Is There Convergence across European Countries? Simple Cluster Analysis Approach[1]

*Stanislav BURIAN – Jakub FRYDRYCH**

Abstract

In this paper, we have verified the convergence process in the EU in the period 2001 – 2013. The methodology of this paper is similar to that of Artis and Zhang (1997), Boreiko (2003), and Crowley (2013), who also focused on the European convergence process. This paper is based on the thesis that the convergence process is proven if the clusters are gathering in shorter squared Euclidean distances during the time, or, alternatively, if the distances between European Union economies and Germany are shorter. First, in order to perform the cluster analysis, the convergence criteria are identified (the choice of the criteria is based on optimum currency area). Second, with regards to the criteria, we conduct thirteen cluster analyses for every year of the period 2001 – 2013. From this perspective, we focus on the differences between the analyses' outputs during the time. According to our results, it is possible to draw the conclusion that the economic convergence process in the EU was not proven.

Keywords: *convergence, convergence process, cluster analysis, European Union, European Monetary Union, optimum currency areas*

JEL Classification: F15

Introduction

The outputs of the theory of optimum currency areas (OCA) include the specification of criteria whose evaluation allows the potential risks resulting from accessing the monetary union to be identified. The aim of this paper is to identify convergence tendencies among selected EU countries and Germany in period 2001 – 2013 using the cluster analysis approach. This article connects the OCA

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theory to a theoretical concept of economic convergence which is specifically expressed through the use of an in-depth analysis. The connection is made through the use of selected criteria of the OCA theory in the role of criteria of a cluster analysis which is applied to the annual summary data of nineteen EU countries. The clusters are calculated for every single year of the 2001 – 2013 period (thus, a cluster analysis is performed in thirteen cases for nineteen subjects for every year of the thirteen-year period in question).

Cluster analysis is used to identify the character of development of the convergence process in member countries of the European Union. This process can be expressed via Squared Euclidean distances (SED) within identified clusters during the time. If the SED between Germany[2] and particular country (included to analysis) is decreasing during the time, economic convergence between Germany and the country may be considered to have been demonstrated. If the opposite occurs, i.e. if distances are increasing over the period, it is possible to consider the development as a divergence. If there is an absence of trends, we cannot prove convergence or divergence.

Moreover, if the composition of clusters is unchanged (at the same level of SED), there are no convergence or divergence tendencies. This methodological approach is derived from methodology in Krcilkova (2006) or in Artis and Zhang (1997). As we pointed out, we perceive our contribution especially in the reinterpretation of changes in the sizes of Euclidean distances.

Data for the convergence criteria of individual countries are obtained from the Eurostat, OECD, and IMF databases. First, elementary time series analysis is used to determine the fundamental characteristics and properties of the time series needed for further clustering (such as distribution, kurtosis, median, outliers, skewness). Second, for the application of cluster analysis is selected Ward's method of clustering, which minimizes the total within-cluster variance (clustered are the groups which creates the lowest within-cluster variance). When the cluster consists of k objects, which are characterized by m variables, then matrix k x m with x_{ij} elements is available. Within-cluster variance is given by following relationship (Meloun and Militký, 2004):

$$WCV = \sum_{j=1}^{m} \sum_{i=1}^{k} (x_{ij} - \bar{x}_j)^2 \tag{1}$$

where

$$\bar{x}_j = \frac{1}{k} \sum_{t=1}^{k} x_{ij} \tag{2}$$

[2] Germany is chosen because it is a permanent member of the Core of the EMU; based on the methodology of Artis and Zhang (1997).

Squared Euclidean distance is used as a measure, which places a progressively greater weight on objects that are farther apart and represents the basis of the Ward's method (Meloun and Militký, 2004).

$$d_E^2\left(x_k, x_l\right) = \sum_{j=1}^{m} (x_{kj} - x_{lj})^2 \tag{3}$$

The selected limit for exclusion variables because of multicollinearity is the value 0.7, using the Spearman's rank correlation coefficient. Spearman's rank correlation coefficient is used because the assumption of normality is violated.

