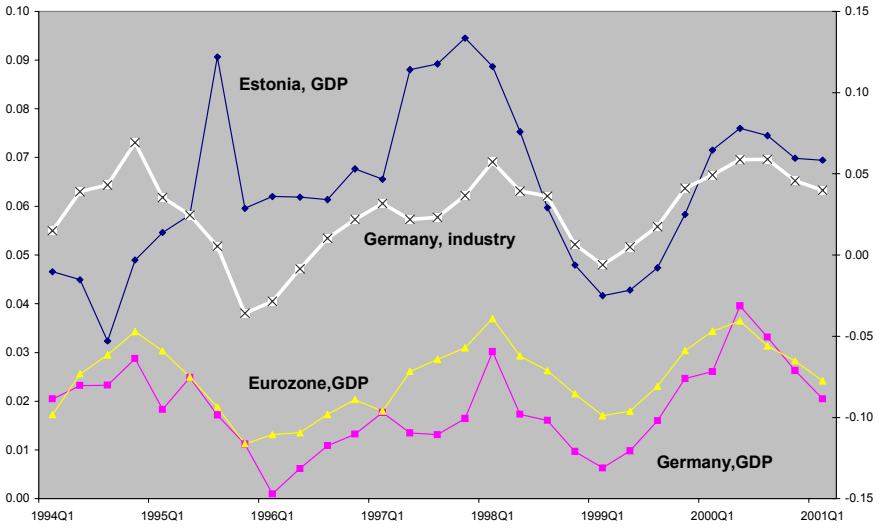

Figure 1. The quarter on quarter growth series of German industrial output, Estonian GDP (all right axis), Eurozone GDP and Germany GDP (left axis). Data is 1st quarter of 1994 to 2nd quarter of 2001.

Given the close comovement of the series I decided to use German industrial production as a proxy for EMU output movement. In the light of the heated debate as to what type of filtering is more appropriate I use two filtering techniques. First, the industrial production series were seasonally adjusted and detrended using the Hodrich-Prescott (H-P) filter with the value of the dampening parameter equal to 50,000[14]. Second, as an alternative, I use the twelfth differences of the logs of the series (i.e. the growth rate of each month relative to the same month of the previous year). Both methods produced comparable results although slightly higher values in the former case, which are used in the analysis thereof. The cross-correlations vis-a-vis Germany were calculated for the whole sample and subsamples. Figure 2 illustrates that the correlation between CEECs and German business cycles has grown considerably and has a tendency to converge to a very close range for all countries. However, the increased divergence after the beginning of the year 2001 merits special attention.

and quarterly GDP growh rate for Estonia for which monthly unemployment rate is not available either.

[14]See Artis and Zhang (1998) for discussion of this choice.

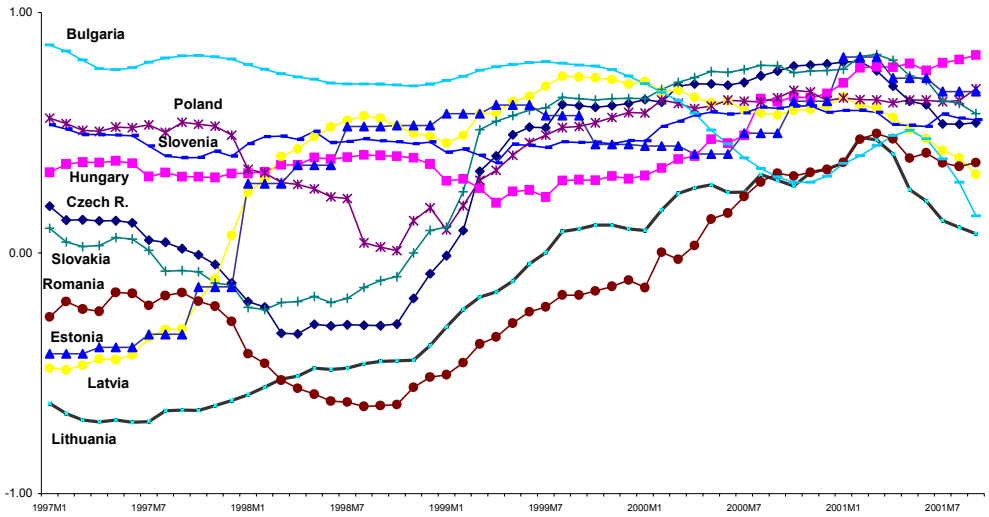

Figure 2. Time - varying correlations of industrial production (CEECs vis-'a-vis Germany over previous three years). Unemployment correlations for Bulgaria and GDP growth rate correlations for Estonia

