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# The Dynamics of Central European Equity Market Integration

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## Abstract

This paper examines bilateral and multilateral cointegration properties of the German stock market and those of the three major Central European countries which recently attained membership in the European Union. Cointegration tests cover the time period of July 6, 1995 to February 10, 2005. Additional techniques are also applied to provide further information concerning the dynamic evolution of the integration process during this period. Application of the Johansen (1988) cointegration procedure indicates that, contrary to results for an earlier time period there is evidence of an emerging long-term relationship between the German and UK markets and the Czech market, as well as cointegration within the group of Central European markets. We also apply the Haldane and Hall convergence analysis, in an effort to determine the extent to which these markets are converging to London or Frankfurt. Overall, the results suggest that the process of integration of the Central European countries into the EU is leading to a closer integration of their equity markets with those of major EU countries.

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# The Dynamics of Central European Equity Market Integration

## 1. Introduction

The hypothesis of economic and financial market integration of developed and emerging countries has been investigated in a number of studies, including Bodurtha *et al.* (1989), Roll (1992), Kasa (1992), Campbell and Hamao (1992), Arshanapalli and Doukas (1993), Bachman *et al.* (1996), Tsetsekos (1997), Kanas (1998), and Bracker and Koch (1999). Most of these studies have concentrated on major US and European stock markets and on emerging markets of Asia and Latin America. While the evidence generally shows that developed equity markets are becoming increasingly integrated across national borders, mixed results have been obtained on financial integration between emerging markets as well as between emerging and developed markets. Surprisingly little attention has been directed toward the question of financial integration between developed and transition economies in Central and Eastern Europe.

The transition economies of Central Europe (CE) represent a unique opportunity to study this important issue because of their rapid and successful transformation from communist to market economies since 1989. Within this region the Czech Republic, Hungary, and Poland have made the greatest progress to date in terms of liberalization of prices, trade, and capital flows. Furthermore, these three countries have developed strong economic ties with Western Europe and have been coordinating their policies with the European Union (EU) for a number of years, providing additional reasons to anticipate that there could be long-term links between their newly reestablished equity markets and those of Western Europe. Several economic relationships leading to the hypothesis of integration between these equity markets are related to trade, exchange rates, and deliberate policy coordination as the Central European countries endeavor to attain full membership in the EU.

A major reorientation in trading of physical goods has occurred in the Czech Republic, Hungary, and Poland since 1989. The percentage of trading of goods between them has fallen and stabilized at less than ten percent of their exports. However, trading with the European Union, particularly Germany, has grown substantially in the 1990s. More specifically, all three CE countries export about seventy percent

of their products to the EU, the majority of it being directed toward Germany. The United Kingdom is less prominent as a trading partner. In addition, cross-border financial transactions with Western Europe, such as foreign direct investment and capital flows, have become sizeable due to liberalizing reforms, privatization, and deregulation. These capital transactions have helped shape the development of the CE stock markets as a source of external financing for firms, in addition to the banking sector, with German banks being the largest creditors. These countries have, to varying degrees, tied their exchange rates to the euro, which may increase the importance of common underlying factors influencing the degree of comovement between their equity markets, as well as with the German market.

Beyond the spontaneous growth of trade and financial ties, the Central European countries have pursued a deliberate policy of integrating their economic systems with the EU. Shortly after the breakup of the communist system in Central Europe in 1989, technical and financial assistance was provided by the EU under the Phare program, initially to just Hungary and Poland. A number of Central European countries signed agreements with the EU in the early 1990s. At its Copenhagen Summit in June 1993 the EU Council provided entry criteria for transition countries wishing to join the EU. During 1994-95, the Czech Republic, Hungary, and Poland became EU associate members. Accession negotiations began in 1998 and were concluded in December 2002 at the Copenhagen European Council meeting. Referenda were held in Hungary on April 12, 2003, in Poland on June 8, 2003, and in the Czech Republic on June 15-16, 2003 to approve accession. On May 1, 2004, they finally became members of the EU and the European Monetary Union (EMU), with each country's adoption of the euro to be accomplished at a later date.

