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Is Eastern Europe ready for the euro?: A cointegration analysis for the Maastricht criteria

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IS EASTERN EUROPE READY FOR THE EURO?

A cointegration analysis for the Maastricht criteria

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ABSTRACT

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This report documents the results of cointegration analyses of the degree of convergence which the economies of the central-eastern european countries (CEECs) have achieved towards the economies of the EMU countries. This cointegration technique is applied to several of the core variables that are important with respect to the Maastricht criteria, namely: inflation, the exchange rate, and the long-term interest rate. The main conclusion that can be drawn from this cointegration analysis is that most of the countries in the first group entering the EU have achieved a considerable degree of convergence for most (but not all) of these EMU criteria variables considered. The countries in the second group of countries to enter the EU in the more distant future, turn out to be lagging behind in the convergence process.

Key words: Cointegration, Convergence, EMU
JEL codes: C22, F36

SAMENVATTING

Is Oost-Europa klaar voor de euro?: Een coïntegratie-analyse voor de criteria van Maastricht
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Dit rapport doet verslag van een coïntegratie-analyse van de mate van convergentie van de economieën van de Centraal- en Oost-Europese landen (CEECs) naar die van de EMU-landen. De coïntegratietechniek wordt toegepast op enkele van de kernvariabelen die in het kader van de Maastricht-criteria van belang zijn, te weten: de inflatie, de wisselkoers en de lange rente. De belangrijkste conclusie die uit de cointegratie-analyse wordt getrokken, is dat de kopgroep van CEECs die momenteel in onderhandeling zijn over toetreding tot de EU, ten aanzien van de meeste (maar niet alle) van de genoemde drie EMU-criteria convergentie hebben bereikt. De beschouwde landen uit de navolgende groep van CEECs die eventueel pas later zullen kunnen toetreden, lopen nog duidelijk achter in dit convergentieproces.

Trefwoorden: Coïntegratie, Convergentie, EMU
JEL codes: C22, F36

1 INTRODUCTION

It is to be expected that in the future there will be an enlargement of the euro currency area. With central and eastern European countries (CEECs) waiting in line to join the EU from 2004 on, it is likely that the EMU will get requests for accession to this Monetary Union as well. This means that many changes are awaiting the EU and EMU, which makes it a challenging subject for researchers. Especially the accessing countries will have to undergo important changes, both socially and economically. In the long term their economies will have to grow towards those of the present EMU members, i.e. they have to 'converge'.

The potential effects of an EMU accession are subject to debate. For example, Gross, Pelkmans and Nunez Ferrer (2000) take the strong position that, from a strictly economic point of view, the present EU-15 will not be strongly affected by an accession of the new EU-entrants to EMU. For these countries it does not matter whether the candidates enter the euro area quickly. But there are also opposing opinions. For example Wagner (2002) finds economic pitfalls for a rapid expansion.

For joining the EMU there are requirements to be met in addition to the conditions for joining the EU. These requirements, also called 'nominal convergence criteria', were stated in the Maastricht Treaty in 1991. The nominal convergence that is mentioned implies co-movement of economies and policies. The treaty contains four criteria, i.e. price stability, sustainable fiscal position, exchange rate stability and low interest rate.

In this report the focus is on economic co-movement or convergence. The research question is whether convergence has already taken place and to what extent for the different economies. An econometric way to look at co-movement between economic variables is cointegration. There have been many studies that looked for cointegration between the variables which play a role in the Maastricht criteria for some of the EU members. Karfakis and Moschos (1990), for example, focus at the interest rate relationship between Germany on the one hand and Belgium, France, Ireland, Italy and the Netherlands on the other. They use the Engle and Granger (1987) bivariate cointegration method and find no cointegration. Haug, Mackinnon and Michelis (2000) use Johansen's (1991, 1995) procedure to search for cointegration between 12 EU countries. They consider all four variables which are relevant for the Maastricht criteria. They conclude that there is only partial convergence of policies among these countries.

This report differs from other studies in several respects. First, I test for cointegration between several CEECs [1] that are presently applying to join the EU in the next few years on the one hand, and the present EMU countries on the other. This will be done for all [2] Maastricht criteria separately. Thus, whereas most existing papers look for cointegration among the EU members, this paper deals with cointegration between the EMU members on the one hand and the applicant CEECs on the other. Second, the approach followed here differs from most existing papers, by using the concept of 'relative cointegration'. Instead of determining how many cointegration vectors exist between EMU countries and CEECs, I find out how many additional vectors are created by adding one CEE country to the EMU area. This is done by comparing the number of cointegration vectors within the set of EMU countries with the number of vectors for the same set of EMU countries plus one CEE country. Hence, in this methodology the number of extra cointegration vectors is a measure of the degree of relative convergence.

The cointegration tests are performed for all the ten CEECs mentioned. The analysis is done in two stages. The first stage consists of estimating the number of cointegration vectors, while the second stage goes deeper into the question where the particular extra cointegration originates. This second stage will be done only for four countries, Bulgaria, Hungary, Poland and Romania. The reason for this is that these countries already exist as independent countries for an extended period of time, while the other CEECs only exist as independent countries for a relatively short period. Consequently, the sample periods for the latter group of countries are short, so that one should be careful drawing conclusions from the cointegration test results. The four 'core' countries, on which the second stage of the analysis focuses, are a good sample of the CEECs, in fact representing two samples for each of the two 'flows' that will enter the EU. The first flow [3] is expected to enter in 2004 (Buch and Lusinyan, 2002) and the second flow [4] in 2007. Gros, Pelkmans and Nunez Ferrer (2000) state that both Bulgaria and Romania recognise that they are likely to join the EU two or three years later.

The report has the following structure. In Section 2 the four Maastricht criteria will be considered in more detail, especially by means of a comparison of the levels of the criterion variables between the CEECs and the EMU members. Section 3 gives a short introduction to the econometrics of stationarity

1 The CEECs that will be used to test for cointegration are The Czech Republic, The Baltic States (Estonia, Lithuania and Latvia), Poland, Hungary, Slovenia, Slovak Republic, Bulgaria and Romania.

2 For the sustainable fiscal position criterion I will not carry out such a cointegration test. The reason for this is the lack and the quality of the data. More explanation will be given later in this report.

3 The first flow consists of The Czech Republic, The Baltic States (Estonia, Lithuania and Latvia), Poland, Hungary, Slovenia, Slovak Republic, Cyprus and Malta.

4 The second flow consists of Bulgaria and Romania.

and cointegration. In Section 4 the results of the cointegration tests are presented and the implications for the degree of convergence of the CEECs towards the EMU are discussed. Section 5 summarises the conclusions.

2 THE MAASTRICHT CRITERIA

In this Section the Maastricht criteria will be discussed subsequently [5]. In the introduction it has been mentioned that there will be two flows of countries entering the EU. The first group (C1Cs) is expected to enter in 2004 and the second group (C2Cs) around 2007. As these two groups find themselves in different stages of transition, and therefore to a different degree adapted to the Maastricht criteria, I will look at these two groups separately.