2)Volatility of the real exchange rate (RER)

According to the OCA criteria, the costs of monetary union are associated with the loss of a separate exchange rate. By influencing the nominal exchange rate the monetary policy presumably changes the real exchange rate which acts as a shock absorber. If there has been little cause for variation in the exchange rate then not much will be lost when moving to a single currency. In this study we represent the variation in the exchange rates as the standard deviation of the log-difference of real DM exchange rate, where deflation is accomplished using the relative wholesale price index.

3)Openness to trade

This criterion is assumed to be represented by trade intensity between EMU members as a whole and each CEEC, i.e. for any country i as $(x_{iEMU} + m_{iEMU})/(x_i + m_i)$, which is the ratio of exports and imports to EMU members over total imports and exports of country i.

4*) Inflation criteria*

The recent addition to the classical OCA theory is that " a strong incentive for monetary union is created by an assurance that the union's inflation will be low" (Artis and Zhang, 1998). This criterion is measured by the annual inflation differential of each CEE country against average EMU inflation.

4.2.2 Estimation results

The data is split into four overlapping periods: 1993 -2001, 1995 -2001, 1997 - 2001 and 1999-2001. This was done in order to see whether the results for the total sample were influenced by the processes of economic restructuring and transition turbulence in the mid-nineties and in order to look at the recent development in the CEECs progress towards economic convergence to the EMU. Several points about the data, which is reported in Table 5, should be mentioned. One of the most important characteristics, that is of business cycle correlation, increased dramatically towards the end of the estimation period and showed the tendency to converge to a close range for all countries by the beginning of the year 2001, as illustrated in Figure 2. Although this finding is confirmed by other studies (Boone and Maurel, 1998 and Fidrmuc and Schardax, 2000), the short time period of only one full business cycle and the presence of only a few supply and demand shocks makes it less robust and conclusive then we would like it to be. The high degree of trade with the EMU countries also merits attention, with the Czech Republic, Hungary and Poland already reaching the average of EMU intra-trade (around 67%). The volatility of the real exchange rate has decreased for countries that used exchange rate arrangements close to the fixed rates, but stayed higher for Poland and Romania for all the sample and quite high for Latvia and Lithuania. The inflation differential was reduced to single digits since 1998 for all the countries except Romania.

Application of the clustering algorithm reveals a substantial level of fuzzyness in the data (Dunn's coefficient is around 0.5) and slightly worse results than in the previous section (average silhouette width is around 0.5 for all subsamples).

Thus, the results of the estimation for the whole period of 1993-2001 show the presence of three groups of countries. The best performing group consists of the Czech Republic, Hungary, Estonia, Poland and Slovenia, which show low volatility of RER (with the exception of Poland and probably the Czech Republic), very high trade openness of above 60%, and relatively high degree of business cycles synchronisation (see Figure 3), although the group statistics for inflation rate is less uniform. The second group is formed by Latvia, Lithuania and Romania, which have much worse values for all the parameters. The third group, consisting of Bulgaria and Slovakia, is much the same as the previous group, as can be seen in the low values of the individual silhouette width (with Slovakia having a negative value indicating that this country can not be classified with a reliable degree of certainty).

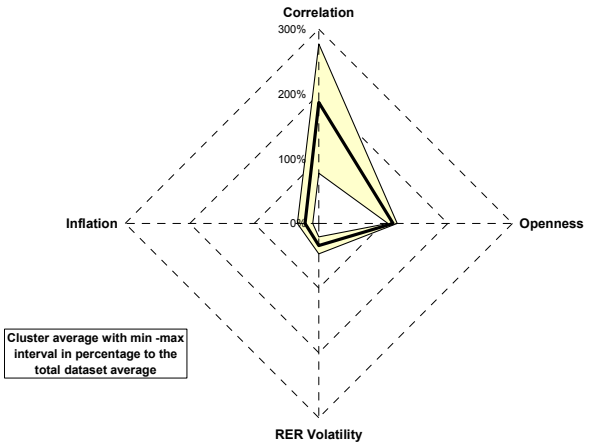

Figure 3. Statistics for the group of best-performers (the Czech Republic, Estonia, Hungary, Poland, Slovenia), 1993-2001.

