Optimum Currency Areas Theory: An Empirical Application to Turkey

Itir Ozer, Ibrahim Ozkan, Okan H. Aktan

Abstract

This study aims to assess Turkey's position relative to European countries with respect to the optimum currency areas (OCA) criteria, taking Germany as the center country and employing Mahalanobis distance as a similarity measure. To this end, we followed a novel approach in the application of Hodrick-Prescott and Baxter-King filters to the industrial production series and the real interest rates under three cases. We then computed OCA similarity indices, calculated countries' similarities with respect to Germany and their nearest neighbors, and compared the results. Our results show that Turkey is the second furthest neighbor country to Germany after Croatia in the first two cases. However, Turkey is the third furthest country to Germany after Norway and Romania in the third case

Key words: Optimum Currency Areas Theory, Turkey, Rate

JEL : F15 DOI: 10.2478/v10033-007-0008-y

1. Introduction

Optimum currency areas (OCA) theory aims to define the optimal geographic domain of a single currency. It was developed by the seminal contributions of Mundell (1961), McKinnon (1963), and Kenen (1969). OCA theory can be examined in three phases. The first is the pioneering phase of the 1960s and early 1970s, followed by the reconciliation phase of the 1970s. In the third phase, OCA theory was reassessed and operationalized through empirical studies beginning in the 1980s.

Empirical studies can be classified as econometric studies, or studies that employ the techniques of pattern recognition. Eichengreen and Bayoumi (1996), Artis and Zhang (2001), Artis and Zhang (2002), Boreiko (2002), Komárek, Cech and Horváth (2003), and Kozluk (2005) applied the techniques of pattern recognition to a set of variables suggested by the OCA theory. Pattern recognition is the act of taking raw data (which are based on a priori information or statistical information formed from patterns) and taking an action based on the "category" of the pattern (Duda, Hart, and Stork 2000, p. 15).

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This paper attempts to assess Turkey's position relative to twenty-four European countries with respect to the OCA criteria, taking Germany as the center country. The nearer (more similar) a country is to Germany in terms of OCA criteria, the more suitable it is for this country to be a part of the currency area centered around Germany. Synchronization in business cycles, volatility in the real exchange rates, synchronization in the real interest rates, the degree of trade integration, and convergence of inflation are the OCA criteria included in our analysis, following Artis and Zhang (2001), Artis and Zhang (2002), Boreiko (2002), and Kozluk (2005). Canada and Japan were included as the control group countries in order to determine whether they can be sharply distinguished from the European countries. We have constructed our analysis under three cases in which we have applied the Hodrick-Prescott (H-P) and the Baxter-King (B-K) filters to industrial production series and real interest rates. The application of H-P and B-K filters to industrial production series and the real interest rates as used in this paper is a novel approach in this area. We then employed Mahalanobis distance as a similarity measure and computed OCA similarity indices. Afterwards, in all three cases we calculated Turkey's and each European country's similarity with respect to Germany, presented the countries' nearest neighbors for Case III, and compared the results of the application of different filtering techniques, as they produce different results for the same data. In order to assess the relative position of the control group, we carried out principal component analysis. The remaining of the paper is as follows. In Section 2, we briefly discuss data and methodology. In Section 3, we provide the results. Section 4 concludes our paper.

2. Data and Methodology

Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Turkey, and the UK are the countries in the sample. Canada and Japan were included as control group countries.

2.1. Filtering Techniques and OCA Criteria

OCA studies carried out with the techniques of pattern recognition generally assume that Germany is the center country (Artis and Zhang (2001), Artis and Zhang (2002), Boreiko

(2002), and Kozluk (2005)). The criteria widely used in these studies are synchronization in business cycles, volatility in the real exchange rates, synchronization in the real interest rates, the degree of trade integration and convergence of inflation. We included the same criteria in our analysis. Artis and Zhang (2001), Artis and Zhang (2002), and Kozluk (2005) included labor market flexibility as another OCA criterion in their analysis. However, because of the lack of data for Turkey and most of the countries, we excluded this criterion from our analysis.

In OCA theory literature, for the calculations of two of the criteria synchronization in business cycles and synchronization in the real interest rates, monthly industrial production series and monthly real interest rates have been detrended with the application of the Hodrick-Prescott (H-P) filter (Hodrick and Prescott (1997)). In some atheoretic studies of business cycles (Murray (2003) and Takaya (2005)), the Baxter-King (B-K) filter has been used to obtain the cyclical components of industrial production series (Baxter and King (1999)). Since the application of different filtering techniques produce different results for the same data, we employed both the H-P and the B-K filtering techniques in our analysis.

Hodrick-Prescott (H-P)Filter. The H-P filter decomposes a time series, y_t , into an additive cyclical component, y_t^c , and a growth component, y_t^g

$$y_t = y_t^g + y_t^c \quad (1)$$

Applying the H-P filter involves minimizing the variance of the cyclical component, y_t^c , subject to a penalty for the variation in the second difference of the growth component, y_t^g

$$\{y_t^c\}_{t=0}^{T+1} = \underset{y_t^c}{\operatorname{argmin}} \sum_{t=1}^T [(y_t - y_t^g)^2 + \lambda [(y_{t+1}^g - y_t^g) - (y_t^g - y_{t-1}^g)]^2] \quad (2)$$

where λ , the smoothing parameter, penalizes the variability in the growth component. The larger the value of λ , the smoother the growth component. As λ approaches infinity, the growth component corresponds to a linear time trend (Guay and St-Amant, 1997, p. 2-3).