1. Literature Review

The basis for the OCA theory (which forms the theoretical basis of this paper) lies in the definition of criteria which may be used for individual countries (or more generally, economic areas) in order to formulate recommendations as to whether it is advantageous to enter into a monetary union or not. Mundell (1961), the original author of the OCA theory, identified the mobility of the workforce and the flexibility of wage costs as key factors in determining the successful functioning of a currency union. These criteria were later supplemented by McKinnon's (1963) criterion of the openness of the economy and subsequently by Kennen's product diversification criterion (1969). These criteria assume that the more open an economy is to a currency union, or the more diversified aggregate production is, the greater the potential benefit brought by membership in the monetary union will be.

From the 1970s until practically the present, the focus of research in this area shifted from theory to empirical analysis. With regards to the further development of OCA theory, Fidrmuc (2002) introduces a clear list of criteria which primarily focus on symmetric shocks in the regional economies in question straightforwardly expressed as symmetries in the business cycle (see, e.g., Frankel and Rose, 1998), the volume of fiscal transfers (see, e.g., Dixit, 2000), and harmonized inflation (Carlin et al., 2001).

However, there does not exist any consensus in a general list of criteria that could be interpreted in relation to the theory of OCA. A particular node of conflict in research carried out to this point concerns the influence of the openness of the economy. On one side, Frankel and Rose (1998) have demonstrated the endogeneity of economic convergence and closer reciprocal trade relations, with economic convergence creating better conditions for the functioning of a single currency within the monetary union. On the other side, researchers such as Bayoumi and Eichengreen (1994) have shown a higher level of openness leads to greater specialization that could increase the risk of asymmetric shocks in a group of countries.

To quantify the level of convergence of individual economies, deviations in real exchange rates are modelled (originally by Eichengreen, 1991), and the distinct manifestations of these fundamentals imply the potential risk arising from the introduction of a single currency. Other models stress the mobility of the workforce (e.g., De Grauwe and Vanhaverbeke, 1991) and, hence, the volume of reciprocal "cross-border" trade (but within the context of the economic unit under study), or the level of internal openness of the economies (e.g., Frankel and Rose, 1998).

Attempts to implement the criteria on a comprehensive basis have led to the creation of a specific area of study involving the quantification of so-called OCA indexes (normally employing vector autoregression), whose values express the suitability (or lack thereof) of membership in the currency union in question for individual countries. Among those concerned with the creation of OCA indexes are Bayoumi and Eichengreen (1997), who define an OCA index as the bilateral deviation in nominal currency rates in dependence on selected exogenous variables (the standard deviation of the log values of first differences of the relative change in total production, the commodity structure of output, the arithmetic mean of mutual exports versus GDP and the arithmetic mean of the log values of GDP for both countries). The lower the OCA index value, the higher the level of economic convergence. Newer papers, such as those of Cincibuch and Vavra (2000), Horvath and Komarek (2002), and Hedija (2011), have made only minor methodological changes to these approaches. The main added value brought by these papers lies in updating the size of the indexes in question.

The dominant approach based upon regression analysis is complemented by the lesser-used method of cluster analysis. An important contribution is the analysis by Artis and Zhang (1997), which classifies a sample of eighteen developed countries around the globe into five groups. Three clusters were identified in the European context: Core (France, the Netherlands, Belgium, and Austria), Northern Periphery (Denmark, Ireland, Sweden, Norway, Finland, and the UK) and Southern Periphery (Italy, Spain, Portugal, and Greece). Note: Because of the particular role that it played in the methodology, Germany was included in the analysis as a core country of the Eurozone.

Cluster analysis is also used to explore the convergence process by Krcilkova (2006), who clusters the countries in the European Union using growth in the GDP, the inflation rate derived from the GDP deflator, the unemployment level, real interest rates, and the public budget deficit versus GDP as convergence criteria. In her conclusions, she points to the evidence for significant convergence in the economies of the member countries during the period analysed (1997 – 2005). Further publications exploring the convergence of countries located in

the European economic area via cluster analysis include Boreiko (2003), who uses a fuzzy approach to cluster analysis to assess the potential entry of countries located in Central and Eastern Europe to the Eurozone; Tsangarides and Qureshi (2006), who use a similar methodology to evaluate the sustainability of a fixed currency regime in Western Africa; and Crowley (2008), who uses correlation indicators as features for cluster analysis (applied to 32 countries).