The results of the test for the 1995 - 2001 period are almost identical to the previous ones. The only exception is that the group of best performing countries is joined by Latvia, the performance of which has improved substantially according to all four criteria.

The analysis of the period 1997-2001 indicates the improved performance of several countries, particularly Slovakia, which is grouped with the best-performers. The algorithm has identified only two groups in this sample - one of the five countries from the first Accession wave along with Latvia and Slovakia and the second group consisting of the other three countries, which are lagging behind. Figure 4 shows the comparative statistics for the first group.

Table 5. Partitioning by OCA Criteria

	1993 - 2001					1995 - 2001					1997 - 2001					1999 - 2001					
	Coefficients[1]			Silhouette width[2]	Cluster	Coefficients			Silhouette width	Cluster	Coefficients		Silhouette width	Cluster		Coefficients				Silhouette width	Cluster
Bulgaria	.01	.03	**.96**	0.13	3	.16	.38	**.46**	0.22	3	.21	**.79**	0.23	2		.00	.00	.00	**.99**	0	4
Czech R.	**.53**	.39	.08	0.29	1	**.50**	.32	.18	0.31	1	**.93**	.07	0.75	1		**.91**	.03	.06	.01	0.67	1
Estonia	**.65**	.27	.08	0.52	1	**.59**	.09	.32	0.68	1	**.81**	.19	0.72	1		**.44**	.14	.31	.12	0.23	1
Hungary	**.94**	.04	.02	0.81	1	**.91**	.04	.06	0.79	1	**.89**	.11	0.76	1		**.78**	.06	.12	.03	0.69	1
Latvia	.11	**.83**	.06	0.25	2	**.40**	.25	.35	0.39	1	**.71**	.29	0.57	1		.12	**.70**	.11	.07	0.35	2
Lithuania	.11	**.73**	.16	0.67	2	.11	**.68**	.22	0.42	2	.18	**.82**	0.27	2		.07	**.73**	.10	.11	0.49	2
Poland	**.70**	.16	.14	0.54	1	**.48**	.14	.39	0.44	1	**.85**	.15	0.75	1		.08	.05	**.85**	.02	0.14	3
Romania	.13	**.68**	.19	0.58	2	.08	**.82**	.10	0.47	2	.29	**.71**	0.29	2		.23	**.43**	.27	.07	0.33	2
Slovak R.	.32	.34	**.34**	-0.08	3	.06	.06	**.88**	-0.07	3	**.57**	.43	0.47	1		.15	.18	**.51**	.16	0.47	3
Slovenia	**.92**	.05	.02	0.81	1	**.94**	.03	.04	0.81	1	**.94**	.06	0.78	1		**.95**	.02	.03	.01	0.79	1
Number of clusters	3					3					2					4					
Silhouettes width[3]	0.59 0.50 0.02					0.57 0.44 0.08					0.69 0.26					0.60 0.39 0.31 0.00					
Average silhouette width	0.45					0.45					0.56					0.46					
Dunn`s coefficient	0.44					0.35					0.41					0.48					

Source: author's calculations

Notes:

1) The coefficients of belonginness of the country to each cluster with the highest in bold.

2) Individual silhouette width

3) Silhouettes widths for each cluster in ascending order

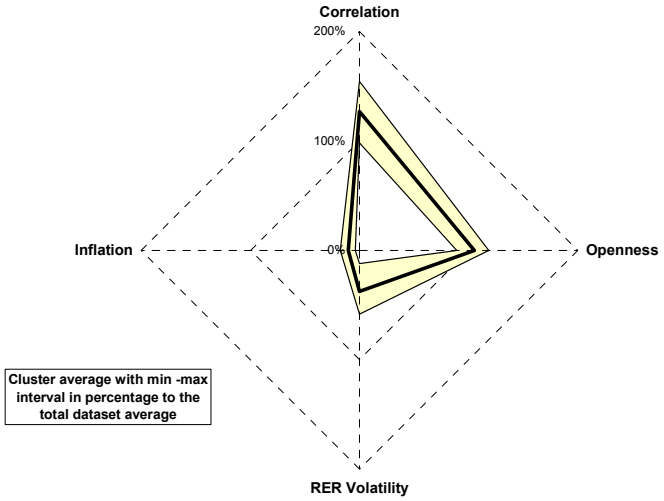

Figure 4. Statistics for the group of the best-performers (the Czech Republic, Estonia, Hungary, Latvia, Poland, Slovakia, Slovenia), 1997-2001.