There are two different approaches to the question of choosing the smoothing parameter. The first approach is the free choice of smoothing parameter. In this approach, the smoothing parameter is usually fixed in an arbitrary way (Schlicht 2005, p. 99). In the OCA studies, Artis and Zhang (2001), Artis and Zhang (2002), and Boreiko (2003) have set

the smoothing parameter's value at 50,000 for relatively noisy industrial production series and real interest rates, whereas Kozluk (2005) has used 14,400 for the smoothing parameter.

The other approach is to find the optimum smoothing parameter by statistical methods, i.e., an automatic estimation method. In this approach, the optimum smoothing parameters are assigned values, which are calculated based on the nature of the time series data (Dermoune, Djehiche and Rahmania, 2006, p. 2-4) following Schlicht (2005). Let $x=(x_1, x_2, \dots, x_T)$ be a non-stationary time series with trend and cyclical components. Then, consistent estimator, λ , can be written as:

$$\hat{\lambda} = \max \left\{ 0, \frac{1}{4} \left(\frac{\frac{3}{2} + (T-3) \sum_{j=1}^{T-2} P x(j)^2}{(T-2) \sum_{j=1}^{T-3} P x(j) P x(j+1)} \right)^{-1} \right\} \quad (3)$$

where, P matrix is:

$$P = \begin{pmatrix} 1 & -2 & 1 & \dots & \dots & 0 \\ 1 & 1 & -2 & 1 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & \dots & \dots & 1 & -2 & 1 \end{pmatrix} \quad (4)$$

Baxter-King (B-K) Filter. The B-K filter computes the cyclical components, $\{y_t\}_{t=1}^T$ of the given time series, $\{x_t\}_{t=1}^T$. It is an approximation of an ideal bandpass filter, which passes only the signals that have periods between selected lower and upper periods. It relies on the use of a symmetric finite odd-order $M=2K+1$ moving average so that:

$$\hat{y}_t = \sum_{n=-K}^K \hat{B}_n x_{t-n} = \hat{B}_0 x_t + \sum_{n=1}^K \hat{B}_n (x_{t-n} + x_{t+n}) \quad (5)$$

A sequence $\hat{B}_{t,j}$ that minimizes the mean squared error between, $y_t y_{t'}^*$ given by:

$$\{\hat{B}_{t,j}\} = \arg \min E \{ (y_t - \hat{y}_t)^2 \} \quad (6)$$

The set of M coefficients $\hat{B}_j$ is obtained by applying condition (6) to the ideal filter coefficients imposing symmetry and stationary restrictions. The solution takes the form:

$$\hat{B}_j = B_j - 1/M \sum_{n=-K}^K B_n \quad (7)$$

Filtering in time domain using moving averages involves the loss of $2K$ data values. In Baxter and King (1999), a value of $K=12$ for the passband $[1.5, 8]$ years is found to be basically equivalent to higher values, such as 16 or 20.

In this study, we constructed our analysis under three cases in order to determine the differences in the results when different filtering techniques are employed. In Case I, we applied the H-P filter to the industrial production series and the real interest rates, in which the smoothing parameter is fixed at 50,000 following Artis and Zhang (2001), Artis and Zhang (2002), and Boreiko (2003). In Case II, we H-P filtered the industrial production series as in Case I, since industrial production series involve trend. As real interest rates are not expected to follow a long-term trend, we have employed the H-P filter to the real interest rates with the estimated smoothing parameters. The smoothing parameters for the countries in the sample for synchronization in the real interest rates are given in Table 1.

Austria	0.12	Netherlands	0.09
Belgium	0.22	Norway	0.49
Croatia	0.47	Poland	1.4
Cyprus	0.8	Portugal	0.32
Czech Republic	0.07	Romania	0.37
Denmark	0.98	Slovak Republic	3.21
Finland	0.13	Slovenia	0.69
France	0.12	Spain	0.87
Germany	1.21	Sweden	0.11
Greece	0.15	Turkey	1.1
Hungary	0.22	United Kingdom	0.1
Ireland	0.15	Canada	0.94
Italy	0.06	Japan	0.27
Luxembourg	0.18		

Table 1.
The Smoothing Parameters Assigned by the Automatic Estimation for the Countries in the Sample for Synchronization in the Real Interest Rates

In Case III, we employed the Baxter-King (B-K) filter to both the industrial production series and the real interest rates with a lower period of 13 and an upper period of 86 following the study of Burns and Mitchell (1946). These three cases are shown in Table 2.

	Case I	Case II	Case III
Industrial Production Series	H-P Filter, $\lambda=50,000$	H-P Filter, $\lambda=50,000$	B-K Filter
Real Interest Rates	H-P Filter, $\lambda=50,000$	H-P Filter, λ automatic estimation	B-K Filter

Table 2.
The Three Cases in which Different Filtering Techniques are Applied to Industrial Production Series and the Real Interest Rates

OCA Criteria. In this study, OCA variables have been computed as follows:

1) *Synchronization of business cycles* has been represented by the cross-correlation of the cyclical components of the deseasonalized industrial production series. The cross-correlations were measured for all the countries in the sample with reference to Germany. Since correlation results in values between -1 and +1 inclusive, we subtracted correlation values from one, so the new values are between zero and two. Zero represents perfect positive correlation, and two represents a perfect negative correlation. We used a distance measure as a similarity measure. Similarly, in order to have a 0 in distance value for perfect correlation, we subtracted correlation values from 1. Therefore, perfect correlation should result in a 0 distance value.

2) *Volatility in the real exchange rates* was represented by the standard deviation of the log-difference of real bilateral DM exchange rates before 1999. After 1999, the Euro has been used instead of DM for exchange rates. Real exchange rates were obtained by deflating nominal rates by relative wholesale (producer) price indices. For Portugal, we have used the consumer price index because of lack of data.