Saint-Arnaud and Bernard (2003), specifically, cluster the economies in the European Union to demonstrate the convergence process with respect to different political regimes. They consider four regimes in the European Union (Liberal, Social-Democratic, Latin, and Conservative). Their results confirm the presence and persistence in these societies of significant distinctions in social policy organization and in the interrelationships between the state and the market. Comparing these results has allowed them to reject, at least for the period from the mid-1980s to the mid-1990s, the hypothesis of an overall convergence of regimes resulting from the constraints of economic markets.

Blajer-Golebiewska (2014) mainly focuses on Eastern Europe and clusters countries in the European Union to demonstrate how these eastern economies converge towards the European Union. Her research shows that artificial changes in the division of Europe are not stable. The structure of countries in accordance to their economic activities has a tendency to change towards the geographical, historical, and political classifications based on the old division into Western Europe, Nordic countries, Central and Eastern Europe and Mediterranean countries. She asserts that it can be stated that the classification of economies due to their economic activities is not stable; however, changes are not very significant.

2. Cluster Analysis

In our paper, we have performed thirteen cluster analyses (one cluster analysis for every year from the period 2001 – 2013), which are applied to nineteen objects (countries) and six variables (OCA criteria). Nineteen member states of the EU (cluster analysis objects) have been chosen based on the aims of this paper and specific data availability.[3] Variables have been defined with respect to OCA theory. More specifically, we have used economic openness of countries, long-term interest rates, GDP in purchasing power parity, position in the business cycle, flexibility in the labour market, and price level. None of these variables is not removed, because the collinearity stronger than 0.7 is not identified. The optimum number of clusters is based on the visual analysis.

[3] We chose only European countries which were OECD members since 2001. Since this year OECD started with evidence of the indicator of protection legislation (in labour market). This variable is used as an indicator of the level of potential mobility of employees.

Generally speaking, according to OCA theory, we suppose that higher *openness of economy* increases positive effects which are influenced by membership to a monetary union (due to a reduction in transaction costs). Open economies are appropriate candidates for a single currency. Openness of economy is defined as an export to GDP ratio.

When *long-term interest rates cycles* are synchronized among countries, it is possible to claim that unified monetary policy will suit candidate countries and members of the Eurozone. In the situation when long-term interest rates are significantly different, it is not possible to recommend monetary union membership. For analysis, we use interest rates of government ten years' bonds, which are used in the framework of nominal convergence criteria.

GDP in purchasing power parity per capita is chosen as a variable because different levels can lead to the fact that, in the long run, economies with a relatively low GDP in PPP per capita grow faster and much more than economies with a relatively high level of this indicator. According this assumption, one monetary policy cannot fit countries which differ in level of development. In other words, members of a monetary union should have relatively similar stats in this indicator. This criterion is important, mainly in the long run.

Position in the business cycle is an important variable because of the different consequences of a "one size" monetary policy. Countries which are overheating need a restrictive monetary policy, while expansive monetary policy is required by economies in recession. Membership in a monetary union can be recommended if member countries have synchronous business cycles. Position in the business cycle is quantitatively defined as a deviation of the real GDP from its potential level as % of potential GDP (with respect to IMF methodology), in the analysis is used the value of output gap from OECD database.

Interpretation of the *labour market flexibility* criterion is not unambiguous. According to OCA theory, a flexible labour market is an important condition for a working monetary union without complication. A higher degree of labour market flexibility causes easier labour mobility, which can serve economies as an adaptive mechanism. When there is a recession in region A, in region B, there will be a growth; performances (and also employment) of both the regions can be equalized due to labour mobility, which is the reason for the formulation of the thesis that a "one size" monetary policy need not be a problem. For a monetary union, it is favourable if members have a higher degree of labour market flexibility. However, cluster analysis compares countries based on similarities, not based on higher values of indicators, which measure labour market flexibility. Labour market flexibility is expressed by the OECD indicator of protection legislation, which measures the difficultness of the process and costs of dismissing

and hiring workers. According to this, it is important to know that ambiguous interpretation and restrictive expression of the labour market flexibility indicator may limit the interpretation of cluster analysis results.