In order to analyse any changes in the performance of CEECs after five of the countries negotiated an accession status (and were subsequently called the 1998 Accession Group) I look at the subsample of the 1999-2001 data. The results indicate that the best partition for this period was of four groups (see Figure 5), the best-performing group not including Poland this time due to its high RER volatility, which is instead grouped with Slovakia, exhibiting high volatility as well. The number two group consists of Latvia, Lithuania, and the Slovak Republic, which are separated because of low business cycles correlation. Bulgaria shows negative correlation between its and German unemployment rate fluctuations and is identified as a singleton.

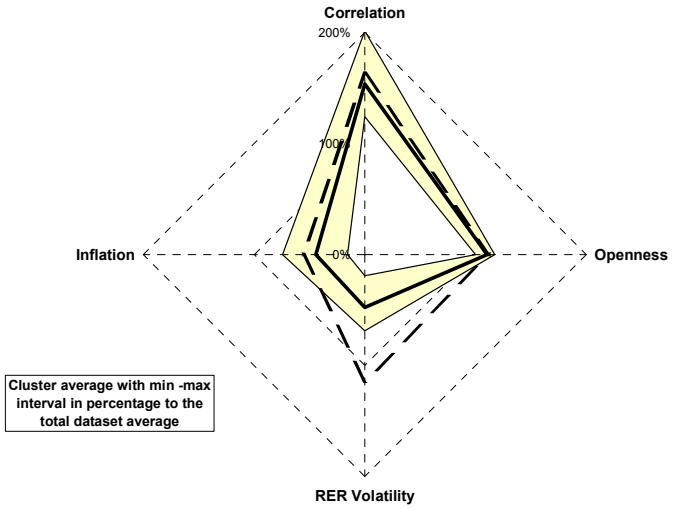

Figure 5. Statistics for the group of best-performers (Czech R., Estonia, Hungary, Slovenia) and Poland separately (the dashed line), 1999 - 2001.

The summary of the findings is as follows (see Table 6). It is possible to identify the group of countries which, by the OCA criteria, is more suited to join the EMU or to euroise. The criteria indicate that this group of countries is the 1998 Accession Group, joined over some periods, by Latvia and Slovakia. It seems, therefore, that the progress in liberalising the economy and restructuring as prescribed, monitored and assessed by the European Commission is correlated with successful integration into the EU economic area if the OCA theory is used. Interestingly, the analysis confirmed that Poland in recent years is lagging behind the more successful applicants and its acceptance will become more a political issue unless it speeds up its reforms.

5 Maastricht and OCA criteria compared

How do our identifications of groups based on nominal convergence compare with the those based on the OCA criteria? If we focus on the latest data period, several interesting conclusions may be drawn. First, only Estonia and Slovenia are classified as the countries that achieved both substantial nominal and real convergence with the EMU countries. In both parts of the analysis these two countries are grouped together in all the subsamples and they always form a part of the most advanced group. Therefore, Estonia and Slovenia may be regarded as the main candidates for joining the EMU among the applicants from the CEECs. Other countries from the 1998 Accession

Table 6. Classification of the countries by OCA criteria[1)]

	Business cycles correlation	Real exchange rate volatility	Trade openness	Inflation differential
1993 - 2001				
{ Czech R., Estonia, Hungary, Poland, Slovenia}	High	Low - Ave	High	Low - Ave
{Latvia, Lithuania, Romania}	Low	High	Ave	High
{Bulgaria, Slovakia}	Ave	High	Low	Mixed
1995 - 2001				
{ Czech R., Estonia, Hungary, Latvia, Poland, Slovenia}	High	Low - Ave	High	Low - Ave
{Lithuania, Romania}	Low	High	Low - Ave	Mixed
{Bulgaria, Slovakia}	Low	Mixed	Low	Mixed
1997 - 2001				
{ Czech R., Estonia, Hungary, Latvia, Poland, Slovakia, Slovenia}	High	Low - Ave	High	Low - Ave
{Bulgaria, Lithuania, Romania}	Low	High	Low - Ave	Mixed
1999 - 2001				
{ Czech R., Estonia, Hungary, Slovenia}	High	Low	High	Low - Ave
{Poland, Slovakia}	High	High	Ave - High	Ave
{Latvia, Lithuania, Romania}	Low	High	Mixed	Mixed
{Bulgaria}	Low	Low	Low	Ave