3) *Synchronization in the real interest rates* was represented by the cross-correlation of the cyclical components of the real interest rate cycle of a country with that in Germany. Real interest rates were obtained by deflating short-term nominal rates by consumer price indices. Cross-correlations were measured for all the countries in the sample with reference to Germany, and again the values were set between zero and two.

4) *The degree of trade integration* was measured by $(x_i^{EU-25} + m_i^{EU-25}) / (x_i + m_i)$ where x_i and m_i are exports and imports (of goods) of country i , respectively, and superscript EU-25 represents European Union countries as of May 2004.

5) *Convergence of inflation* was measured by $e_i - e_g$, where e_i and e_g are the rates of inflation in country i and Germany, respectively. The calculated values of the OCA variables for each country are given in Table 3 for Case I.

In Case I, Turkey's synchronization of business cycles with Germany had a value of 0.5966. The cross-correlation of the cyclical components of industrial production series between Germany and Turkey are given in Figure 1, whereas the cyclical components of the industrial production series of Germany and Turkey are given in Figure 2.

Figure 1 shows lagged correlation of the series used in the synchronization of business cycles. Turkey's business cycle followed Germany's business cycle with an average lag of four months. As can be seen in Table 3, the Netherlands, Ireland, Slovak Republic, Norway, Cyprus, Romania, Czech Republic, Croatia and Portugal's synchronization of business cycles with Germany were also low. Turkey's synchronization of business cycles with Germany was relatively better than these countries. However, Austria, Hungary, Finland, Belgium, Slovenia, the United Kingdom, Greece, Poland,

	Synchronisation in Business Cycles ^a	Volatility in the Real Exchange Rates ^c	Synchronisation in the Real Interest Rates ^b	The Degree of Trade Integration ^d	Convergence of Inflation ^e
Austria	0.0965	0.0046	0.5336	76.38	0.3436
Belgium	0.2821	0.0121	0.7062	75.52	0.8296
Croatia	0.9736	0.0253	1.5117	67.49	1.3846
Cyprus	0.8874	0.0047	0.5391	63.82	0.6046
Czech Republic	0.9351	0.0129	0.7322	80.03	-0.1080
Denmark	0.4276	0.0046	0.0817	70.49	-0.1454
Finland	0.2459	0.0044	0.6910	62.00	-1.0923
France	0.4427	0.0028	0.6755	66.83	-0.2098
Greece	0.3882	0.0047	0.7480	57.33	1.6073
Hungary	0.1536	0.0206	1.1266	75.27	1.5975
Ireland	0.6647	0.0046	0.7156	62.75	0.4617
Italy	0.4642	0.0031	0.1487	59.61	0.0313
Luxembourg	0.5957	0.0111	0.4748	81.54	0.5360
Netherlands	0.6107	0.0042	0.6878	66.98	-0.2906
Norway	0.7397	0.0342	0.4395	75.46	-0.4319
Poland	0.3994	0.0261	0.2802	76.36	0.1528
Portugal	1.1110	0.0053	0.7600	78.20	0.3397
Romania	0.9328	0.0338	0.6828	71.61	7.0354
Slovak Republic	0.6833	0.0145	1.3815	83.13	0.7549
Slovenia	0.3025	0.0145	0.7545	74.16	0.5250
Spain	0.5056	0.0033	0.0715	69.25	1.4138
Sweden	0.4373	0.0123	0.3648	67.49	-1.5007
Turkey	0.5966	0.0672	0.7215	49.81	6.2252
United Kingdom	0.3170	0.0161	0.8902	53.38	0.8768
Canada	0.3371	0.0241	0.5195	8.38	0.2802
Japan	0.3931	0.0252	1.0793	14.43	-2.2271

Table 3.

OCA Criteria^a, Case I

^a OCA criteria values for Germany are not given in Table 3 since Germany is the center country. For Germany, the only variable that is different from zero in value is the degree of trade integration and it is equal to 62.96.

^b Values are between zero and two, where zero represents perfect synchronization.

^c Volatility in the real exchange rates has been calculated for the values after January 1999.

^d Degree of trade integration are 2004 data.

^e Convergence of inflation are 2005 data.

Denmark, Sweden, France, Italy, and Spain's synchronization of business cycles with Germany were better than Turkey's, whereas Luxembourg has a synchronization value of 0.5957 which was slightly better than Turkey's.

Figure 1
Case I: Cross-correlation of Industrial Production Series of Germany and Turkey

Figure 2.
Case I: Cyclical Components of Industrial Production Series of Germany and Turkey

The volatility of the real New Turkish Lira had the highest value in the sample. This can be explained by the fact that Turkey experienced a currency crisis in February 2001 and a long history of high inflationary periods. We did not eliminate the high volatility of the Turkish Lira in 2001 caused by the currency crisis; therefore the high volatility of the Turkish Lira was expected in the results. When we treated big deviations observed during the currency crisis as outliers, we found better values. For example, when the ten-month period between February 2001 and December 2001 was excluded from the analysis, volatility of the real Turkish Lira became 0.032980 until February 2001, and 0.049919 after

December 2001, whereas volatility of the real Turkish Lira between February 2001 and December 2001 had a value of 0.12692, which is quite high. This high volatility of the real Turkish lira shows the effect of the currency crisis in February 2001. For Turkey, we included this period in order to make a realistic analysis. However, it should be noted that this currency crisis adversely affected both the volatility of the real Turkish Lira and Turkey's real interest rate synchronization in our analysis.