In many articles, see for example Cavelaars and Roovers (2000) or Halpern and Nemenyi (2002), it is mentioned that the C1Cs are now, in terms of the Maastricht criteria, better prepared than most of the EU members at a comparable time before entering. Even if one looks at Greece and Portugal only a few years ago one can see that these countries did not meet most of the Maastricht criteria, while many of the CEECs at the moment meet them or are close to meeting them. Lithuania for example has had a lower monthly inflation since April 1999 than the average euro country.

2.1 **Price stability**

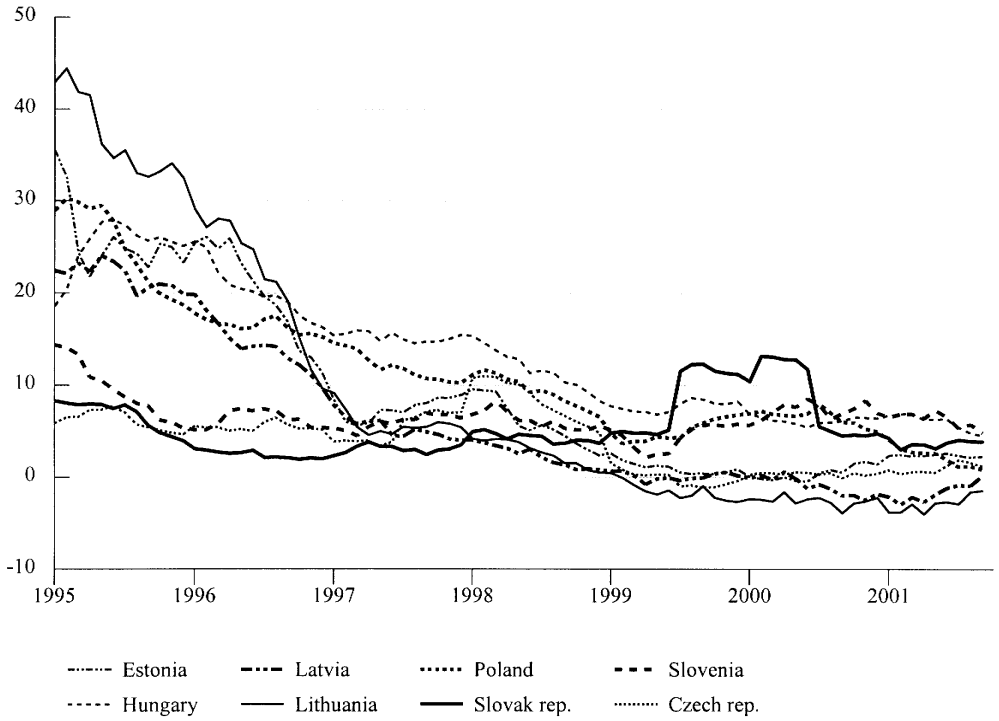
The first Maastricht criterion is price stability, i.e. an average inflation rate (measured on the basis of the consumer price index) that does not exceed by more that 1.5 percent points that of, at most, the three best performing EU countries [6].

Figure 1 shows for the C1Cs the distance of the inflation rates from the maximum level according to the criterion, for the period from 1995 until 2001. When the lines are below the zero axis, this means that the respective countries fulfill the Maastricht criterion. The inflation rate of most of the C1Cs has diminished substantially during recent years. From the figure it can be concluded that some of the countries are already fulfilling the criterion and most of them are close to fulfilling (at most five percent above the maximum level allowable). Of the two C1Cs this paper focuses on, Hungarian inflation is still a little less than five percent above the maximum but it is going steadily down, and Polish inflation is close to meeting the criterion. Bulgaria and Romania are lagging behind with the

[5] One can argue that a link exists between the four different nominal convergence criteria. For example, a tight monetary policy can contribute to inflation convergence; fiscal austerity may lead to convergence of long-term interest rates, and to reductions in budget deficits and debts over time, thus leading to exchange rate stability (Haug, MacKinnon and Michelis, 2000).

[6] I deviate from the official interpretation of the three best performing member states. First, by considering EMU members instead of EU members and, second, by considering annual averages instead of twelve-month moving averages. Due to lack of data at the time of writing this report, the year 2001 could not be included.

Figure 1 Excess inflation (deviations from maximum level according to criterion)



convergence of their inflation rates; Romania more so than Bulgaria in the period from 1998 until 2000. In 1997 Bulgaria even reached an inflation rate of more than 2000 percent and Romania above 170 percent.

2.2 **Sustainable fiscal position**

The second criterion is a sustainable fiscal position. This means that there is no excessive deficit. An excessive deficit exists if:

- The budget deficit is higher than 3 per cent of GDP, unless, either the ratio declined substantially and continuously and has reached a level that comes close to 3 per cent, or the excess over the 3 per cent reference value is only exceptional and temporary and the deficit remains close to 3 per cent.
- The ratio of gross government debt to GDP exceeds 60 per cent, unless the ratio is sufficiently diminishing and approaching the reference value at a satisfactory pace.

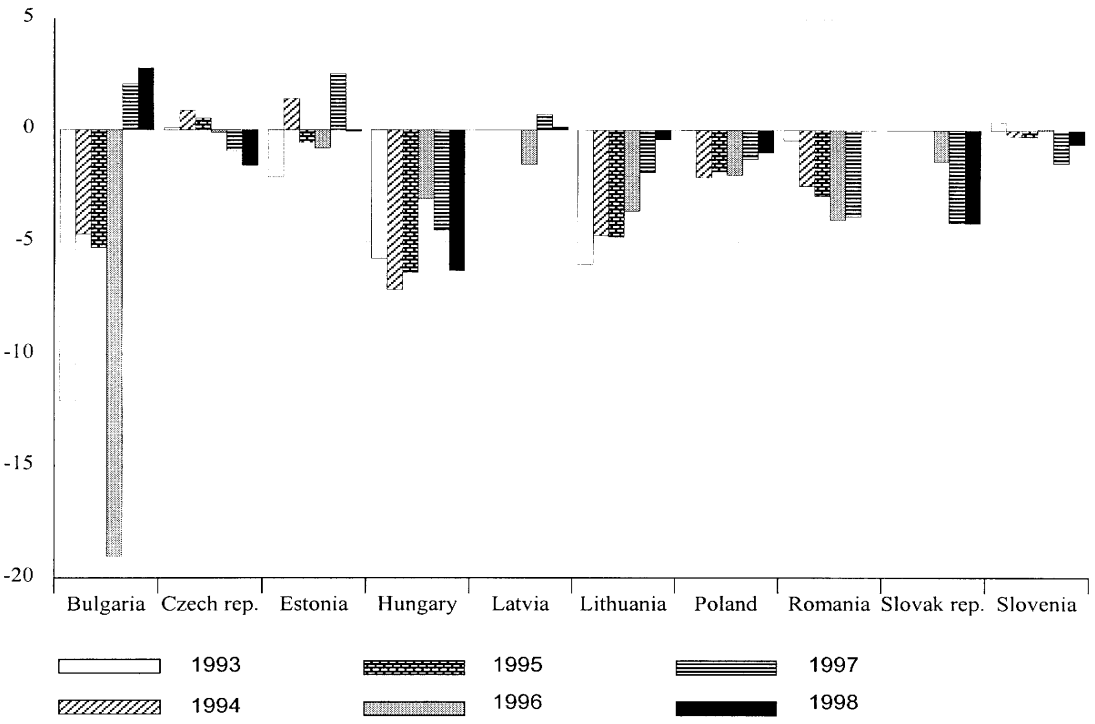
In this report, due to limited data availability, only the first part of the definition will be focused upon, i.e. the budget deficit. As Gros, Pelkmans and Nunez Ferrer (2000) state, the debt criterion will not constitute a major hurdle, because most of the candidate countries have at present a debt to GDP ratio