Source: author's calculations

Notes:

1) Table shows groups' classification according to whether the countries in each group have low (Low), average (Ave) or high (High) values for each criteria. If the countries in a group have a large dispersion of values for a criterion, then Mixed is reported

Wave (Czech Republic, Hungary, Poland) are leading only in real convergence while lagging behind in terms of inflation achievement, the stance of fiscal policy and exchange rate behaviour. Second, Poland is shown to lag behind the rest of the countries from the 1998 Accession Wave and it does not make a part of the leading group even by the OCA criteria during the last years. Fourth, all three countries (Bulgaria, Estonia, Lithuania) that have implemented the currency board arrangements show considerable nominal convergence but only Estonia is leading in economic convergence as well. Fifth, Romania with its high inflation, interest rate, loose fiscal policy and volatile exchange rate is a clear outlier and during the recent periods it is classified as a separate group according to the Maastricht criteria. Neither it shows any substantial economic convergence to the EMU.

6 Conclusions

This paper has analysed the empirical evidence on the topic of readiness of CEECs to join the EMU or euroise their economies. The problem was split into three parts and cluster analysis to identify the groups of countries that are closer to being ready to do so was employed in each case.

First, the paper looked at the Maastricht Criteria as a set of requirements to be fulfilled by the applicants in order to qualify. Support was found for the existence of a clear-cut structure in the data. Several countries, among them all the CEECs that have implemented the currency board arrangement, joined by Slovenia and Latvia, consistently outperformed others in coming close to satisfying the Maastricht Criteria. Assuming that the countries do attempt to satisfy the criteria to look "ready" for the EMU this evidence might be an indicator of considerable tensions and problems of transition economies in satisfying the Maastricht criteria beforehand. Whether the stability orientation of an economy is improved by fixing its currency against the euro remains a question deserving further attention.

Second, the question of the economic convergence of CEECs to the EU was tackled by analysing their performance with respect to the OCA criteria. The findings regarding the best-performing group, consisting of the countries of 1998 Accession Group contradict the findings about the nominal convergence as only Slovenia and Estonia are leaders both in nominal and real convergence. Additionally, the recent economic and restructuring performance of Poland is identified as the main reason for associating it with the other group of countries, which are not converging at such a fast rate to the EU economic area.

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7 Appendix

7.1 Data sources and description

Maastricht criteria data

Budget Deficit:
CEECs' data is taken from EBRD (2000) and Deutsche Bank Research; EMU countries' data from Eurostat (2001)
Public Debt:
Croatia - from WDI database (World Bank);
Lithuania - NSO of Lithuania; the rest of CEECs' from Deutsche Bank Research
Exchange rates:
all from IFS (IMF)
Inflation:
CEECs' data - EBRD (2000), Deutsche Bank Research and national statistics;
EMU average inflation is taken from OECD Economic Outlook (2001)
Interest rates:
Slovenia - Slovenian Central Bank; rest of CEECs from EBRD (2000);
EMU interest rates from Eurostat(2000)

OCA criteria data

Business cycles correlation:
Bulgarian unemployment, Polish, Slovak Republic, Slovenian industrial output from PlanEcon Monthly Report (various issues); the rest of CEECs' data and Germany industrial output and unemployemnt from IFS (IMF) and NSO of Estonia; Eurozone GDP from Beyer et al (2001).
Real Exchange Rates:
all from IFS (IMF)
Trade openness:
all from European Commision Statistics
Inflation differential:
CEECs' data - EBRD (2000); EMU average inflation is taken from OECD Economic Outlook (2001)
Unemployment:
all from EBRD (2000) and National Statistics offices