Turkey's real interest rate synchronization with Germany had a value of 0.7215. This value was better than Czech Republic, Greece, Slovenia, Portugal, United Kingdom, Hungary, Slovak Republic and Croatia's synchronizations of the real interest rates with Germany, but worse than those of Spain, Denmark, Italy, Poland, Sweden, Norway, Luxembourg, Austria, Cyprus, France, and Romania, Netherlands,

Figure 3.
Case I: Cross-correlation of Real Interest Rates of Germany and Turkey

Figure 4.
Case I: Cyclical Components of Real Interest Rates of Germany and Turkey

Finland, Belgium, and Ireland. The cross-correlation of real interest rates of Germany and Turkey are given in Figure 3, whereas cyclical components of the real interest rates of Germany and Turkey are given in Figure 4.

In Figure 3, the highest cross-correlation value of the real interest rates of Germany and Turkey was measured at 4 lags.

According to Table 3, Turkey had the lowest degree of trade integration (excluding Japan and Canada) and had the second worst convergence of inflation value after Romania when compared to the other European countries.

Table 4 shows the calculated values of the OCA variables for Cases II and III.

In Case II, Turkey's real interest rate synchronization with Germany improved and became 0.4547 compared to Case I (0.7215). Besides, compared to Case I, the Netherlands, France, Belgium, Romania, Italy, Finland, and Ireland's synchronizations of the real interest rates with Germany worsened; these countries' synchronization values were worse than Turkey's. Cyclical components of real interest rates of Germany and Turkey which improved in Case II compared to Case I are given in Figure 5.

	Case II		Case III		Volatility in the Real Exchange Rates	The Degree of Trade Integration	Convergence of Inflation
	Synchronisation in Business Cycles	Synchronisation in the Real Interest Rates	Synchronisation in Business Cycles	Synchronisation in the Real Interest Rates			
Austria	0.0965	0.3633	0.1666	0.8889	0.0046	76.38	0.3436
Belgium	0.2821	0.5183	0.2679	1.1420	0.0121	75.52	0.8296
Croatia	0.9736	1.6042	0.6137	1.5185	0.0253	67.49	1.3846
Cyprus	0.8874	0.4384	0.9908	0.3985	0.0047	63.82	0.6046
Czech Republic	0.9351	1.2068	0.5229	0.5238	0.0129	80.03	-0.1080
Denmark	0.4276	0.0497	0.3813	0.0784	0.0046	70.49	-0.1454
Finland	0.2459	0.5648	0.2638	1.0970	0.0044	62.00	-1.0923
France	0.4427	0.5049	0.6445	1.1125	0.0028	66.83	-0.2098
Greece	0.3882	1.1608	0.3918	0.9497	0.0047	57.33	1.6073
Hungary	0.1536	1.4870	0.2356	0.9508	0.0206	75.27	1.5975
Ireland	0.6647	0.6415	0.6387	1.1186	0.0046	62.75	0.4617
Italy	0.4642	0.5366	0.5228	0.1182	0.0031	59.61	0.0313
Luxembourg	0.5957	0.2620	0.7352	0.8319	0.0111	81.54	0.5360
Netherlands	0.6107	0.4927	0.6992	1.1388	0.0042	66.98	-0.2906
Norway	0.7397	0.2538	0.8497	0.7174	0.0342	75.46	-0.4319
Poland	0.3994	0.3448	0.3982	0.3252	0.0261	76.36	0.1528
Portugal	1.1110	0.5307	0.9859	1.2249	0.0053	78.20	0.3397
Romania	0.9328	0.5271	0.9158	1.0528	0.0338	71.61	7.0354
Slovak Republic	0.6833	1.3264	0.2643	1.4626	0.0145	83.13	0.7549
Slovenia	0.3025	0.8753	0.3463	0.9651	0.0145	74.16	0.5250
Spain	0.5056	0.2794	0.5619	0.0207	0.0033	69.25	1.4138
Sweden	0.4373	0.3722	0.5813	0.3213	0.0123	67.49	-1.5007
Turkey	0.5966	0.4547	0.4498	0.6090	0.0672	49.81	6.2252
United Kingdom	0.3170	1.0504	0.4456	1.1981	0.0161	53.38	0.8768
Canada	0.3371	0.4975	0.3641	0.2441	0.0241	8.38	0.2802
Japan	0.3931	1.0198	0.4027	1.3631	0.0252	14.43	-2.2271

Table 4.
OCA criteria, Cases II and III

Figure 5.
Case II: Cyclical Components of Real Interest Rates of Germany and Turkey

In Case III, Turkey's synchronization of business cycles with Germany improves and becomes 0.4498 compared to Cases I and II (0.5966). Besides, Slovak Republic's synchronization of business cycles with Germany improves and becomes better than Turkey's compared to Cases I and II, whereas Italy, Spain, Sweden, France, and Luxembourg's synchronizations of business cycles with Germany worsen and become worse than Turkey's compared to Cases I and II. Cyclical components of the industrial production series of Germany and Turkey which have improved in Case III compared to Cases I and II are given in Figure 6.

In Case III, Turkey's real interest rate synchronization with Germany became 0.6090. This synchronization value was better than Case I (0.7215) but worse than Case II (0.4547). When Cases I and III are compared for other countries in the sample, it was observed that the Czech Republic's real interest rate synchronization with Germany improved in

Figure 6.
Case III: Cyclical Components of Industrial Production Series of Germany and Turkey

Case III and became better than Turkey's, whereas Norway, Luxembourg, Austria, Romania, Finland, France, Ireland, Netherlands, and Belgium's real interest rate synchronizations with Germany worsened in Case III and became worse than Turkey's. When Cases II and III were compared, it was observed that Italy and Czech Republic's real interest synchronizations with Germany improved in Case III and became better than Turkey's, whereas Norway, Luxembourg, and Austria's real interest rate synchronizations with Germany worsened in Case III and became worse than Turkey's. Cyclical components of real interest rates of Germany and Turkey which improved in Case III compared to Case I but worsened compared to Case II are given in Figure 7.