below the 60 percent ceiling. In Section 4 I will not perform a cointegration test on the budget deficit, though, as was already mentioned in the Introduction. This is due to data limitations as well.

Figure 2 shows that, in the last few years, Hungary and the Slovak Republic are the only C1Cs that do not meet the criterion. The other C1Cs, except for Lithuania, have too high deficits during the whole period. Romania shows a steady deficit, but does not meet the criterion in the last years. Bulgaria meets the criterion the last two years, but fluctuates heavily. This shows the difference between the C1Cs and the C2Cs.

Halpern and Nemenyi (2002) emphasise an important caveat. They argue that one should be careful with drawing conclusions on the basis of these data because of heterogeneity. In many CEECs the official figures often exclude large state-owned institutions financed by off-budget money (direct transfers, guarantees, etc.), appearing sooner or later as an increase in the public debt. They conclude that by taking the headline indicators of general government balances and debts at face value, it is not easy to make a judgement about the true fiscal stance in the CEECs, or to estimate the necessary adjustments for an early EMU membership.

Figure 2 Deficit CEECs (% gdp)

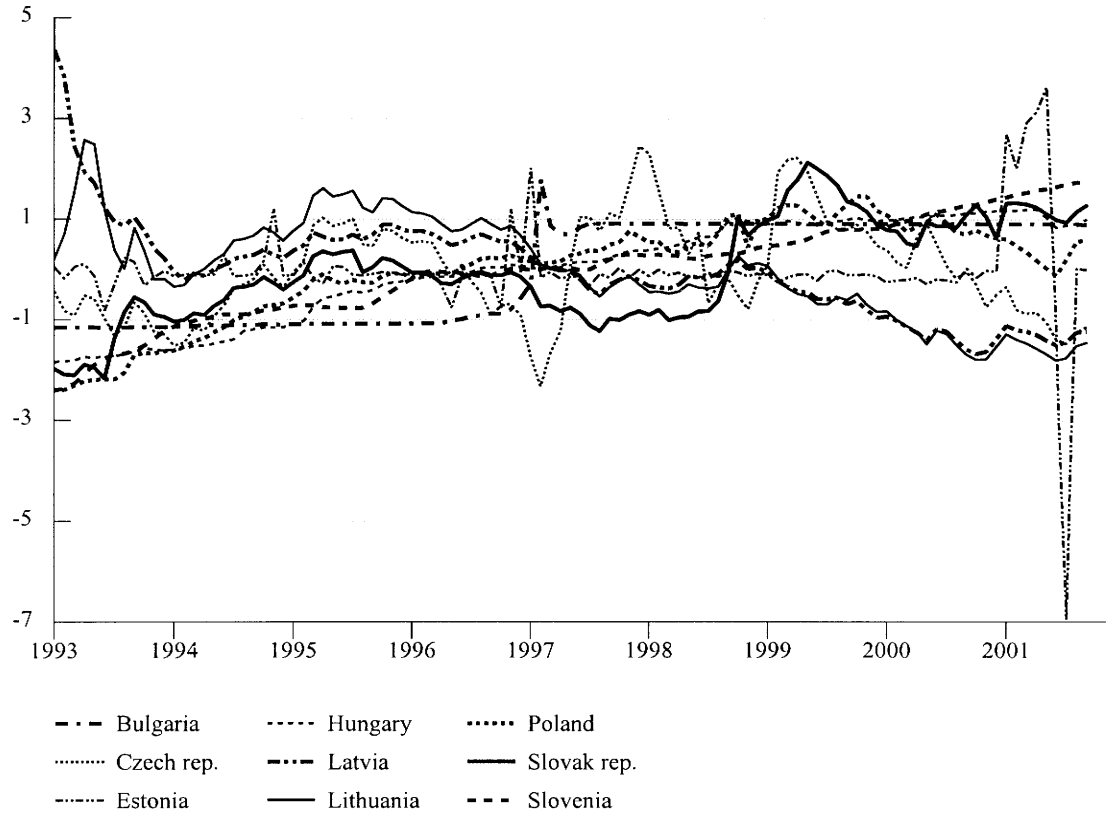


2.3 **Exchange rate stability**

The third criterion of the Maastricht Treaty concerns the exchange rate. It states that the exchange rate should be stable, meaning that the currency had respected the 'normal' fluctuation margins of the ERM, without severe tensions for at least two years. To this end, in 1998 it was decided to start a new Exchange Rate Mechanism (ERM2). Members of the EU have to be a member of the ERM2 for at least two years before entering the EMU.

Figure 3 shows the exchange rates of the CEECs vis-à-vis the D-mark c.q. the euro, after being 'normalised' (the mean value is adjusted to zero and the variance is standardised). The Estonian kroon shows a heavy fluctuation at the end of 2000. The other C1C currencies fluctuate around their means. Also the Bulgarian lev seems to have a steady exchange rate with the D-mark, except at the end of 1996 and the beginning of 1997.

Figure 3 Normalised exchange rates
(mean=0; standard dev.=1)



Stabilising the exchange rate vis-à-vis the euro has its influences on policy [7]. Such a country gives up the policy instrument of the exchange rate. On the other hand, if such a country has a lot of foreign trade with the euro countries, this engagement reduces a lot of exchange rate uncertainty. Cavelaars, van Oorschot and Vijselaar (2000) argue that a country is forced to link its level of wages and prices to that of the euro area after engaging its currency to the euro, and that this is a good way to terminate a period of high inflation. They conclude that with the simultaneous obligation to stabilise both the price level and the exchange rate, these countries are forced to have a converging prosperity.

Exchange rates are of course strongly related with interest rates. Stabilising the exchange rate vis-à-vis the euro indirectly means pegging the interest rate to the rest of Euro zone. Gros, Pelkmans and Nunez Ferrer (2000) argue that interest rate convergence will result from a stable exchange rate. The subsequent section will discuss the interest rate criterion.

2.4 **Low interest rate**

The fourth and last Maastricht criterion deals with the interest rate. It requires a low interest rate, meaning that the average long term interest rates should not exceed by more than 2 percentage points the interest rates in, at most, the three best performing countries in terms of price stability.