Discussion

Ryszard Kokoszczyński
National Bank of Poland and Universiy of Warsaw

1. Boreiko`s paper is an interesting attempt to formalize some of the important strands in the discussion on the European Union`s enlargement. Both the legal framework of the accession process and official statements of the majority of accession countries imply that their next step – to be undertaken sooner rather than later – is the membership in the Economic and Monetary Union. The major part of the literature covering that subject seems to focus only on the issue of the exchange rate regime – what choice would be optimal from that point of view[1]. However, finding an optimal solution is somewhat complicated, because of different requirements of real and nominal convergence. The former, usually understood as the process closing the income gap between EU and accession countries, brings indisputable benefits. The latter, meaning control over inflation, interest rates, exchange rates etc., is also beneficial in the long run, but when pursued in the relatively short period, brings substantial costs attributable to the process of delivering price stability. Finding a balance between nominal and real convergence becomes then a very complicated issue when addressed form an empirical perspective.
2. Boreiko`s approach is refreshingly simple: let us measure both real and nominal convergence for various periods of time. Results of such an exercise may enable us to assess the performance of accession countries in more objective way. This exercise constitutes, in my opinion, the most relevant part of the paper. I like the idea of applying multivariate statistical tools, particularly pattern recognition techniques, to the problem; moreover, I think that Boreiko is right assuming that the nature of the problem requires application of "fuzziness". I can only praise the paper for clear and comprehensive presentation of the method applied.
3. I have really only one critical comment to make regarding the technical part of the paper. Notwithstanding mostly intuitive results I would feel more certain if their robustness could be more extensively checked. My suggestion would be twofold. First, to apply

[1] Cf. P. Gaspar (2001), Real and Nominal Convergence of Pre-Accession Economies and the Choice of Exchange Rate Regime, International Centre for Economic Growth, mimeo, Deutsche Bundesbank (2001), Währungspolitische Aspekte der EU-Erweiterung, *Monatsbericht*, Oktober, 15-31, and Boreiko`s references.

different metrics within fuzzy cluster analysis; second, to apply different pattern recognition techniques. Some of Dmitri`s remarks in our personal communication seemed to support the idea that his result are robust enough and some of this work has been already done. It would be nice to have this written explicitly.

4. I like the idea of applying the same approach to the measurement of both real and nominal convergence. I understand reasons behind equaling real convergence with OCA theory requirements and nominal convergence with Maastricht criteria. Nevertheless, there are two issues here I have some problems with. First is the well-known problem of endogeneity of OCA criteria[2]. EU accession will be indisputably a major factor influencing both real and nominal convergence. One can try to argue that the strength of the factor will be stronger for countries that are "further" from the EMU. That simply means that results Boreiko got now may be prone to serious disruption after some time accession countries spend within the EU. The second issue is the different implication of one kind of exchange rate volatility for real and nominal convergence, as they are understood in the paper. From an OCA perspective any exchange rate volatility means that losing one´s own currency may be harmful or, at the very least costly, for the country concerned, especially in the case of asymmetric shocks. However, the Maastricht criteria treat very differently appreciation and depreciation of the currency. The former is not an obstacle in the process of EMU accession, the latter – definitely so[3]. Some of the accession countries` currencies appreciated, even in nominal terms, in the 1990s (this is also the case of Poland). That may mean problems in terms of real convergence, but it does not mean the exchange rate instability in terms of Maastricht criteria. I am afraid I do not have any practical suggestions how to cope with this problem here – some metrics may be applied which treat the direction of change differently but they will complicate tremendously the algorithm used. I am, however, convinced that the problem is important enough to be mentioned in these comments.
5. My last - and truly minor - remark regards the use of industrial production as a proxy for GDP. The share of industrial output in the GDP diminished substantially in the 1990s in most countries studied by Boreiko, so I have some doubts regarding the validity of this approach, particularly for the longest sample studied. I do understand problems with

[2] Cf. J.A.Frankel, A.K.Rose (1998), The Endogeneity of the Optimum Currency Area Criteria, *Economic Journal*, 108, 1009-1025; G.Corsetti, P.Pesenti, Self-validating optimum currency areas, paper presented at the 2002 AEA Meetings in Atlanta.

[3] It is, probably, not only a coincidence that this argument may improve Poland`s position in the results. However, I am convinced that this issue is truly relevant for the problem this paper addressed.

obtaining data on GDP, I also know that algorithms applied by some researchers (for example, Cuche (2000) for decomposing statistically quarterly GDP data into monthly figures may become another source of noise. I think, nevertheless, that some form of checking the robustness of results for business cycle convergence would be a nice addition to the paper.

Reference

Cuche, Nicolas A. (2000): "Monetary Policy Rules and Indicators: Empirical Evidence for Switzerland", Studienzentrum Gerzensee (http://www.szgerzensee.ch/publications)

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