Figure 7.
Case III: Cyclical Components of Real Interest Rates of Germany and Turkey

All of these results under different filtering techniques indicate that the results are very sensitive to the filtering techniques employed. Consequently, the proper use of filtering techniques gains importance, requiring that findings be evaluated cautiously.

2.2. OCA Similarity Matrix

In this study, we calculated similarity measures for every country in the sample in terms of OCA criteria, taking Germany as the center country. In general, distance measures were used as similarity measures. Among these, the Euclidean distance measure was the most widely used:

Let $y_i = (y_{i1}, \dots, y_{i5})$ be a vector of OCA criteria for country i , where, $i=1, \dots, 27$,

y_{i1} = synchronization in business cycles, y_{i2} = volatility in the real exchange rates,

y_{i3} = synchronization in the real interest rates, y_{i4} = the degree of trade integration,

y_{15} = convergence of inflation, and OCA data matrix, $Y = (Y_1^T, Y_2^T, \dots, Y_{27}^T)$.

The Euclidian distance between country i and country j is given as:

$$Dist_{Euclidian}(y_i, y_j) = \sqrt{(y_i - y_j)^T (y_i - y_j)} \quad (8)$$

A drawback of this measure is that if the mean of any one of the variables is higher than the others, this variable dominates the similarity measure. In order to neutralize this effect, two methodologies have been widely used in literature. In the first one, variables are standardized as in Artis and Zhang (2002), Boreiko (2002), and Kozluk (2005). In the second, Mahalanobis distance has been used (Mahalanobis (1936)). Mahalanobis distance between country i and country j is given by:

$$Dist_{Mahalanobis}(y_i, y_j) = \sqrt{(y_i - y_j)^T \Sigma^{-1} (y_i - y_j)} \quad (9)$$

where Σ is the covariance matrix of Y . The OCA similarity (distance) matrix can be written as:

$$D = \begin{bmatrix} d_{1,1} & d_{1,2} & \dots & d_{1,27} \\ d_{2,1} & d_{2,2} & \dots & d_{2,27} \\ \dots & \dots & \dots & \dots \\ d_{27,1} & d_{27,2} & \dots & d_{27,27} \end{bmatrix} \quad (10)$$

where d_{ij} is the similarity measure between country i and country j . The OCA similarity matrix for Case III is given in Appendix B.

3. Result

Table 5 shows the similarity values of each country with respect to the center country, Germany, for all three cases.

CASE I		CASE II		CASE III	
Denmark	1.68	Austria	1.28	Denmark	1.70
Austria	1.73	Denmark	1.67	Austria	2.09
Italy	1.81	Belgium	1.79	Italy	2.19
Spain	1.89	Finland	1.81	Spain	2.30
Finland	2.16	Spain	1.91	Slovenia	2.44
Belgium	2.19	France	1.91	Hungary	2.63
Slovenia	2.22	Italy	2.04	Greece	2.69
France	2.24	Slovenia	2.28	Finland	2.72
Luxembourg	2.49	Luxembourg	2.42	Belgium	2.74
Greece	2.50	Netherlands	2.45	Czech Republic	2.84
United Kingdom	2.56	Sweden	2.62	Poland	3.13
Sweden	2.59	Ireland	2.70	United Kingdom	3.19
Netherlands	2.67	United Kingdom	2.70	Sweden	3.20
Ireland	2.83	Poland	2.95	Ireland	3.39
Poland	2.92	Greece	3.07	France	3.42
Cyprus	3.35	Cyprus	3.32	Luxembourg	3.49
Hungary	3.40	Canada	3.77	Slovak Republic	3.54
Canada	3.76	Hungary	3.87	Netherlands	3.63
Czech Republic	3.78	Slovak Republic	3.88	Canada	3.78
Portugal	4.19	Portugal	4.09	Cyprus	4.05
Slovak Republic	4.21	Czech Republic	4.28	Croatia	4.17
Norway	4.29	Norway	4.29	Portugal	4.58
Romania	4.48	Romania	4.45	Turkey	4.89
Japan	4.64	Japan	4.53	Japan	5.04
Turkey	4.81	Turkey	4.79	Norway	5.04
Croatia	4.83	Croatia	4.85	Romania	5.09

Table 5.

Similarities with Respect to Germany^a

^a This table has been derived from OCA Similarity Matrices for Cases I, II and III. OCA Similarity Matrix for Case III is given in Table B-1 in Appendix B.

According to Table 5, in Case I, the nearest neighbor of Germany was Denmark and the furthest neighbor is Croatia. Turkey was the second furthest neighbor of Germany after Croatia. In Case II, the nearest neighbor of Germany was Austria, and the furthest neighbor was again Croatia. Similarly, Turkey was the second furthest neighbor of Germany after Croatia. In Case III, the nearest neighbor of Germany was Denmark, and the furthest was Romania. Turkey became the third furthest neighbor of Germany after Norway and Romania. Again, we would like to recall our observation that the results are highly sensitive to the filtering techniques employed, requiring that findings be evaluated cautiously.

In order to assess the relative position of the control group, we carried out principal component analysis.

	Variability Explained (%)		
	CASE I	CASE II	CASE III
1 st Principal Component	38.13	35.88	33.56
2 nd Principal Component	63.12	60.87	58.70
3 rd Principal Component	82.05	80.84	77.59
4 th Principal Component	93.95	93.79	93.76
5 th Principal Component	100	100	100

Table 6.
Principal Component Analysis

Table 6 illustrates that the first three principal components explain almost 80 percent of the variability in data for all cases. The relative position of the control group countries could have been observed in three dimensional figures but we preferred, for the sake of clarity, to present the projection of these data in two dimensional figures, as the distances between data points in three dimensional figures are difficult to interpret.