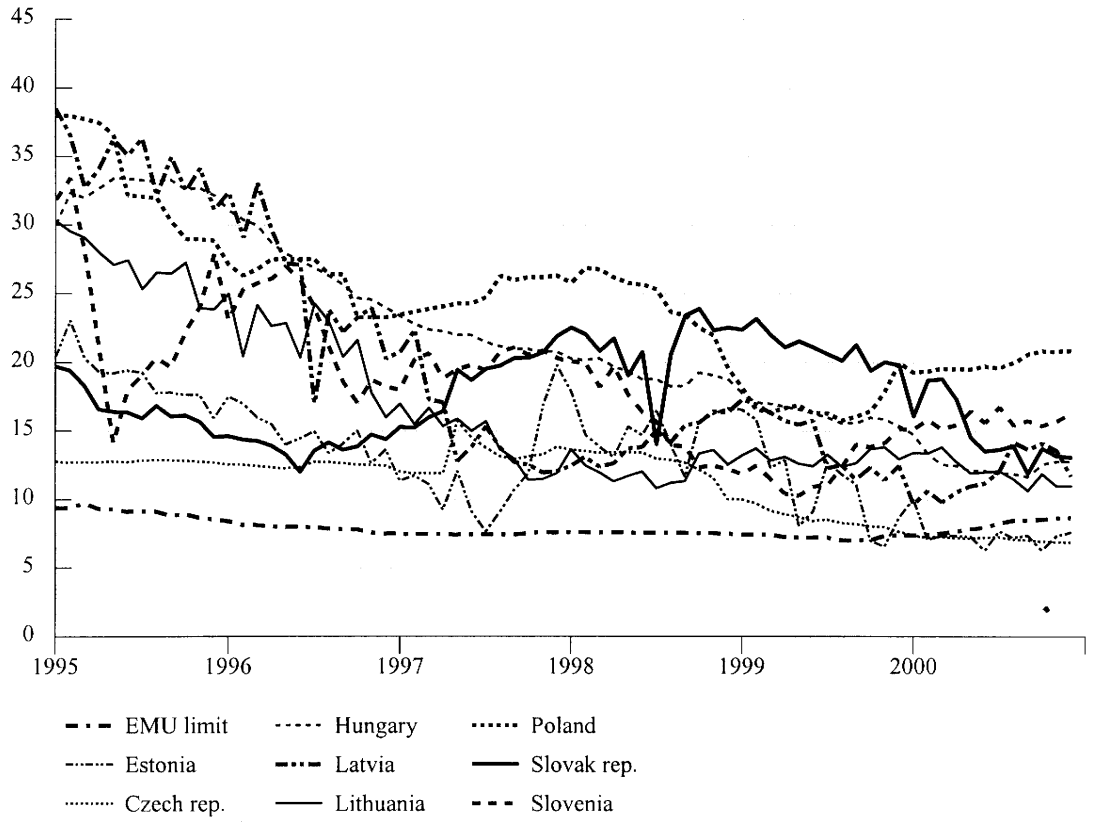
Figure 4 shows the interest rates for the C1Cs in 1995 till 2000, where the Maastricht criterion is plotted as the bold line. The interest rate criterion requires that a country should be under this level for at least one year before adopting the euro [8].

Every C1C country has a declining interest rate over the period. The Czech Republic and Estonia already meet the Maastricht criterion. The other countries seem to steadily converge to the criterion. Latvia and Lithuania are close to meeting the criterion. Only Poland is far off line. Bulgaria shows heavily fluctuating interest rates.

[7] See for more information on policy http://europa.eu.int/comm/enlargement/report2001/index.htm#context.

[8] To calculate the Maastricht criterion Belgium, France and Germany are used as the three best performing countries in terms of price stability. Austria, due to missing data, could not be considered for this purpose. For CEECs with no long-term government bonds, lending rates were taken.

Figure 4 Interest rate C1Cs



3 METHODOLOGY

In this report cointegration is used as an econometric method to assess whether or not the economies of the CEECs are co-moving with or converging to those of the EMU countries. In other words, the research question is: do the economies of the CEECs cointegrate with the EMU members? In this Section the cointegration test, and the assumptions made, are discussed.

Engle and Granger (1987) showed that two or more non-stationary time series combined linearly might be stationary. If a stationary linear combination exists, the time series are said to be cointegrating. The linear combination is called the cointegrating equation and can be interpreted as a long-run equilibrium relationship among the variables [9].

3.1 **Unit root**

To test for cointegration, one needs non-stationary time series, in particular time series with a unit root. Two frequently used tests for a unit root, among others, are the (augmented) Dickey-Fuller (ADF/DF) test and the Phillips-Perron (PP) test [10]. I will use the ADF test, because it is closest related with the Johansen cointegration method that will be used here.

In this paper the overall ADF test results are compared with the critical values of MacKinnon (1991). The tests are done including a constant but excluding a trend variable, basically because of the economic background of the variables. As a matter of fact, none of the time series from the Maastricht criteria should have a trend. In cases of doubt a test with a trend is done as well and the results are compared with the results of the test with only a constant. The appropriate lag length is chosen with the help of Akaike's criterion (see Ng and Perron, 1995).

After these unit root tests have been done, a unit root test on the first difference is executed, of course only for the time series that seemed to have a unit root in their levels. It appears that all the unit root tests on the first differences reject the null hypothesis of a unit root. This means that all the series for which a unit root is found are integrated of order one, which is denoted below by I(1). In other words, if a unit root is found the series can be used for the Johansen cointegration test.

[9] The tests have been executed in Econometric-Views (Eviews), a computer program that is especially designed to analyse econometric topics. Most of the results, graphs and tables are obtained using this program.

[10] See Enders (1995) for more information.

Cushman, Lee and Thorgeirsson (1996) argue that it is not a problem for the Johansen cointegration approach if some of the variables are stationary. Including a stationary time series means that one will find a cointegration relation of that series 'with itself'. What I want to investigate in this report however, is how the CEECs cointegrate with the EMU countries. Hence including a stationary time series would make it impossible to distinguish between the cointegration of a series with itself and the cointegration of that series with those of the EMU countries. For this reason, if a unit root has to be rejected at the 1 percent level the time series will not be included in the cointegration test.

3.2 **Cointegration**

Once it is concluded that the time series are non-stationary, one can start with the test on cointegration. The purpose of the cointegration test is to determine whether a group of non-stationary series are cointegrated or not. Here the vector auto-regression (VAR) based cointegration tests, using the methodology developed in Johansen (1991, 1995), is used. The reason for using this test is, among other reasons, its ability to detect more than one cointegration vector and its control for endogeneity[11].

Similar to the unit root test, the Johansen test is carried out with a constant and without a trend, for the same reasons as given above with respect to the unit root test. To exclude a linear drift in the time series, the constant is restricted to be inside the ECM term. The lag length will be chosen with the help of the Schwarz information criterion [12]. Haug (2001) claims that the Schwarz information criterion estimates the lag order consistently in contrast to the Akaike's criterion. The cointegration test results, i.e. the Trace statistic [13] values, from the test with the null hypothesis of r cointegrating relations against the alternative of k cointegrating relations, will be compared with the (non-standard) critical values from Osterwald-Lenum (1992).

