

Cluster analysis of OCA Criteria in Euro zone

Diploma thesis

Thesis supervisor:

doc. Ing. Lubor Lacina, Ph.D.

Bc. Marek Korenko

Brno 2015

Acknowledgment

I would like to express my sincerest gratitude to my parents for supporting me and encouraging me throughout my whole studies and also to my supervisor doc. Ing. Lubor Lacina, Ph.D. for his highly professional approach, time and effort he dedicated into this thesis and also for all valuable pieces of advice and recommendations I was given from him.

Statutory Declaration

Herewith I declare that I have written my final thesis: “Cluster analysis of OCA criteria in Euro zone” by myself and all used sources and data are quoted in the list of references. I agree that my work will be published in accordance with Section 47b of Act No. 111/1998 Coll. on Higher Education as amended thereafter and in accordance with the *Guidelines on the Publishing of University Student*.

I am aware of the fact that my thesis is subject to Act. No. 121/2000 Sb., the Copyright Act and that the Mendel University in Brno is entitled to close a licence agreement and use the results of my thesis as the “School Work” under the terms of Section 60 para. 1 of the Copyright Act.

Before closing a licence agreement on the use of my thesis with another person (subject) I undertake to request for a written statement of the university that the licence agreement in question is not in conflict with the legitimate interests of the university, and undertake to pay any contribution, if eligible, to the costs associated with the creation of the thesis, up to their actual amount.

In Brno on: 21. 05. 2015

Abstract

KORENKO, M. *Cluster analysis of OCA criteria in Euro zone* Brno, 2015. 68p. Diploma thesis. Mendel University in Brno.

The main objective of this diploma thesis is to examine the OCA (Optimal Currency Area) criteria via cluster analysis on the European countries and identify an existence of the “core group” and “periphery groups” within in a time. The data set is composed from 25 European countries which are divided in two groups and separately examined by cluster analysis as well. The first group is created from 15 Western European countries and the second group is created from 10 CEE (Central Eastern European) countries. There are three observation periods for the applying the cluster analysis. The main and the longest period is 14 years (2000-2013), which is divided in two sub-periods in order to see the changes of clusters in a time. Hence, the second observation period is pre-crisis period (2000-2008) and the third observation period is after the crisis period (2008-2013).

Keywords

Optimal currency area criteria, cluster analysis, monetary integration, monetary union

Abstrakt

KORENKO, M. *Zhluková analýza OCA kritérií v Euro zóne* Brno, 2015. 68p. Diplomová práca. Mendelova Univerzita v Brne.

Hlavným cieľom tejto diplomovej práce je preskúmať OCA (Optimálna menová Oblasť) kritéria pomocou zhlukovej analýzy na európskych krajinách a identifikovať tak „základnú skupinu“ a „periférne skupiny“ v čase. Dáta sú tvorené z 25 európskych krajín, ktoré sú rozdelené do dvoch skupín a taktiež samostatne preskúmané zhlukovou analýzou. Prvá skupina je vytvorená z 15 západoeurópskych krajín a druhá skupina je vytvorená z 10 východoeurópskych krajín. Zhluková analýza je aplikovaná na tri pozorovacie obdobia. Hlavné a najdlhšie pozorovacie obdobie má 14 rokov (2000-2013) a je rozdelené do dvoch pod období a to s cieľom zachytiť zmeny zhlukov v čase. Teda, druhé pozorovacie obdobie je pred krízové (2000-2008) a tretie pozorovacie obdobie je po krízové (2008-2013).