Austria	Slovenia	0.77	Belgium	0.79	Hungary	1.13	Turkey	4.58
Belgium	Slovenia	0.68	Austria	0.79	Hungary	0.79	Turkey	4.22
Croatia	United Kingdom	1.45	Netherlands	1.76	France	1.82	Turkey	3.90
Cyprus	Italy	1.92	Portugal	1.99	Spain	2.07	Turkey	5.13
Czech Republic	Luxembourg	1.16	Sweden	1.18	Poland	1.28	Turkey	4.24
Denmark	Italy	1.05	Spain	1.34	Czech Republic	1.45	Turkey	4.51
Finland	Slovenia	0.29	Belgium	1.25	Austria	1.34	Turkey	4.83
France	Netherlands	0.29	Ireland	0.50	United Kingdom	1.39	Turkey	4.92
Germany	Denmark	1.70	Austria	2.09	Italy	2.19	Turkey	4.89
Greece	Ireland	1.42	United Kingdom	1.43	Slovenia	1.60	Turkey	4.54
Hungary	Belgium	0.79	Austria	1.13	Slovenia	1.18	Turkey	3.59
Ireland	France	0.50	Netherlands	0.68	United Kingdom	1.20	Turkey	4.76
Italy	Spain	0.96	Denmark	1.05	Cyprus	1.92	Turkey	4.62
Luxembourg	Czech Republic	1.16	Netherlands	1.37	France	1.45	Turkey	4.43
Netherlands	France	0.29	Ireland	0.68	Portugal	1.24	Turkey	4.93
Norway	Sweden	2.14	Poland	2.22	Czech Republic	2.42	Turkey	4.43
Poland	Czech Republic	1.28	Sweden	1.59	Denmark	2.06	Turkey	3.73
Portugal	Netherlands	1.24	France	1.45	Luxembourg	1.49	Turkey	5.30
Romania	Greece	3.33	Ireland	3.48	Croatia	3.59	Turkey	3.78
Slovak Republic	Belgium	0.89	Hungary	1.29	Slovenia	1.48	Turkey	4.53
Slovenia	Belgium	0.68	Austria	0.77	Finland	1.12	Turkey	4.39
Spain	Italy	0.96	Denmark	1.34	Cyprus	2.07	Turkey	4.58
Sweden	Czech Republic	1.18	Poland	1.59	Denmark	1.73	Turkey	4.62
Turkey	Romania	4.48	Romania	4.48	Romania	3.78	Turkey	0
United Kingdom	Hungary	3.59	Poland	3.73	France	1.39	Turkey	4.03
Canada	Japan	3.03	Italy	3.05	United Kingdom	3.19	Turkey	4.47
Japan	United Kingdom	2.95	Canada	3.03	Finland	3.22	Turkey	5.29

Table 7.

The Three Nearest Neighbors and Turkey's Similarity (distance)^a, Case III

^a This table has been derived from 27 x 27 OCA Similarity Matrix, Case III, Table B-1 given in Appendix B.

In Figures 8 and 10 Canada and Japan can be distinguished from the European countries. Similarly, Turkey and Romania are also observed as a different group.

Table 7 shows each country's three nearest neighbors, and Turkey's distance (similarity) to each country in the sample for Case III. For Cases I and II, principal components figures, OCA similarity matrices, the three nearest neighbors of the countries and Turkey's similarity (distance) are available from the authors upon request.

The three nearest neighbors of Turkey are Hungary, Poland and Romania with quite low similarities. The higher is the OCA similarity value in Table 7, the lower is the similarity. Turkey, Romania, Canada, Japan, Norway and Cyprus exhibit low similarities to their nearest neighbors. Canada and Japan are the control group countries, and they exhibit low similarities to their nearest neighbors as expected. The other countries' low similarities might be explained by the fact that Turkey launched its EU accession negotiations in

October 2005, Romania joined EU in January 2007, and Norway is not a European Union member, whereas Cyprus became a full member in May 2004. Therefore, this might be a sign of the endogeneity of OCA criteria. As Frankel and Rose (1996) have asserted: "Countries which join the EMU, no matter what their motivation, may satisfy OCA criteria ex

post even if they do not ex ante!" (Frankel and Rose 1996, p. 3).

Surprisingly, despite the geographic proximity of the UK and Ireland, Ireland's nearest neighbor is France. UK is the third nearest neighbor of Ireland with very little difference in similarity. The nearest neighbor of the UK is Ireland and France's nearest neighbor is the Netherlands.

4. Conclusion

Integration efforts in Europe started in the 1950s, and the OCA theory has played an important role in deepening this process by not only providing a theoretical framework for the Economic and Monetary Union, but also by being the driving force with the empirical studies carried out aiming to operationalize the theory. During the last decades, considerable progress has been experienced in the techniques of data analysis and modelling. These include pattern recognition techniques, which have been applied widely in the literature from the natural to social sciences. Cluster analysis is a part of pattern recognition technique, and similarity measures are the key elements of cluster analysis. In this study, our aim was to evaluate the relative position of Turkey with respect to European countries. Therefore, cluster analysis was left out of the scope of this paper for future work. We followed a novel approach in the application of the Hodrick-Prescott (H-P) and the Baxter-King (B-K) filters to monthly industrial production series and the real interest rates. After that, we employed Mahalanobis distance as a similarity measure to these widely used OCA criteria in the literature. We then created OCA similarity indices, computed countries' similarities with respect to Germany, their nearest neighbours and Turkey's similarity (distance) to these countries and to Germany. Afterwards, we compared the results. To our knowledge, this is the first analysis in this area that uses the filtering techniques as applied in Cases II and III. We included Canada and Japan as control group countries to assess the reliability of the results; indeed, our analysis did produce nonsensical results.