The number of endogenous variables minus the number of cointegration vectors is the number of common stochastic trends. Complete convergence is reached when there is only one stochastic trend. This means that the level of co-movement depends on the number of cointegration vectors in the

[11] For more advantages of the Johansen approach see Gonzalo (1994) and/or Campbell and Perron (1991).

[12] A VAR regression is done with the chosen variables, for various values of p, and then the results are compared based on the Schwartz information criterion in order to gain insight in the right number of lags to use in the Johansen cointegration test.

[13] The trace statistic of r cointegration relations is computed as $l_{trace}(r) = -T \sum_{i=r+1}^{k} \log(1-\hat{l}_i)$ where $\hat{l}_i$ is the estimated value of the characteristic roots (also called eigenvalue) obtained from the estimated Π matrix. T is the number of usable observations.

system, see Hafer and Kutan (1994). More than one stochastic common trend in the system means that there is co-movement but not yet complete convergence.

To get some insight in the origin of the cointegration, first a cointegration test is done for the EMU countries. Second, the cointegration test is redone for the EMU countries plus one additional CEEC. This step is repeated for every CEEC, separately. If cointegration is found for the four 'core' CEECs, extra tests will be performed to see where the cointegration originates from. These tests will consist of imposing zero restrictions on the parameters of the EMU countries and bilateral cointegration tests between the CEEC and every one of the EMU countries, separately.

The question of the minimal time span for a sufficiently powerful cointegration test is difficult to answer. Cushman, Lee and Thorgeirsson (1996) find that 12 years can be sufficient to detect cointegration relationships using the Johansen approach. In this research, the time span ranges from 7 until 18 years.

Cointegration is a necessary but not a sufficient condition for convergence. The time series can have almost simultaneous time series, but at different levels. Therefore, visual inspection of charts showing the development of the time series is used as a complementary method to assess whether converge occurs.

4 RESULTS

This Section presents the cointegration testing results for the following Maastricht criterion variables: inflation, exchange rate, and the interest rate[14]. At the end of the Section conclusions are drawn for each CEE country separately.

Not all EMU countries are considered in the search for cointegration between the CEECs and the EMU countries. Austria and Finland are left out because they were not part of the EU until 1995, and are therefore not considered as a representative sample of the EU countries. Ireland and Luxembourg are left out because of missing data.

As mentioned in the introduction there are four countries of the CEECs: Bulgaria, Hungary, Poland and Romania. The reason for this is that the period of existence for most of the other CEE countries is very short. The four CEECs focused upon here are a representative sample of the CEECs, though. Included are two countries of both C1C and C2C, as mentioned in Section 2. These four countries are Hungary and Poland from the C1Cs and Bulgaria and Romania from the C2Cs.

The cointegration tests are carried out for eight EMU countries and ten CEE countries. The range of the time series differs over the different criteria; at maximum it ranges from 1982 until September 2001. For the above mentioned four CEECs the source of cointegration, if any, is examined through extra tests. For the other six CEE countries this second step in the analysis is not done.

4.1 **Price stability**

As explained in Section 3, before applying the cointegration tests one should be positive that the time series are integrated of order one. An ADF test is used to determine whether the time series contain unit roots. Table 1 shows the results of these ADF unit root tests. The null hypothesis of a unit root can not be rejected for most of the countries. Exceptions are Estonia, France and Lithuania. For these three countries a unit root is rejected. Looking more closely at the underlying data, it appears that the three countries show quite different inflation trends. France's inflation shows a slowly descending trend since 1985. Consequently, a unit root test with an additional trend from 1985 included does not reject the null hypothesis of a unit root. Estonia’s inflation shows a steeply descending trend in the first few

[14] Monthly data are derived from the International Financial Statistics CD-ROM (International Monetary Fund, February 2002).

years and a less steep slope later on. Tests for a unit root with a trend cannot reject the null hypothesis of a unit root. Lithuania's sample period has to be shortened to 1994 until 2001 and a trend included, for the null hypothesis of a unit root not to be rejected. In view of these problems, I leave these three countries out of the cointegration analysis below. Consequently, the EMU group for the inflation criterion is represented by seven countries.

In all cases where a unit root can not be rejected, a second ADF unit root test is performed on the series in first differences to test whether they are integrated of second order or higher. For all seven EMU countries and eight CEE countries this test was negative, implying that they are all I(1) and therefore can be used for the Johansen cointegration test.

Table 1 Augmented Dickey-Fuller (ADF) test results for inflation

Country	Sample period	ADF	Significance	Critical value a)
Spain	January 1982-September 2001	-2.42	10%	-2.57
Portugal	January 1982-September 2001	-1.14	10%	-2.57
Netherlands	January 1982-September 2001	-3.33	1%	-3.46
Italy	January 1982-September 2001	-3.13	1%	-3.46
Greece	January 1982-September 2001	-0.68	10%	-2.57
Germany	January 1982-September 2001	-2.78	5%	-2.87
France	January 1982-September 2001	-5.48	1%	-3.46
Belgium	January 1982-September 2001	-2.28	10%	-2.57
Slovenia	January 1992-September 2001	-2.96	1%	-3.49
Slovak republic	January 1994-September 2001	-2.29	10%	-2.58
Romania	January 1991-September 2001	-1.86	10%	-2.58
Poland	January 1988-September 2001	-2.61	5%	-2.88
Lithuania	January 1993-September 2001	-4.67	1%	-3.50
Latvia	January 1992-September 2001	-3.26	1%	-3.49
Hungary	January 1982-September 2001	-1.43	10%	-2.57
Estonia	January 1993-September 2001	-3.55	1%	-3.50
Czech republic	January 1994-September 2001	-1.41	10%	-2.58
Bulgaria	January 1991-September 2001	-2.89	1%	-3.48

a) MacKinnon critical values for rejection of hypothesis of a unit root. If ADF > critical value then the null hypothesis of a unit root can not be rejected.
Note: 'Significance' denotes the highest among the significance levels of 1, 5 or 10 percent, for which the test does not reject the null hypothesis.

After the unit root test is performed, the cointegration analysis can be carried out. The first step is the determination of the lag length. VAR regressions on Belgium, Germany, Greece, Italy, The Netherlands, Portugal and Spain are done for all relevant periods [15] after which the optimal lag length is chosen by minimising the Schwarz information criterion. Analogously the optimal lag length is estimated for the EMU countries plus one of the eight CEECs added. After determining the lag length the cointegration test is performed. The results of the cointegration tests are presented in Table 2.