An essential objective of monetary policy is a relatively low but stable growth rate of the *price level* which is expressed via Harmonised Index of Consumer Prices (HICP). When the price level of the monetary union (Eurozone) core differs from the price level of periphery or candidate countries, a "one size" monetary policy cannot be successful. Therefore, it is important to have synchronization in price level cycles among all countries.

We suppose that the results of the cluster analysis allow us to classify the countries into several groups which have similar features. In this context, we may compare cluster analysis results for single years. This comparison allows us to find out whether there are certain changes in defined clusters or not. At the centre of our interest is the question whether the group (which represents the Core of Eurozone) is defined more widely during the analysed period or not. A more widely defined core can lead to the thesis that certain countries converge to the Eurozone core.

3. Analysis Results

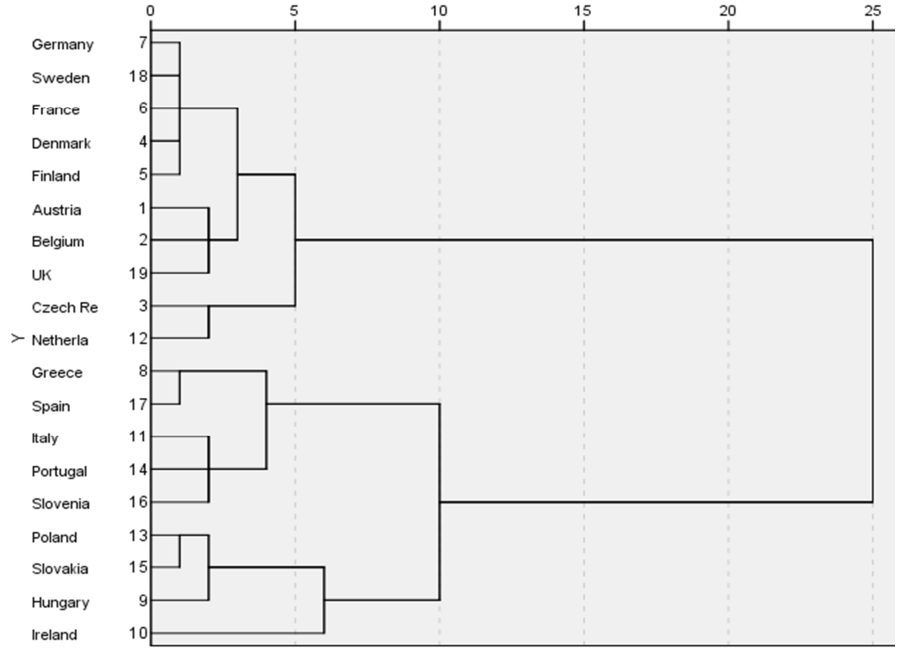
When analysing the dendrogram results for the 2013 data, it is possible to identify the composition of clusters which approximate the results of the study Artis and Zhang (1997), i.e. dividing European Union countries into three groups: "Core", "Southern Periphery" and "New Periphery". The cluster categorisation is presented in Figure 1.