Gilmore and McManus, in 2003, were the first to search for evidence of long-term links of the equity markets of the Czech Republic, Hungary, and Poland with the German market during the years 1995 through early 2002. They found a lack of cointegration for that time period. However, now that the process of accession of these Central European countries to the EU has been completed, the cointegration question can be revisited with updated data. In this paper we find a significant change in the long-term relationship of the German equity market with those of Central Europe. We find evidence of cointegration between the Czech and the German equity markets, as well as between the Central European countries themselves. We also investigate the question of cointegration between the UK stock

market and the Central European markets to shed some light on whether policy convergence of the Central European countries with the EU is also a contributing factor to this nascent development. Our findings indicate a developing cointegration involving the Czech market with the UK market. In addition, we apply newly developed dynamic cointegration techniques, which provide additional insight about changes in market integration over time.

The rest of this paper is organized as follows. Section 2 explains the methodology being used, while the data are described in Section 3. Section 4 presents the empirical results, and Section 5 contains the concluding remarks.

## **2. Methodology**

This study uses three approaches. The first is the well known methodology of cointegration analysis to test the presence of long-run relationships between the German and the major Central European equity markets. We also use the Haldane and Hall (1992) convergence analysis. Finally, we examine the eigenvalues of the data. Details of the methodologies applied are discussed in the appendix.

Cointegration tests allow us to determine whether stock prices of different national markets move together over the long run, while providing for the possibility of short-run divergence. The first step in the analysis is to test each index series for the presence of unit roots, which would show whether the series are nonstationary. Nonstationarity is a precondition for cointegration; additionally, all the series must be integrated of the same order. The Augmented Dickey-Fuller (ADF) test, an extension of the Dickey and Fuller (1979) method, is used. However this test assumes that the errors are statistically independent and have a constant variance. To circumvent these limiting assumptions, Phillips and Perron (1988) developed a generalization of the Dickey-Fuller test, which is also applied here.

Once the nonstationarity requirements are met, we can use the Johansen (1988) procedure to determine whether the time series are cointegrated. This test determines the rank of the coefficient matrix of a vector autoregression (VAR) of the series, with the rank indicating whether there is cointegration, as

well as the number of cointegrating relationships. Further, several techniques, including the dynamic Haldane-Hall Kalman filter method, can be used to assess how the nature and extent of integration change over time. These techniques may also shed some light on the relative rates of convergence of the Central European equity markets to the German and UK equity markets.

Complementary to cointegration analysis which inquires after comovements in the levels of the equity market indices, an eigenvalue analysis inquires after comovements in their returns. Thus an eigenvalue analysis serves to complement the previous analysis by capturing interdependencies of a relatively short-term nature. Essentially, it is a means of extracting the most important uncorrelated sources of information in a multivariate system. Components thus extracted are constructed in such a manner that the explanatory power of the incremental component is maximized given the restriction of orthogonality. This collapses to an inquiry into the eigenvalues and vectors of the data matrix. In this context eigenvalues may be understood as the unconditional variances of the projections of points on each of the components. Eigenvectors are the direction cosines: how far the original variable space is to be rotated.

### **3. Data**

The data consist of MSCI daily closing price indices for the Czech, Hungarian, Polish, German and UK stock markets, for the time period covering July 6, 1995, through February 10, 2005. Relevant descriptive statistics are provided in Table 1. Both mean returns and standard deviations for the three Central European markets are higher than for the German or UK markets. As expected, all the series are generally negatively skewed and leptokurtic. Table 2 reports the correlation coefficients between the various indices. Although not shown here, calculations of correlation coefficients over sub periods indicate an increase in recent years.

### **4. Results**

#### *4.1. Multivariate Cointegration*

Determining that the level series are integrated of the same order is a precondition for application

of a cointegration test. Appropriate lag lengths for the ADF and PP tests were selected according to the Akaike information criterion (AIC); the Box-Ljung Q test on residuals showed a lack of serial correlation in each case. F tests and t tests were also used to determine lag lengths and produced somewhat longer lag structures, but the qualitative results of the unit root tests were unchanged. Both the ADF and PP tests were applied to the levels and first differences of each series. The results using the AIC criterion are presented in Table 3. For the level series Table 3 shows that the null hypothesis of a unit root cannot be rejected at the 5 percent significance level. The first-differenced series reject the null hypothesis, indicating that they are stationary. Consequently, all five series are integrated I(1).

The Johansen (1988) procedure was then applied to determine whether any of the three Central European equity markets are pairwise cointegrated with the German or UK equity market and whether these three Central European equity markets as a group are cointegrated with the German or UK equity market. Lag structures were chosen according to the Schwarz-Bayes criterion (SBC). As can be seen from Table 4, we find evidence of bilateral cointegration of the Czech market with that of Germany and the UK, but none involving Hungary or Poland. In the multilateral context of the Central European markets as a group, with either Germany or the UK, results in Table 5 indicate a long-term relationship with one cointegrating vector. Results of dynamic tests on the long-term relationships will be included in the next draft of the paper.