As explained in Section 3 the cointegration test concerns a null hypothesis of *r* cointegration vectors, which is tested against an alternative hypothesis of *k* cointegration values (*k* is the number of endogenous variables). The null hypothesis is rejected if the trace-statistic is larger than the critical

Table 2 Cointegration test results for inflation

Number of cointegration vectors	Trace Statistic	5% critical value a)	Trace Statistic	5% critical value a)	Trace Statistic	5% critical value a)
1982 - 2001	EMU		EMU + Hungary			
None	151.87	131.70				
At most 1	99.30	102.14	132.07	131.70		
At most 2			85.42	102.14		
1988 - 2001	EMU		EMU + Poland			
None	115.54	131.70	195.93	165.58		
At most 1			126.24	131.70		
1991 - 2001	EMU		EMU + Romania		EMU + Bulgaria	
None	143.99	131.70	208.72	165.58	179.07	165.58
At most 1	93.99	102.14	116.60	131.70	120.76	131.70
1992 - 2001	EMU		EMU + Slovenia		EMU + Latvia	
None	162.24	131.70	201.33	165.58	184.15	165.58
At most 1	88.10	102.14	127.94	131.70	126.85	131.70
1994 - 2001	EMU		EMU + Slovak Rep.		EMU + Czech Rep.	
None	140.71	131.70	160.08	165.58	174.09	165.58
At most 1	90.06	102.14			115.21	131.70

a) 5 percent critical value of Osterwald-Lenum (1992). If Trace Statistic > critical value then the null hypothesis as concerns the number of cointegration vectors is rejected.

[15] There are six periods in Table 1, however the sample period of January 1993 to September 2001 is only used for Estonia and Lithuania. For both countries the time series are found to be stationary and therefore they are left out of the cointegration test. Consequently, it is not necessary to look for cointegration among the EMU members in this period.

value. The tests are done for all values of r running from 0 to k. Table 2 shows the test for $r = s$-1, where the null hypothesis is still rejected, and the test for $r = s$ that for the first time does not reject H_0. In this case, s is the number of cointegration vectors.

From the first column of Table 2, concerning the EMU countries, it can be seen that the five cointegration tests for the five different periods yield different results. For the period of 1988 until 2001 no cointegration vectors are found, while for the other periods one cointegration vector is found.

The number of cointegration vectors found for the EMU countries is surprisingly low. One would expect more evidence for convergence among the EMU members. This outcome could relate to the lag length. The lag length recommended by the Schwarz criterion is low, mostly one. While experimenting with longer lag lengths, more cointegration vectors are found. However, in this case fewer observations are used and therefore the results may be less reliable. The finding of low convergence among EMU countries is not totally unexpected, though. Haug, MacKinnon, Michelis (2000) also find little cointegration among the 15 EU countries. They conclude that political considerations probably weighted heavily in the decision which EU countries would form the monetary union. They claim that when considering economic factors only, the proposed EMU would look different.

The next step in the analysis is to add one CEE country to the seven EMU countries and to see how many additional cointegration vectors are found. The results are the following:

- First, Hungary is added. As a result, one extra cointegration vector is found. Extra tests indicate that Hungary is especially cointegrated with Italy. It also shows some linkages with Germany and The Netherlands, but mostly with Italy.
- When adding Poland instead of Hungary to the seven EMU countries, one extra cointegration vector is found as well. Additional tests show that Poland is especially cointegrated with Greece. Next to Greece Belgium shows a strong linkage with Poland.
- For neither Slovenia nor Latvia extra cointegration is found by adding either one of them.
- The Czech Republic shows no extra cointegration in relation to the EMU countries either.
- For the Slovak Republic a strange result is found. When adding this country, not more but less cointegration is found as compared to the EMU group alone. The reason might be the short sample period of less than eight years. By adding an extra time series, the dimensions increase, which makes the estimates less reliable. In Section 2 it was already observed that the Slovak Republic had a sudden jump in its inflation in 1999 and 2000, which may have had repercussions on the stability of the estimates.

- Neither Bulgaria nor Romania yields additional cointegration vectors when added. These countries are the only two C2Cs in the sample. Hence, the degree of cointegration of the C2Cs is in general lower than that of the C1Cs.

The above results have been derived using the Schwarz criterion for the optimal lag length. It has already been noted that by using more lag lengths, more cointegration can be found. Cushman, Lee and Thorgeirsson (1996) mention in their paper that with more lag lengths, the number of parameters estimated would be quite large, and the resulting estimates would become less reliable. This warning is of less importance in the present case, where the focus is not so much on the absolute number of vectors for a group of countries but on the number of additional vectors found when adding one country to that group. Therefore, an experiment is performed by redoing the above analysis where the only difference is that a fixed lag length of four is used. Table 3 gives the additional number of cointegration vectors found.

From Table 3 it is clear that these additional lag lengths changes the results. Every country except Hungary shows more cointegration than in Table 2. The difference between the C1Cs and the C2Cs remains. Again, except for Hungary, all the C1Cs have more cointegration relations with the EMU countries than the C2Cs.

Hence, on the basis of the cointegration analysis indicates my provisional conclusion as to the criterion of inflation is that these four C1Cs are on their way to convergence. The inflation rates of the C2Cs are not yet converging sufficiently.

Table 3 Cointegration test results for inflation, using four lag lengths

Country	Extra cointegration
C1C	
Czech Republic	2
Hungary	1
Latvia	2
Poland	2
Slovak Republic	2
Slovenia	3
C2C	
Bulgaria	1
Romania	1

4.2 **Exchange rate stability**

Table 4 shows the results of the ADF unit root tests for this Maastricht criterion. Again the optimal lag lengths are found by using the Akaike's criterion. As can be seen from the table, the test for Lithuania is the only one that rejects a unit root. The reason for this is the data set; it shows a 100 percent steady exchange rate with the US dollar from April 1994 until September 2001. For this reason Lithuania is left out from the cointegration tests.

Table 4 Augmented Dickey-Fuller (ADF) test results for the exchange rate

Country	Sample period	ADF	Significance	Critical value a)
Germany	September 1988-September 2001	-0.91	10%	-2.58
Slovenia	January 1993-September 2001	-1.44	10%	-2.58
Slovak republic	January 1993-September 2001	0.14	10%	-2.58
Romania	September 1988-September 2001	-1.33	10%	-2.58
Poland	January 1993-September 2001	-2.76	5%	-2.89
Lithuania	January 1993-September 2001	-37.64	1%	-3.50
Latvia	January 1993-September 2001	-1.76	10%	-2.58
Hungary	September 1988-September 2001	-0.76	10%	-2.58
Estonia	January 1993-September 2001	-0.50	10%	-2.58
Czech Republic	January 1993-September 2001	-1.00	10%	-2.58
Bulgaria	January 1991-September 2001	-1.30	10%	-2.58

a) MacKinnon critical values for rejection of hypothesis of a unit root. If ADF > critical value then the null hypothesis of a unit root can not be rejected.
Note: 'Significance' denotes the highest among the significance levels of 1, 5 or 10 percent, for which the test does not reject the null hypothesis.

The ADF unit root tests on the first differences are applied to all the time series that have a unit root. For all these series the null hypothesis of a unit root is rejected at the 5 per cent level. Therefore it can be concluded that all these time series are I(1), and hence usable for the Johansen cointegration test.