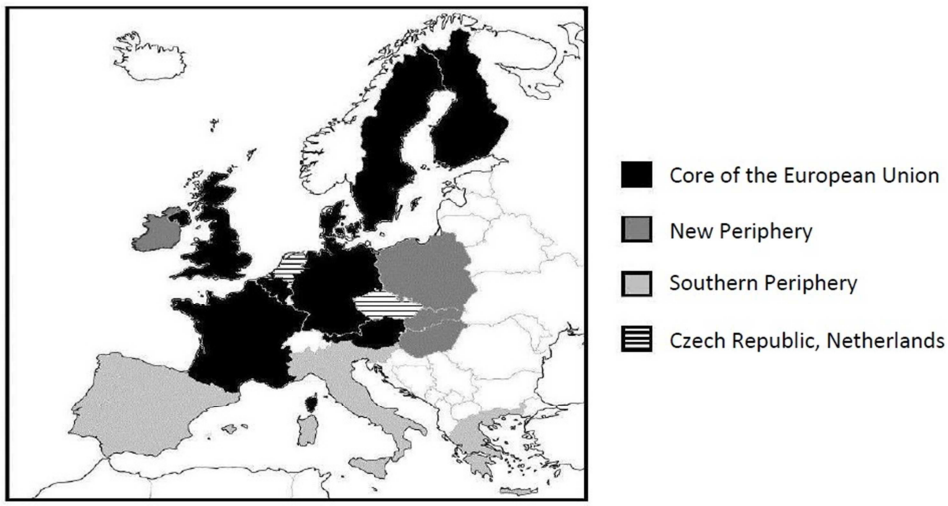
The cluster entitled the Core of the EU consists of Germany, France, Belgium, Denmark, Finland, Sweden, Austria, and the UK. The Netherlands and the Czech Republic joined this cluster later (jointly forming a cluster at higher SED). The Core may be characterised by low interest rates (less than 2% on average), a lower inflation rate (98.88% on average; 100% = 2015), and low negative values of the production gap (2.16% on average), indicating the dying out of the 2009 financial crisis. The Czech Republic and the Netherlands reach similar values in these criteria, but are significantly more open to foreign trade (Netherlands 83% and Czech Republic 84% compared to the Core average of 47%).

The Southern Periphery includes a cluster consisting of the southern Eurozone countries (Portugal, Spain, Italy, Greece, and Slovenia). This cluster differs from the Core particularly in higher interest rates determined by a higher risk premium (6.2% on average), a higher production gap (–8.8%), and a lower labour flexibility rate (the mean of the indexes of labour market flexibility for this cluster is 2.5).

F i g u r e 1

Cluster Analysis' Results for 2013 – Dendrogram and Map





Source: Own calculations.

The last identified cluster is the New Periphery, consisting of Hungary, Slovakia and Poland. Ireland is included in this cluster only at higher SED. Compared to the Core (on average), the New Periphery (with Ireland included) shows a higher

openness to foreign trade (85.6%), higher interest rates (4.2%), higher labour market flexibility (1.8), and a higher negative value of the production gap (–3.7%). According to the values measured, the condition of economies in this cluster is situated between the Core and the Southern Periphery economies.

When structural changes in the individual clusters in time are examined, it is possible to reach the conclusion that their compositions are not stable in individual years. Thus, the analysis results did not confirm the anticipated existence of three stable clusters within the European Union (EMU core, Southern Periphery, New Periphery), unlike in the original study by Artis and Zhang (1997). In the first three years of the 21st century, the similarity of these clusters was relatively stable, while the SED between them showed no tendencies towards extending, which may be considered to be a manifestation of a higher level of the cluster composition stability. In other words, no convergence or divergence tendencies could be proven. However, the cluster composition showed a higher variability in the following period, and differences between economies expressed by SED increased in most cases. Thus, the assumption of the European monetary union economic core getting extended (to the same distances) did not prove to be correct. On the contrary, in the following years, it was practically impossible to identify the Core in a stabilised form (Germany, considered to be the most important economy of the EMU, was part of clusters of highly variable composition which changed almost every year).

A detailed examination of the results of the cluster analyses was performed with the use of SED of all the economies included in the analyses in relation to Germany. The development of the SED between the economies and Germany in 2001 – 2013 is given in Appendix 1.

Belgium and the UK remained in higher SED than the other members of the cluster during the whole period monitored, although their distance to Germany was comparable to other economies of the Core in the final year. The average value of the SED was about 3.3 in 2013; with economies of the broader Core included, it was 4.0. Although the monitored SED were relatively low, their course showed no apparent long-term trends indicating the existence of provable convergence or divergence.

The Southern Periphery cluster consists of the economies of Greece, Spain, Italy, Portugal, and Slovenia, as is clearly shown in the dendrogram compiled from the 2013 data. Those are economies of the southern wing of the Eurozone, for which it was established that the SED development was variable over time; however, there was an observable increase of the distances in relation to Germany over the last four years. The only exception is Italy which, despite a worsened squared distance indicator, remained within the interval of values similar to