Our results show that Turkey is the second furthest neighbor country to Germany after Croatia in Cases I and II. However, Turkey is the third furthest country after Norway and Romania in Case III. The nearest neighbors of Turkey are Romania, Poland, and United Kingdom in Case I, Romania, Poland, and Belgium in Case II, and Hungary, Poland, and Romania in Case III. Therefore, this analysis shows that the

Figure 8.
Case III: 1st and 2nd Principal Components

Figure 9.
Case III: 1st and 3rd Principal Components

Figure 10.
Case III: 2nd and 3rd Principal Components

results are sensitive to the filtering technique employed.

Turkey experienced two currency crises in 1994 and 2001. For this reason, it is reasonable to expect Turkey's data to be affected adversely because of these currency crises. This was clearly seen in the results. Since Turkey started EU accession negotiations recently, it has not fully benefited from the accession stage yet. Both in the accession stage and the full membership, the probability of experiencing a currency crisis as in 1994 and 2001 is very low. Therefore, Turkey will be on its path to convergence in accordance with the OCA theory. We believe that one of the factors that play a very important role in this convergence is the young and dynamic population of Turkey, which makes the Turkish economy highly adaptive.

5. Appendices

Appendix A

OCA Variables

Variables	Frequency	Data Sources	Time Interval
Industrial production series	monthly	IFS	1996:1-2005:6
Real exchange rates	monthly	IFS, TURKSTAT	1991:1-2006:12
Real interest rates	monthly	IFS, EUROSTAT, Central Bank of Luxembourg	1997:2-2006:10(H-P Filter) 1996:2-2005:10(B-K Filter)
Trade data	annual	UNCTAD; Handbook of Statistics Online	2004
Inflation data	annual	WDI	2005

Table A-1.
Frequency, Data Sources and the Time Interval of the OCA Variables

Austria	: Government Bond Yield	Netherlands	: Government Bond Yield
Belgium	: Government Bond Yield	Norway	
Croatia	: Money Market Rate	Poland	: Money Market Rate
Cyprus	: Deposit Rate	Portugal	: Money Market Rate
Czech Republic	: Money Market Rate	Romania	: NBR Structural Credit Rate
Denmark	: Call Money Rate	Slovak Republic	: Average Lending Rate
Finland	: Government Bond Yield	Slovenia	: Money Market Rate
France	: Government Bond Yield	Spain	: Call Money Rate
Germany	: Call Money Rate	Sweden	: Call Money Rate
Greece	: Government Bond Yield	Turkey	: Interbank Money Market Rate
Hungary	: Treasury Bill Rate	United Kingdom	: Government Bond Yield
Ireland	: Government Bond Yield	Canada	: Bank Rate
Italy	: Money Market Rate	Japan	: Government Bond Yield
Luxembourg	: Government Bond Yield		

Table A-2.
Interest Rates

AT	Austria	DE	Germany	PL	Poland	UK	United Kingdom
BE	Belgium	GR	Greece	PT	Portugal	CA	Canada
HR	Croatia	HU	Hungary	RO	Romania	JP	Japan
CY	Cyprus	IE	Ireland	SK	Slovak Republic		
CZ	Czech Republic	IT	Italy	SI	Slovenia		
DK	Denmark	LU	Luxembourg	ES	Spain		
FI	Finland	NL	Netherlands	SE	Sweden		
FR	France	NO	Norway	TR	Turkey		