#### 4.2. *Recursive Cointegration*

Hansen and Johansen (1992) provide a method to analyze not only the extent but also the dynamics of integration. The recursive cointegration approach in essence runs a JJ analysis for an initial period, and thereafter updates as new data are added. It derives the statistic of interest over the chosen period  $t_0$  to  $t_n$ . This period is then extended by  $j$  and the statistic is re-estimated from  $t_0$  to  $t_{n+j}$ . Eventually, the estimation procedure reaches the end of the data (equivalent to the standard static JJ estimation over all time periods). The relevant statistic is then plotted. The interpretation proceeds by examination of the plotted statistic. An upward trend indicates either increased integration and/or a move towards integration; a downward trend indicates decreased integration and/or a move away from



integration. We update on a daily basis. It is typical, for presentation purposes, to rescale the calculated lambda trace statistic to a critical value, usually 90% or 95%. The interpretation then of rescaled values above 1 is of cointegration, below, not.

Shown in **Figure 1** is the evolution of the Lambda Trace statistic for two multivariate representations, one system consisting of the CEE countries and Germany, the other the CEE countries and the UK. It is immediately obvious that, while overall there is evidence, as we have seen, in both systems of cointegration, there are significant periods of time when the normalized trace statistic is less than the 90% critical value (below 1 in the graph) and so a conclusion of cointegration at all periods would be inappropriate. The results are entirely consistent with the previous findings of Gilmore and McManus (2003). It is evident that examination of the data to a period ending in 2002 would clearly result in a finding of no cointegration. What is clear however is that the accession to the European Union, from mid 2004, has been associated with a dramatic increase in the lambda trace statistic, with both systems now showing consistent evidence in favour of cointegration.

#### 4.3. *Haldane and Hall*

The Haldane and Hall (1991) Kalman Filter based methodology <sup>1</sup> (hereafter HH) estimates a simple equation of the following specification. Both the  $\alpha$  and  $\beta$  parameters evolve stochastically.

$$\ln\left(\frac{\mathbf{E}_{jt}}{\mathbf{E}_{Bt}}\right) = \alpha + \beta_t \ln\left(\frac{\mathbf{E}_{jt}}{\mathbf{E}_{Xt}}\right) + \varepsilon_{jt} \quad (1)$$

via kalman filter estimation. Here the market subscripted  $B$  is the preimposed internal base market and that subscripted  $X$  is the preimposed external market. Thus, for example, in testing for integration among SE Asian markets, Manning (2002) imposes the US market as the external market (to which the SE Asian

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<sup>1</sup> Manning (2002) examines Asian stock market integration taking the Haldane and Hall (1991) approach of specifying time varying coefficients via a Kalman filter. Most papers using this time varying approach have examined currency or interest rate relationships (e.g., Zhou (2003)).

markets are assumed to be converging) and Hong Kong as the dominant local market. Negative values of  $\beta_i$  indicate divergence, as does a tendency to move further from zero. We examine convergence to both potential dominant markets – Frankfurt and London.

Show in Figure 2 are the results for the three CEE countries. By contrast to the cointegration estimation, the Haldane and Hall approach indicates that the extent of convergence (the closer the series are to zero) was substantially completed by the turn of the millennium. This finding of earlier integration of markets when considering the Haldane and Hall approach is also found in Aggarwal, Lucey and Muckley (2004) and in Kim, Lucey and Wu (2005).

#### *4.4. Eigenvalue analysis*

Shown in Figure 3 are two recursive eigenvalue analyses. In each case the eigenvalue is estimated over the first 250 observations, and recursively with the addition of each daily observation thereafter. We note that over the period of analysis we find that the first eigenvalue explains approximately 50 of the variation in the variance of the series. This is independent of whether we examine the system including the UK or Germany. A number of major changes are evident however. The first corresponds to the period of the Asian and Russian crises, where the CEE countries move much more closely to the developed markets. The second corresponds to the period moving towards the finalization of monetary union. It is interesting here to note that the correspondence with Germany falls more rapidly and to a lower level than that of the UK, perhaps reflecting market perceptions of the emergent difficulties Germany would develop as part of monetary union with the inflation anchor of the Deutsches Bundesbank removed. The final period reflects the timing around the referenda on accession, and it is noticeable that a rapid reassessment and convergence towards the developed markets is evident after this period of political uncertainty.