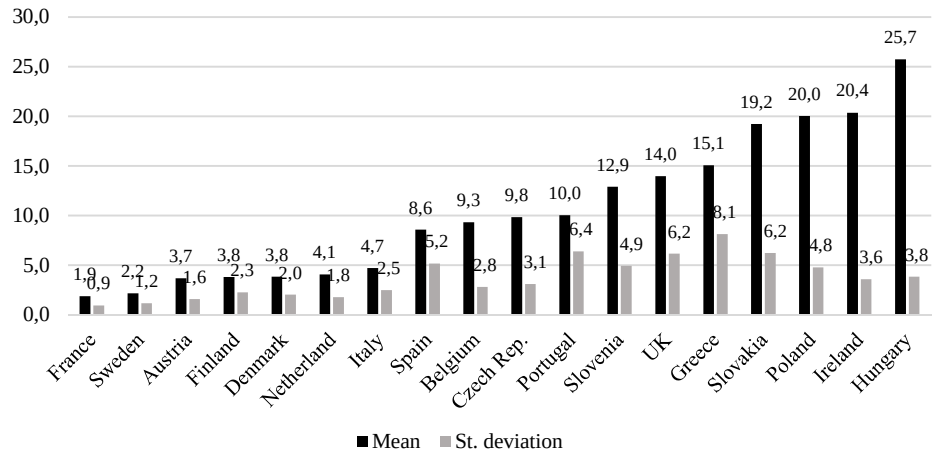
those of the Core. The average distance of this cluster (in relation to Germany) was 17.45 in 2013 and, therefore, significantly higher than the average distance of the Core (4.0). However, due to the high volatility of values, the final increase of the distance may not be considered to be a long-term trend.

Although the SED of the New Periphery of the EU oscillated in higher values than those in the other clusters in all periods, it must be noted that the distances kept decreasing in most economies in the final period. This development of the distances, different from that in the Southern Periphery, means that the average distance of economies in this cluster was 16.46 in 2013, i.e. lower than in the previous cluster. The evaluation of the distance development in time is similar to both the previous clusters; once again, due to significant oscillation of values the decreasing of SED may not be considered to be a long-term trend.

Figure 2 shows the means and standard deviations of the SED between individual European Union economies and Germany (covering the period of 2001 – 2013).

F i g u r e 2

Means and Standard Deviations of the SED between European Union Countries and Germany, period 2001 – 2013



Source: Own calculations.

The results presented indicate that France shows the lowest mean SED value in relation to Germany when OCA criteria are included in the cluster analysis. France also shows minimum SED volatility (standard deviation). Thus, as comprehensive evaluation indicates, France has the highest level of structural similarity with Germany from all the economies included in the analysis in the period monitored. Other countries with low mean SED include the Core cluster members – Sweden, Austria, Finland, and Denmark (below 4 for all of them). The SED volatility in the period in question is also at low levels.

The highest mean SED are those of Slovakia (19.2), Poland (20.0), Ireland (20.4), and Hungary (25.2), all members of the New Periphery cluster. Hungary and Ireland also show an average size of the standard deviation, which may be interpreted as the relative stability of lasting structural differences compared to the economy of Germany.

Conclusions

The 2013 analysis defined the composition of the EU Core as a relatively broad area of economies, in most cases, geographically close to Germany. The analysis results show that the Core of the European Union in the early 21st century cannot be defined definitely and that its composition varied in the years monitored. Despite a missing SED decreasing trend which would indicate convergence tendencies, these economies were significantly closer to each other than the economies of the Southern and New Peripheries of the European Union.

The average distances of countries forming the Southern and New Peripheries were very similar; however, there was an observable difference between them in the recent development when the distances of the New Periphery members to Germany were reduced, but the distances of the Southern Periphery members were extended. However, these changes need not present the beginning of a long-term trend which would indicate the existence of deeper convergence tendencies.

Besides their geographical proximity to Germany, the EU Core members are distinguished by the relatively good conditions of their economies with lower interest rates and production close to the potential product level. The Southern Periphery cluster, formed by economies of the southern wing of the EU, reach significantly worse values than the Core economies practically in all criteria. Higher interest rates and under-potential performance of economies are the defining elements of the Southern Periphery as well as the New Periphery, whose dissimilarity from the other two clusters lies especially in high openness to foreign trade.