A Schwarz information test on the residuals of the VAR results on Germany and all the CEECs separately (except for Lithuania) yields the optimal lag length, which is used for the cointegration test. The results are given in Table 5.

Among the seven C1Cs considered only the tests for the Czech Republic and the Slovak Republic reject any cointegration with Germany. This means that for this criterion most of the C1Cs do cointegrate with Germany.

For the two C2Cs considered the test for Bulgaria rejects any cointegration with Germany, while the test for Romania does not reject the null hypothesis of a cointegration vector with Germany. In this respect the sudden devaluation of the Bulgarian exchange rate in the beginning of 1997 can be mentioned as one possible factor explaining this outcome.

Table 5 Cointegration test results for the exchange rate

Number of cointegration vectors	Trace Statistic	5% critical value a)	Trace Statistic	5% critical value a)	Trace Statistic	5% critical value a)
1988-2001	Germany + Romania		Germany + Hungary			
None	26.60	19.96	37.31	19.96		
At most 1	4.68	9.24	5.67	9.24		
1991-2001	Gemany + Bulgaria					
None	15.44	19.96				
At most 1	5.12	9.24				
1993-2001	Germany + Slovenia		Gemany + Slovak rep.		Germany + Poland	
None	25.09	19.96	11.21	19.96	21.83	19.96
At most 1	2.28	9.24	3.05	9.24	3.43	9.24
1993-2001	Germany + Latvia		Gemany + Estonia		Germany + Czech rep.	
None	49.59	19.96	40.68	19.96	10.62	19.96
At most 1	1.08	9.24	1.15	9.24	1.27	9.24

a) 5 percent critical value of Osterwald-Lenum (1992). If Trace Statistic > critical value then the null hypothesis as concerns the number of cointegration vectors is rejected.

Hence, the cointegration tests indicate that, roughly speaking, the C1Cs are more ready to fulfil the exchange rate criterion than the C2Cs. As concerns the C2Cs, the cointegration tests indicate convergence for Romania only, not for Bulgaria.

4.3 **Low interest rate**

In Table 6 the results of the ADF unit root tests for the interest rate time series are shown [16]. For none of the EMU countries the null hypothesis of a unit root in the interest rate series is rejected. Hence, the cointegration tests can be done with all eight EMU countries.

Table 6 Augmented Dickey Fuller test results for the interest rate

Country	Sample period	ADF	Significance	Critical value a)
Spain	September 1988-December 2000	-0.41	10%	-2.57
Portugal	September 1988-December 2000	0.42	10%	-2.57
Netherlands	September 1988-December 2000	-0.74	10%	-2.57
Italy	September 1988-December 2000	-0.99	10%	-2.57
Greece	September 1988-December 2000	0.42	10%	-2.57
Germany	September 1988-December 2000	-2.35	10%	-2.57
France	September 1988-December 2000	-0.78	10%	-2.57
Belgium	September 1988-December 2000	-1.12	10%	-2.57
Slovenia	January 1992-December 2000	-2.13	10%	-2.58
Slovak Republic	January 1993-December 2000	-1.72	10%	-2.58
Poland	January 1992-December 2000	-1.33	10%	-2.58
Lithuania	January 1993-December 2000	-4.48	1%	-3.51
Latvia	September 1993-December 2000	-4.36	1%	-3.52
Hungary	September 1988-December 2000	-1.67	10%	-2.58
Estonia	January 1993-December 2000	-2.91	1%	-3.50
Czech Republic	January 1993-December 2000	-0.12	10%	-2.58
Bulgaria	January 1991-December 2000	-2.68	5%	-2.89

a) MacKinnon critical values for rejection of hypothesis of a unit root. If ADF > critical value then the null hypothesis of a unit root can not be rejected.
Note: 'Significance' denotes the highest among the significance levels of 1, 5 or 10 percent, for which the test does not reject the null hypothesis.

As concerns the CEECs, the tests for Lithuania and Latvia reject the null hypothesis of a unit root at the 1 percent level. The test for Latvia also rejects the null hypothesis when tested with a trend. Lithuania's test does not reject the null hypothesis when tested with a trend. The tests for both countries do not reject the null hypothesis when tested without a trend and for a shorter period, for

[16] For Romania there is not sufficient data available. Therefore it is completely left out of the cointegration analysis for this criterion.

example from 1996 onwards. This period is however too short to test for cointegration. Therefore these two countries are not included in the cointegration tests.

Again, before starting with the cointegration tests, the optimal lag lengths are determined by minimising the Schwarz information criterion for the VAR regressions. The results of the cointegration tests are presented in Table 7.

The left side of Table 7 displays cointegration for the EMU members. These results are more convincing than other studies. Hafar and Kutan (1994) only find partial convergence between Belgium, France, Germany, Italy and the Netherlands for the short-term interest rates. Haug, MacKinnon and Michelis (2000) find no cointegration among the EU members for the long-term interest rate.

Table 7 Cointegration test results for the interest rate

Number of cointegration vectors	Trace Statistic	% critical value a)	Trace Statistic	5% critical value a)	Trace Statistic	5% critical value a)	Trace Statistic	5% critical value a)
1988-2000	*EMU*		*EMU + Hungary*					
At most 2	106.78	102.14						
At most 3	72.60	76.07	103.32	102.14				
At most 4			71.27	76.07				
1991-2000	*EMU*		*EMU + Bulgaria*					
At most 1	139.17	131.70	167.79	165.58				
At most 2	90.71	102.14	115.65	131.70				
1992-2000	*EMU*		*EMU + Poland*		*EMU + Slovenia*			
At most 1	152.52	131.70	178.49	165.58				
At most 2	99.75	102.14	123.62	131.70				
At most 3					178.49	165.58		
At most 4					123.62	131.70		
1993-2000	*EMU*		*EMU + Czech rep*		*EMU + Slovak rep*		*EMU + Estonia*	
At most 2	103.32	102.14						
At most 3	72.77	76.07	105.64	102.14				
At most 4			75.10	76.07	78.47	76.07	76.93	76.07
At most 5					49.21	53.12	47.21	53.12

a) 5 percent critical value of Osterwald-Lenum (1992). If Trace Statistic > critical value then the null hypothesis as concerns the number of cointegration vectors is rejected.

Again, by including extra lag lengths in the cointegration tests, the method finds more cointegration vectors among the EMU countries (not reported). For example in the period 1988-2000 one lag length is used (Schwarz optimal) and three cointegration vectors are found. If four lag lengths are used

instead, eight cointegration vectors are found. But, as argued before, the latter test is less reliable as it uses less information.

Table 7 further shows the extra cointegration is found when one CEEC is added:

- Hungary yields one extra cointegration vector when it is added to the group of EMU members.
- Extra tests suggest that Hungary is especially cointegrated with Portugal and secondly, with France.
- The adding of Bulgaria does not yield any extra cointegration.
- For Poland no extra cointegration is found either.
- Slovenia yields two extra cointegration vectors.
- The Czech Republic shows one extra cointegration vector with the eight EMU countries.
- Estonia and the Slovak Republic both show two extra cointegrating vectors with the eight EMU countries.