## **5. Conclusion**

This paper has reexamined bilateral and multilateral cointegration properties of the Czech, Hungarian, and Polish equity markets with respect to the German and UK markets. In contrast to earlier results reported by Gilmore and McManus (2003) we find evidence of a greater degree of integration

between these equity markets by extending the time frame to include the final stages of accession to the EU. This increased integration is demonstrated across a variety of methods.

There are several factors which may explain these interesting results. First, greatly increased trade ties are likely to have contributed to growing integration with Germany. However, that appears not to be the only factor involved, since we find similar evidence of integration with the UK market, even though the UK is not a leading trade partner for the Central European countries. Rather, the process of alignment with the economic, financial, and legal framework of the EU, in which both Germany and the UK are important members, is a likely contributing factor. In the future, further policy developments related to adoption of the euro by the three Central European countries are likely to result in increasing integration of their equity markets, at least with respect to Germany.

## Appendix

This appendix presents some of details of cointegration and the Kalman Filter approach used . If there are two variables,  $x_t$  and  $y_t$ , which are both nonstationary in levels but stationary in first differences, then  $x_t$  and  $y_t$  are integrated of order one,  $I(1)$ , and their linear combination having the form

$$z_t = x_t - ay_t \tag{i.}$$

is generally also  $I(1)$ . However, if there is an (a) such that  $z_t$  is integrated of order zero,  $I(0)$ , the linear combination of  $x_t$  and  $y_t$  is stationary and the two variables are said to be cointegrated (see Engle and Granger, 1987). If two variables are cointegrated, there is an underlying long-run relationship between them. In the short run the series may drift apart, but if they are cointegrated, they will move toward long-run equilibrium through an error-correction mechanism.

To test for nonstationarity properties the ADF test uses a regression of the first differences of the series against the series lagged once, and lagged difference terms, with optional constant and time trend terms:

$$\Delta y_t = a_0 + a_1 t + \gamma y_{t-1} + \sum b_i y_{t-i+1} + e_t \tag{ii.}$$

$\Delta$  is the first difference operator,  $a_0$  is an intercept,  $a_1 t$  is a linear time trend,  $e_t$  is an error term, and  $i$  is the number of lagged first-differenced terms such that  $e_t$  is white noise. The null hypothesis is that  $\gamma = 0$ . If the coefficient is significantly different from zero, the hypothesis that  $y_t$  contains a unit root is rejected. If the test on the level series fails to reject, the ADF procedure is then applied to the first-differences. Rejection leads to the conclusion that the series is integrated of order one,  $I(1)$ . In 1988, Phillips and Perron (PP) generalized the ADF test:

$$y_t = b_0 + b_1 y_{t-1} + b_2 (t - T/2) + \mu_t \tag{iii.}$$

$T$  is the number of observations and the disturbance term  $\mu_t$  is such that  $E(\mu_t) = 0$ , but there is no requirement that the disturbance term is serially uncorrelated or homogeneous. The equation is estimated by ordinary least squares and the t-statistic of the  $b_1$  coefficient is corrected for serial correlation in  $\mu_t$  using the Newey-West (1987) procedure for adjusting the standard error. The Johansen (1988) cointegration test relies on the relationship between the rank of a matrix and its characteristic roots, or eigenvalues. Let  $X_t$  be a vector of  $n$  time series variables, each of which is integrated of order (1) and assume that  $X_t$  can be modeled by a vector autoregression (VAR):

$$X_t = A_1 X_{t-1} + \dots + A_p X_{t-p} + \varepsilon_t \tag{iv.}$$

Rewrite the VAR as

$$\Delta x_t = \Pi x_{t-1} + \Sigma \Gamma \Delta x_{t-1} + \varepsilon_t \tag{v.}$$

where  $\Pi = \Sigma A_i - I$ ,  $\Gamma_i = -\Sigma A_i$ . If the coefficient matrix  $\Pi$  has reduced rank  $r < k$ , there exist  $k \times r$  matrices  $\alpha$  and  $\beta$  each with rank  $r$  such that  $\Pi = \alpha\beta'$  and  $\beta' x_t$  is stationary. The number of cointegrating relations is given by  $r$ , and each column of  $\beta$  is a cointegrating vector. Three cases are possible. First, if  $\Pi$  is of full rank, all elements of  $X$  are stationary, and none of the series has a unit root. Second, if the rank of  $\Pi = 0$ , there are no combinations which are stationary and there are no cointegrating vectors. Third, if the rank of  $\Pi$  is  $r$  such that  $0 < r < k$ , then the  $X$  variables are cointegrated and there exist  $r$  cointegrating vectors. Equation (5) can be modified to allow for an intercept and a linear trend.