In conclusion it may be said that the assumption regarding the convergence of European Union economies, expressed through the inclusion of the economies in the Core cluster with permanently decreasing SED, did not prove to be correct. Neither convergence nor divergence could be proven in the development of the distance of individual European Union economies in relation to Germany, because no trend-like tendencies were identified here, either.

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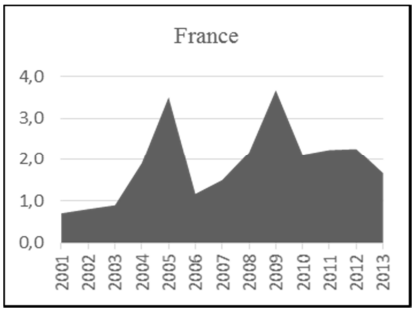
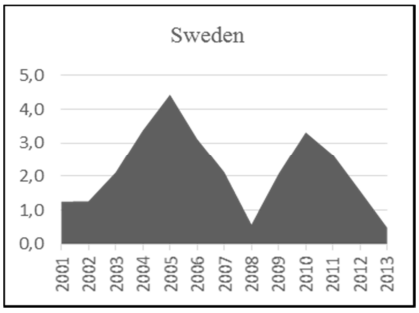
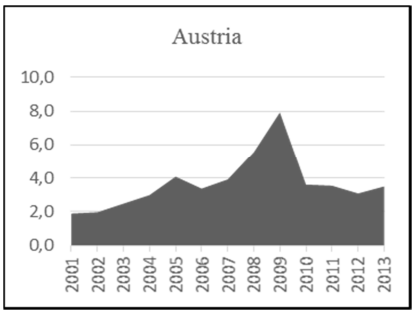
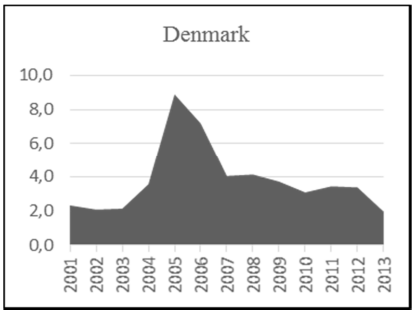
A p p e n d i x 1

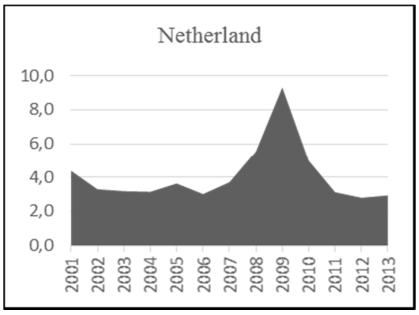
Development of Distances between Germany and Selected Countries