According to the Schwarz criterion, as was the case in section 4.1 as well, a small number of lag lengths should be used, mostly one. The question again is whether significantly more cointegration is found when adding extra lag lengths. Table 8 shows the results of the cointegration tests for the same periods as in Table 7, only now with four lag lengths.
In general the results change: all the C1Cs show extra cointegration, including Poland. For Bulgaria, Hungary and the Czech Republic nothing changes. Estonia and the Slovak Republic show one

Table 8 Cointegration test results for the interest rate, using four lag lengths

Country	Extra cointegration
C1Cs	
Czech Republic	2
Estonia	1
Hungary	1
Poland	1
Slovak Republic	1
Slovenia	1
C2Cs	
Bulgaria	0

remains visible. Bulgaria does not show any cointegration, irrespective of the numbers of lag lengths used. The C1Cs all show cointegration in both cases, except for Poland that does not show any cointegration when only one lag length is used.

4.4 **Summing up for separate countries**

The analysis presented suggests that there is a clear difference between the C1Cs and the C2Cs (Romania and Bulgaria) considered here, in the sense that the latter group has not yet converged sufficiently to EMU standards. The cointegration analysis shows that Romania is converging only with respect to the exchange rate stability criterion, while Bulgaria does not show any convergence at all. On the other hand, most of the C1Cs show cointegration with respect to more than one criterion. Table 9 summarises the already discussed results concerning the number of extra cointegration vectors found for the three used criteria.

On the basis of earlier sections of this Section and the observations in Section 2, I give a summary of the main conclusions separately for the CEE countries below:

Table 9 Number of extra cointegration vectors over the Maastricht criteria

	Inflation	Exchange	Interest
Slovenia	0	1	2
Slovak Rep.	-1	0	2
Poland	1	1	0
Lithuania	n.a.	n.a.	n.a.
Latvia	0	1	n.a.
Hungary	1	1	1
Estonia	n.a.	1	2
Czech Rep.	0	0	1
Romania	0	1	n.a.
Bulgaria	0	0	0

Note: 'n.a.' means a cointegration test is not available. The reason is that the ADF tests for those countries reject the null hypothesis of a unit root and therefore these countries are left out of the sample. For the Romanian interest rate the test was not executed due to the lack of data.

Slovenia cointegrates with the EMU countries for both the exchange rate criterion and the interest rate criterion. This confirms Section 2, which documented positive developments for these two criteria as well. However, with inflation being around five percent above the criterion since 1999, the price stability criterion still asks for extra effort.

The *Slovak Republic* shows two cointegration vectors with EMU for the interest rate criterion. With the other criteria it does not cointegrate at all. The first cointegration test for the inflation criterion even indicates negative cointegration, which is very unusual. In Section 2 it was documented that

Slovakian inflation is volatile and not low enough yet. The Slovak Republic should take care of its exchange rates as well. The Slovak koruna devaluates faster than the euro since 1999.

Poland cointegrates with both the inflation and the exchange rate criterion. In Section 2 positive results for these two criteria were also mentioned. However the interest rate in Poland is high and not diminishing. Hence, extra effort is needed to meet this criterion.

Lithuania is completely left out of the cointegration tests, because the unit root tests reject the null hypothesis for every criterion. However, as mentioned in Section 2 this country appears to do better than the other CEE countries for the inflation and the interest rate criteria respectively. Unfortunately the data on its exchange rate are unreliable, which makes it impossible to draw any conclusions for that criterion.

Latvia only cointegrates with the exchange rate criterion. Latvia has for the inflation rate criterion two cointegration vectors with the EMU in the second cointegration test. As the interest rate for Latvia is stationary there are no cointegration test results. However, in Section 2 we saw that the interest rate is close to the criterion since mid-1999.

Hungary shows cointegration with the EMU for all the criteria. In Section 2 it was observed that Hungary is converging steadily to the criteria.

Estonia shows cointegration with the EMU with respect to the exchange rate criterion and the interest rate criterion. In Section 2 it was observed that Estonia is already fulfilling the interest rate criterion. The test on a unit root for the inflation rate criterion for Estonia rejects the null hypothesis and is therefore left out of the cointegration test. However, in Section 2 this country appeared to be close to meeting the inflation criterion; it was even below the limit for some periods.

The *Czech Republic* only cointegrates with the interest rate criterion. In Section 2 it was mentioned that its interest rate is under the criterion since 1999. In addition the Czech Republic was close to meeting the inflation criterion since 1999. It was fluctuating heavily before, which might explain why it does not show any cointegration.

Bulgaria does not show any cointegration at all. Its inflation is fluctuating heavily. The interest rate almost reached a level of 300 percent in 1996 and 1997.

Romania appears to be cointegrated with the EMU only by its exchange rate. Its inflation rate is still too high. With inflation reaching over 300 percent in 1993 and still over 175 percent in 1997 it is not close to meeting the criterion. It shows a steady downward trend though. For the interest rates data was lacking so nothing can be said about this criterion.

From all this the general conclusion emerges that the C1Cs, according to the analysis on these criteria, are well underway to convergence towards the EMU. For the C2Cs convergence seems to be lagging.

5 SUMMARY AND CONCLUSIONS

In this report I investigate whether the Central and Eastern European Countries (CEECs) are converging towards the EMU. The focus is on the analysis of the co-movements in key economic variables between these countries and a sample of EMU member countries. Haug (2001) argues that co-movement of economies is necessary (although not sufficient) for a monetary union. In this report co-movement with the current EMU members is taken as the measure of readiness for EMU. The Johansen cointegration test is applied to assess whether the CEECs co-move with the EMU countries.

The group of CEECs has been split into two groups, the C1Cs, which are expected to enter the EU in 2004, and the C2Cs, which are expected to enter a few years later. After joining the EU, some of the Maastricht criteria need to be met for at least two years before subsequent accession to EMU is allowed. This means that the earliest possible entry time will be the end of 2006 or more reasonably the beginning of 2007. The analysis suggests that the first group is much closer to meeting the Maastricht criteria than the second group. Therefore, this first group is closer to the EMU.

The largest part of the C1C group seems, according to these criteria, converging at a steady pace. A few countries need some extra efforts with respect to one or two criteria, however.

The C2C group, consisting of Bulgaria and Romania, are lagging behind. However, they show a positive development during recent years. Hence it would be interesting to do the same research in two or three years time to see if there is any progress.

Among the four Maastricht criteria the sustainable fiscal position had to be left out of the cointegration analysis because of lacking data. However, most of the CEE countries already seem to meet the criterion, although Halpern and Nemenyi (2002) underline that one should be very careful drawing conclusions from the deficits calculated in the CEECs.

One caveat seems in place. Cointegration tests need long time series, but the convergence of the CEE economies to the reference values appear to have started only recently. Maybe this convergence has been too recent to be detected by the cointegration analysis.

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