	AT	BE	HR	CY	CZ	DK	FI	FR	DE	GR	HU	IE	IT	LU	NL	NO	PL	PT	RO	SK	SI	ES	SE	TR	UK	CA	JP
AT	0	0.79	2.54	3.83	2.10	2.12	1.34	2.22	2.09	1.96	1.13	2.27	2.60	2.41	2.43	4.25	2.74	3.38	4.36	1.50	0.77	2.76	2.93	4.58	1.99	4.32	4.41
BE	0.79	0	1.82	3.76	2.04	2.48	1.25	1.98	2.74	1.99	0.79	2.03	2.85	2.14	2.14	3.87	2.65	3.03	4.03	0.89	0.68	3.04	2.90	4.22	1.58	4.33	4.09
HR	2.54	1.82	0	3.42	2.42	3.36	2.08	1.82	4.17	2.61	2.04	1.87	3.36	1.96	1.76	3.10	3.02	2.24	3.59	1.82	1.96	3.66	2.98	3.90	1.45	4.28	3.42
CY	3.83	3.76	3.42	0	2.74	2.68	3.54	2.25	4.05	3.04	3.91	2.24	1.92	2.11	2.17	3.67	3.69	1.99	3.72	4.37	3.18	2.07	2.61	5.13	3.08	3.86	4.69
CZ	2.10	2.04	2.42	2.74	0	1.45	2.20	2.12	2.84	2.95	1.93	2.39	2.00	1.16	2.12	2.42	1.28	2.60	4.33	2.50	1.75	2.30	1.18	4.24	2.48	4.23	4.37
DK	2.12	2.48	3.36	2.68	1.45	0	2.43	2.50	1.70	2.62	2.37	2.60	1.05	2.10	2.61	3.61	2.06	3.31	4.47	3.24	1.99	1.34	1.73	4.51	2.74	3.65	4.65
FI	1.34	1.25	2.08	3.54	2.20	2.43	0	1.61	2.72	1.98	1.80	1.76	2.58	2.32	1.78	3.88	2.90	2.95	4.69	1.76	1.12	3.12	2.58	4.83	1.36	3.74	3.22
FR	2.22	1.98	1.82	2.25	2.12	2.50	1.61	0	3.42	1.80	2.48	0.50	2.20	1.45	0.29	3.58	3.23	1.45	3.81	2.45	1.50	2.60	2.46	4.92	1.39	3.85	3.60
DE	2.09	2.74	4.17	4.05	2.84	1.70	2.72	3.42	0	2.69	2.63	3.39	2.19	3.49	3.63	5.04	3.13	4.58	5.09	3.54	2.44	2.30	3.20	4.89	3.19	3.78	5.04
GR	1.96	1.99	2.61	3.04	2.95	2.62	1.98	1.80	2.69	0	2.34	1.42	2.27	2.66	2.05	4.83	3.80	2.97	3.33	2.74	1.60	2.37	3.48	4.54	1.43	3.41	4.06
HU	1.13	0.79	2.04	3.91	1.93	2.37	1.80	2.48	2.63	2.34	0	2.50	2.87	2.28	2.61	3.68	2.21	3.40	3.93	1.29	1.18	2.99	2.84	3.59	1.91	4.27	4.29
IE	2.27	2.03	1.87	2.24	2.39	2.60	1.76	0.50	3.39	1.42	2.50	0	2.19	1.72	0.68	3.87	3.44	1.65	3.48	2.58	1.57	2.52	2.76	4.76	1.20	3.65	3.61
IT	2.60	2.85	3.36	1.92	2.00	1.05	2.58	2.20	2.19	2.27	2.87	2.19	0	2.17	2.30	3.84	2.77	2.97	4.14	3.66	2.25	0.96	1.99	4.62	2.53	3.05	4.33
LU	2.41	2.14	1.96	2.11	1.16	2.10	2.32	1.45	3.49	2.66	2.28	1.72	2.17	0	1.37	2.59	2.30	1.49	3.67	2.52	1.76	2.34	1.81	4.43	2.21	4.38	4.36
NL	2.43	2.14	1.76	2.17	2.12	2.61	1.78	0.29	3.63	2.05	2.61	0.68	2.30	1.37	0	3.39	3.22	1.24	3.85	2.56	1.71	2.73	2.40	4.93	1.52	3.91	3.55
NO	4.25	3.87	3.10	3.67	2.42	3.61	3.88	3.58	5.04	4.83	3.68	3.87	3.84	2.59	3.39	0	2.22	3.32	5.28	3.95	3.80	4.24	2.14	4.43	3.83	5.05	4.48
PL	2.74	2.65	3.02	3.69	1.28	2.06	2.90	3.23	3.13	3.80	2.21	3.44	2.77	2.30	3.22	2.22	0	3.71	4.91	2.99	2.61	3.06	1.59	3.73	3.16	4.37	4.56
PT	3.38	3.03	2.24	1.99	2.60	3.31	2.95	1.45	4.58	2.97	3.40	1.65	2.97	1.49	1.24	3.32	3.71	0	3.70	3.27	2.65	3.17	2.88	5.30	2.57	4.77	4.41
RO	4.36	4.03	3.59	3.72	4.33	4.47	4.69	3.81	5.09	3.33	3.93	3.48	4.14	3.67	3.85	5.28	4.91	3.70	0	4.41	3.88	3.67	5.00	3.78	3.62	5.12	6.01
SK	1.50	0.89	1.82	4.37	2.50	3.24	1.76	2.45	3.54	2.74	1.29	2.58	3.66	2.52	2.56	3.95	2.99	3.27	4.41	0	1.48	3.85	3.38	4.53	2.13	5.05	4.34
SI	0.77	0.68	1.96	3.18	1.75	1.99	1.12	1.50	2.44	1.60	1.18	1.57	2.25	1.76	1.71	3.80	2.61	2.65	3.88	1.48	0	2.46	2.56	4.39	1.44	4.05	4.07
ES	2.76	3.04	3.66	2.07	2.30	1.34	3.12	2.60	2.30	2.37	2.99	2.52	0.96	2.34	2.73	4.24	3.06	3.17	3.67	3.85	2.46	0	2.62	4.58	2.95	3.67	5.14
SE	2.93	2.90	2.98	2.61	1.18	1.73	2.58	2.46	3.20	3.48	2.84	2.76	1.99	1.81	2.40	2.14	1.59	2.88	5.00	3.38	2.56	2.62	0	4.62	2.87	3.82	3.95
TR	4.58	4.22	3.90	5.13	4.24	4.51	4.83	4.92	4.89	4.54	3.59	4.76	4.62	4.43	4.93	4.43	3.73	5.30	3.78	4.53	4.39	4.58	4.62	0	4.03	4.47	5.29
UK	1.99	1.58	1.45	3.08	2.48	2.74	1.36	1.39	3.19	1.43	1.91	1.20	2.53	2.21	1.52	3.83	3.16	2.57	3.62	2.13	1.44	2.95	2.87	4.03	0	3.19	2.95
CA	4.32	4.33	4.28	3.86	4.23	3.65	3.74	3.85	3.78	3.41	4.27	3.65	3.05	4.38	3.91	5.05	4.37	4.77	5.12	5.05	4.05	3.67	3.82	4.47	3.19	0	3.03
JP	4.41	4.09	3.42	4.69	4.37	4.65	3.22	3.60	5.04	4.06	4.29	3.61	4.33	4.36	3.55	4.48	4.56	4.41	6.01	4.34	4.07	5.14	3.95	5.29	2.95	3.03	0

Table B-1.

OCA Similarity Matrix, Case III*

*This matrix has been calculated by Mahalanobis distance function employed in Matlab.

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