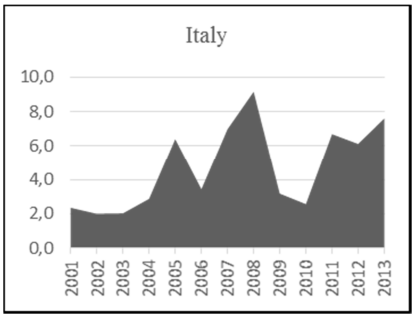


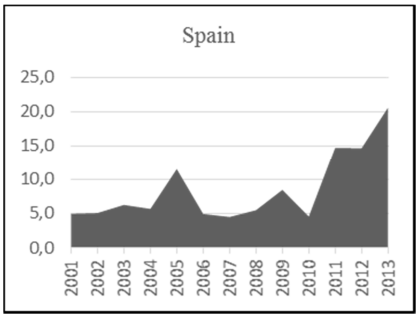


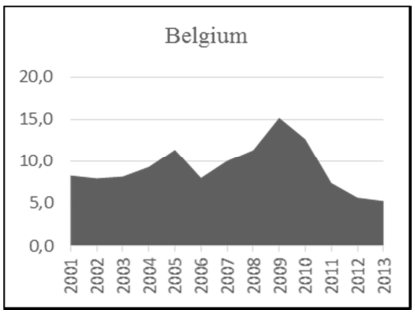








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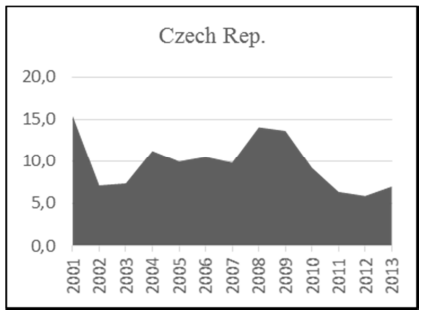
2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013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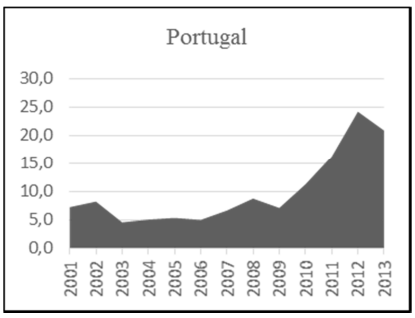
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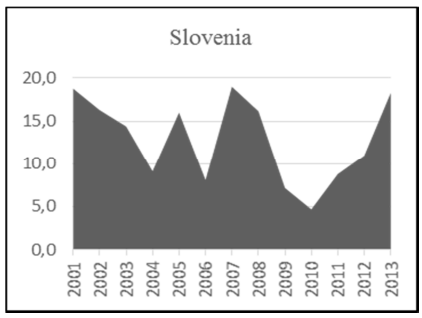
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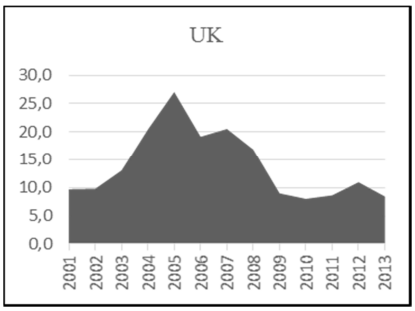
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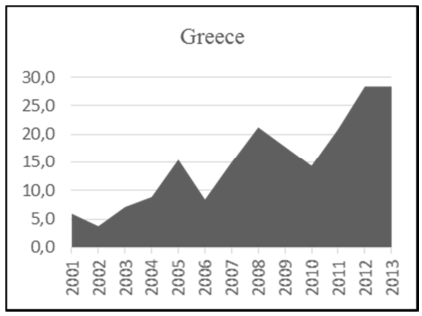
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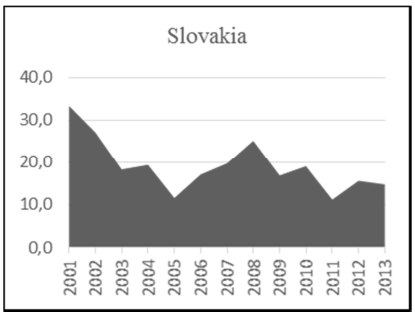
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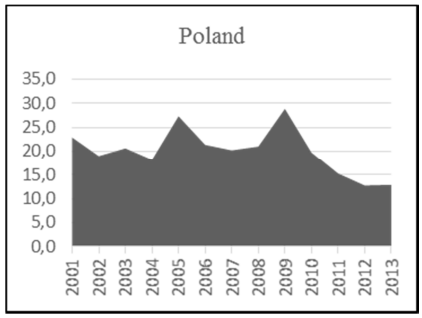
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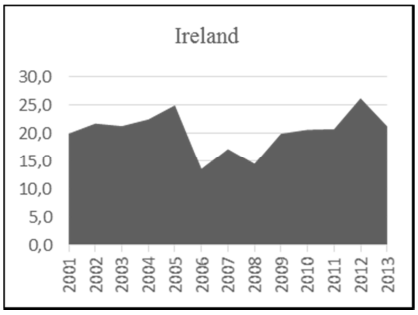

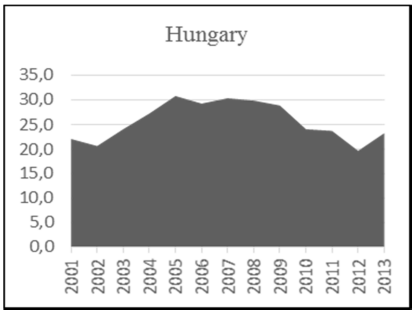

Note: The value on the vertical axis represents the distance between Germany and particular economy.
Source: Own calculation.