The number of distinct cointegrating vectors can be obtained by determining the significance of the characteristic roots of  $\Pi$ . To identify the number of characteristic roots that are not different from unity we use two statistics, the trace test and the maximum eigenvalue test:

$$\lambda_{\text{trace}}(r) = -T \sum \ln(1 - \lambda_i) \tag{vi.}$$

$$\lambda_{\text{max}}(r, r+1) = -T \ln(1 - \lambda_{r+1}) \tag{vii.}$$

where  $\lambda_i$  = the estimated values of the characteristic roots (eigenvalues) obtained from the estimated  $\Pi$  matrix,  $r$  is the number of cointegrating vectors, and  $T$  = the number of usable observations. The trace test evaluates the null hypothesis that the number of distinct cointegrating vectors is  $\leq r$  against a general alternative. The maximum eigenvalue test examines the number of cointegrating vectors versus that number plus one. If the variables in  $X_t$  are not cointegrated, the rank of  $\Pi$  is zero and all the characteristic roots are zero. Since  $\ln(1) = 0$ , each of the expressions  $\ln(1 - \lambda_i)$  will equal zero in that case.

The Kalman filter used in this paper works in the following way. The equation is estimated over an initial period, 100 days in this case, to initialize the coefficients and related information. Thereafter it is updated with the addition

of each daily data point. Let

$$Y_t = \alpha_t + X_t \beta_t + \varepsilon_t, \text{var}(\varepsilon_t) = \eta_t \quad \text{viii.}$$

be the measurement equation of interest. If we set  $\beta_t$  as the coefficient of interest at time t, then the transition equation is given by  $\beta_t = \beta_{t-1} + \nu_t$ ,  $\text{var}(\nu_t) = M_t$ . Given the estimate of  $\beta_{t-1}$  from information up to that period ( $\beta_{t-1|t-1}$ ) with the associated covariance matrix  $\Sigma_{t-1}$ , the updated estimate is given by

$$S_t = \Sigma_{t-1} + M_t \quad \text{ix.}$$

$$\Sigma_t = S_t - S_t X_t' (X_t S_t X_t' + \eta_t)^{-1} X_t S_t \quad \text{x.}$$

$$\beta_{t|t} = \beta_{t-1|t-1} + S_t X_t' (X_t S_t X_t' + \eta_t)^{-1} (Y_t - \alpha_{t-1} X_t \beta_{t-1|t-1}) \quad \text{xi.}$$

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**Table 1**  
**Statistical Properties of Daily Stock Market Returns**

Statistic	Country					
	Czech. Republic		Hungary	Poland	Germany	United Kingdom
N	2423	2423	2423	2423	2423	
Mean	0.0006	0.0009	0.0002	0.0002	0.0002	
Median	0.0009	0.0010	0.0003	0.0006	0.0003	
Maximum	0.0676	0.1300	0.0902	0.0689	0.0526	
Minimum	-0.0795		-0.1901		-0.1159	-0.00684
Standard deviation	0.0156	0.0199	0.0193	0.0152	0.0110	
Skewness	-0.2162		-0.5795		-0.2408	-0.1239
Kurtosis	5.0960	12.7117	5.7650	5.0765	5.0201	
Jarque-Bera	462.3939	657.7179	5.2704	441.4964	18.478	
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	

Descriptive statistics are calculated using the MSCI indices for all 5 countries from July 6, 1995 to February 10, 2005.



**Table 2**  
**Correlation Coefficients of Daily Stock Market Returns**

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Market	Czech Republic	Hungary	Poland	Germany	United Kingdom
Czech Republic	1.0000	0.3599	0.3536	0.3274	0.2989
Hungary	0.3599	1.0000	0.4292	0.3557	0.3183
Poland	0.3536	0.4292	1.0000	0.3234	0.2907
Germany	0.3274	0.3557	0.3234	1.0000	0.6596
United Kingdom	0.2989	0.3183	0.2907	0.6596	1.0000

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Correlations are calculated using the MSCI indices for all 5 countries from July 6, 1995 to February 10, 2005.

**Table 3**  
**Unit Root Tests for Daily Stock Market Indices**

Country Index	Index Level		First Differences	
	ADF	PP	ADF	PP
Czech Republic (2)	4.136	0.982	-34.360*	-11.889*
Hungary (2)	0.552	0.774	-11.838*	-11.664*
Poland (2)	0.368	0.368	-12.836*	-12.889*
Germany (2)	-0.420	-0.391	-14.744*	-14.759*
United Kingdom (2)	0.176	0.286	-15.156*	-15.146*

Unit root tests are conducted using the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests. Lag lengths, in parentheses, were chosen according to the Akaike information criterion (AIC). The critical values are based on MacKinnon (1996); an asterisk indicates significant at the 5 percent level.

**Table 4**  
**Bilateral Johansen Cointegration Test Results**

Panel A: German and Central European Stock Markets					
Hypotheses		5 percent	Germany-	Germany-	Germany-
H <sub>0</sub>	H <sub>a</sub>	Critical	Czech Rep.	Hungary	Poland
		Values	(1)	(1)	(1)
Maximum Eigenvalue Test					
r=0	r=1	15.892	21.340*	13.630	4.851
r≤1	r=2	9.165	2.865	1.242	3.525
Conclusion			r=1	r=0	r=0
Trace Test					
r=0	r≥1	20.262	24.264*	14.873	8.376
r≤1	r≥2	9.165	2.865	1.242	3.525
Conclusion			r=1	r=0	r=0
Panel B: UK and Central European Stock Markets					
Hypotheses		5 percent	UK-	UK-	UK-
H <sub>0</sub>	H <sub>a</sub>	Critical	Czech Rep.	Hungary	Poland
		Values	(1)	(1)	(1)
Maximum Eigenvalue Test					
r=0	r=1	15.892	20.752*	11.774	4.463
r≤1	r=2	9.165	3.228	1.959	3.429
Conclusion			r=1	r=0	r=0
Trace Test					
r=0	r≥1	20.262	23.980*	13.733	8.072
r≤1	r≥2	9.165	3.228	1.959	3.429
Conclusion			r=1	r=0	r=0

The Johansen (1988) procedure (no intercept in cointegrating equation and no deterministic trend in data) is used to test bivariate cointegration between the German or the UK stock market and each of the Central European stock markets. The  $r$  denotes the maximum number of cointegrating vectors. Two forms of the Johansen test were used. The 5% critical values are provided by MacKinnon-Haug-Michelis (1999). The test results indicate cointegration between Germany or the UK and the Czech Republic. All other tests indicate a lack of cointegration.

**Table 5**  
**Multilateral Johansen Cointegration Test Results**

Panel A: German and Central European Stock Markets				
Number of Cointegrating Vectors	5 percent Critical Value	Statistic	5 percent Critical Value	Statistic
	Maximum Eigenvalue Test		Trace Test	
0	28.588	29.588*	54.079	57.291*
1	22.300	18.850	35.193	27.703
2	15.892	6.046	20.262	8.853
3	9.165	2.807	9.165	2.807
Conclusion		r=1		r=1
Panel B: UK and Central European Stock Markets				
Number of Cointegrating Vectors	5 percent Critical Value	Statistic	5 percent Critical Value	Statistic
	Maximum Eigenvalue Test		Trace Test	
0	28.588	29.314*	54.079	59.711*
1	22.300	20.863	35.193	30.397
2	15.892	6.659	20.262	9.534
3	9.165	2.875	9.165	2.875
Conclusion		r=1		r=1

The Johansen (1988) procedure (no intercept in cointegrating equation and no deterministic trend in data) is used to test multilateral cointegration between the German or the UK stock market and the Central European stock markets of the Czech Republic, Hungary and Poland as a group. The  $r$  denotes the maximum number of cointegrating vectors. Two forms of the Johansen test were used. The 5% critical values provided by MacKinnon-Haug-Michelis (1999) indicate cointegration.

Figure 1: Dynamic Cointegration Analysis

### Recursive Lambda-Trace Statistic

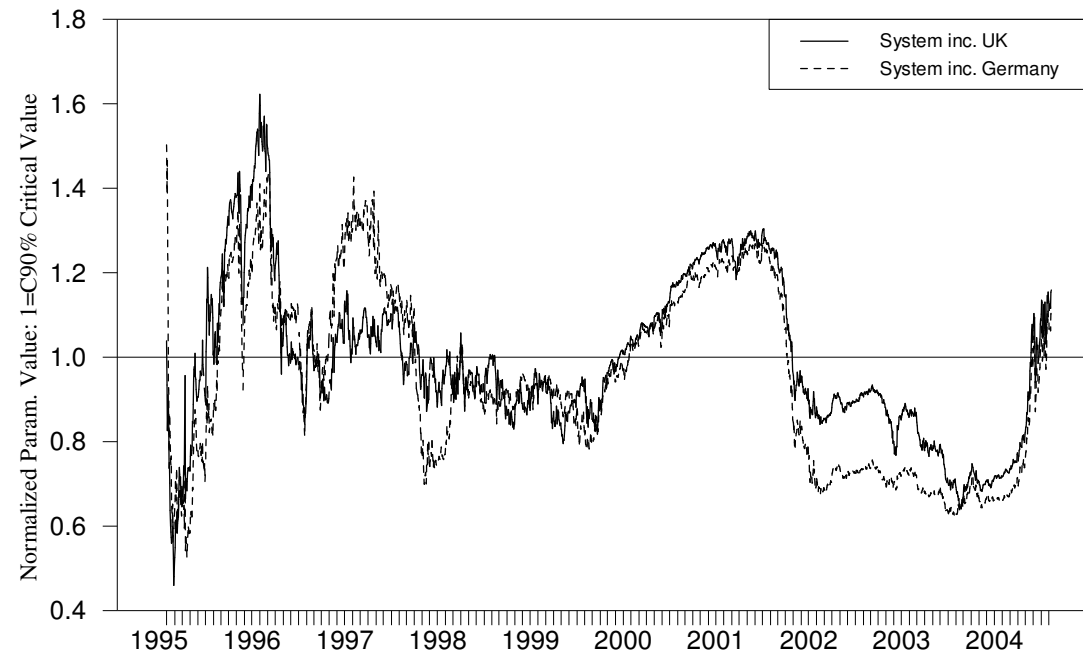


Figure 2: Haldane and Hall Convergence Parameters

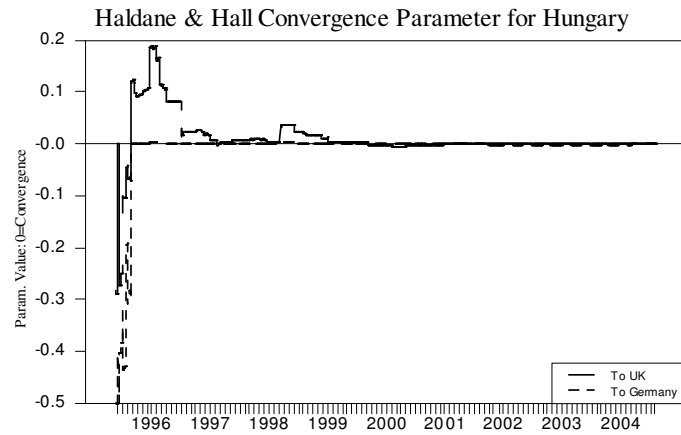
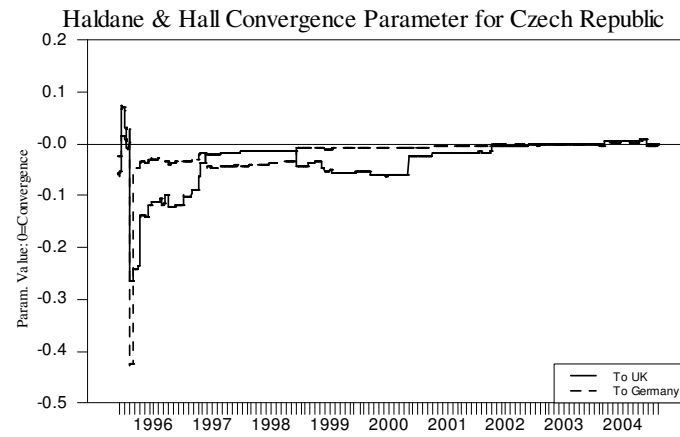
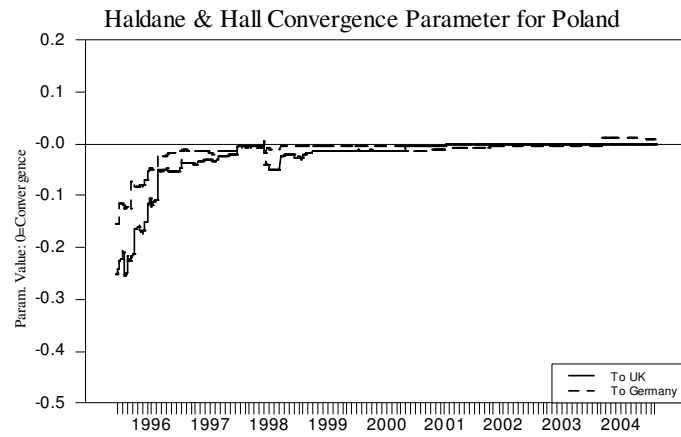
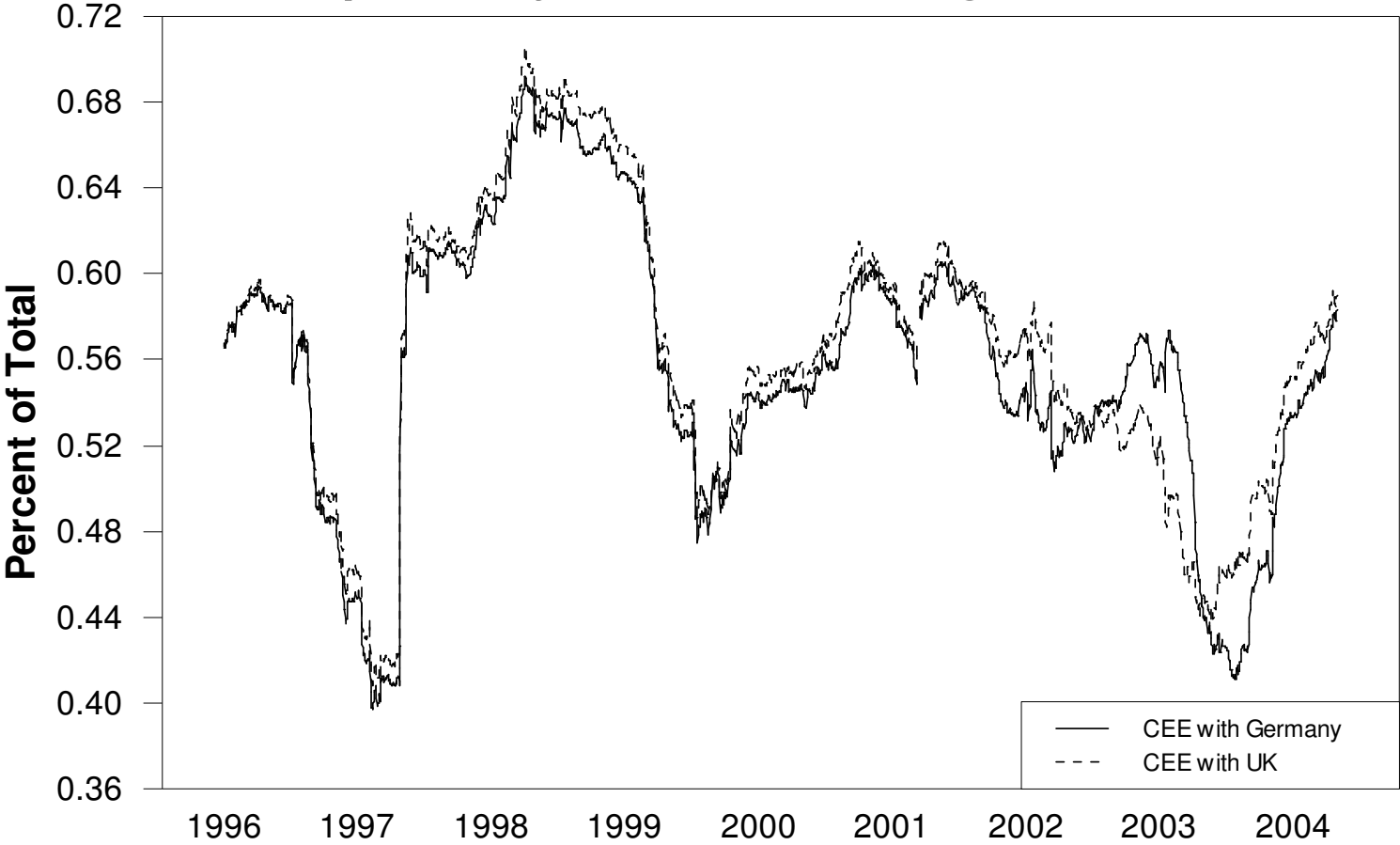


Figure 3 : Eigenvalue analysis

### Explanatory Power of First EigenValue





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