Kľúčové slová

Kritéria optimálnej menovej oblasti, zhluková analýza, monetárna integrácia, monetárna únia

Content

1	Introduction	9
2	Objectives	10
3	Literature review	11
3.1	The OCA theory and its progression.....	11
3.1.1	Fragility of the OCA theory.....	15
3.1.2	The endogeneity hypothesis.....	17
3.2	Elaboration of the OCA criteria.....	20
3.2.1	Elaboration of the OCA criteria via cluster analysis of Western European countries.....	22
3.2.2	Elaboration of the OCA criteria via cluster analysis of CEECs.....	25
4	Methodology	32
5	Practical part	36
5.1	Merging process of Western European countries.....	36
5.2	Merging process of CEECs.....	43
5.3	Merging process of all the countries.....	49
6	Discussion	57
7	Conclusion	60
8	Bibliography	63
A	Alternative method of cluster analysis	67

List of Figures

Figure 1	The basic functioning of the OCA criteria	12
Figure 2	Benefits from forming the monetary union based on two key OCA characteristics	17
Figure 3	Process of endogeneity of OCA criteria	19
Figure 4	Merging process by group average clustering (1979 – 1995)	24
Figure 5	Merging process by centroid clustering (1979 – 1995)	25
Figure 6	Merging process of Western European countries with respect to Germany (2000-2008)	38
Figure 7	Merging process of Western European countries with respect to Germany (2008-2013)	40
Figure 8	Merging process of CEECs with respect to EMU (2000-2008, 2008-2013)	45
Figure 9	Merging process of all the countries from the data set with respect to Germany (2000-2008)	51
Figure 10	Merging process of all the countries from the data set with respect to Germany (2008-2013)	54
Figure 11	Merging process of all the countries from the data set with respect to Germany (2000-2013)	55
Figure 12	Merging process of CEEC with respect to EMU, Weighted pair-group average method (2000-2008,2008-2013)	67
Figure 13	Merging process of Western countries with respect to Germany, Weighted pair-group average method (2000-2008, 2008-2013)	68
Figure 14	Merging process of all the countries with respect to Germany, Weighted pair-group average method (2000-2008,2008-2013)	68

List of tables

Tab. 1	Description of the OCA criteria	14
Tab. 2	Measurement of the chosen OCA criteria with respect to Germany (1979 - 1995)	23
Tab. 3	OCA criteria and economic convergence of CEEC to the EMU	26
Tab. 4	Evolution of CEEC clusters between 1993-2001 based on OCA criteria with respect to the EMU countries	27
Tab. 5	Correlation of GDP and Inflation for chosen EU countries (1991-2000)	29
Tab. 6	Cross concordance indexes of the growth business cycles of the Eurozone member and candidate countries (1996-2009), (HP filter, BP filter)	31
Tab. 7	Summarization of methodology	35
Tab. 8	Correlation matrix of OCA criteria (Merging process of Western European countries)	36
Tab. 9	Criteria by Optimal Currency Area calculated for Western European countries with respect to Germany	37
Tab. 10	Merging process of CEECs with respect to Germany (Ward's method)	42
Tab. 11	Correlation matrix of OCA criteria (Merging process of CEECs)	43
Tab. 12	Criteria by Optimal Currency Area calculated for CEECs with respect to EMU	44
Tab. 13	Merging process of CEECs with respect to EMU (Ward's method)	48
Tab. 14	Correlation matrix of OCA criteria (Merging process of all the countries)	49
Tab. 15	Criteria by Optimal Currency Area calculated for all the countries with respect to Germany	50

1 Introduction

After the financial crisis in 2008 and debt crisis, more and more people have become Euro skeptical and they have started to proclaim that EuroZone is more a political project than an economical project. Of course, it is well known that the EU is a project of politicians and politics should be closely related and connected to an economic science in order to make optimal decisions for people. The main reason of scepticism is that countries fulfill neither the Maastricht criteria nor the Optimal Currency Area theory (OCA).

The OCA theory was originally composed by the Canadian economist Robert Mundell in 1961 and the theory has been advanced several times. This theory describes criteria/conditions that must be met by countries that want to benefit from a common currency area. Mundell stated that if a country does not meet the conditions, costs to enter the currency area will outweigh benefits from the entering and the country will not be better off. Once the candidate is ready to do this so, the country has to be aware that potential asymmetric shocks are not going to be adjusted on a national level, according their preferences and needs, but according to the needs of all members of the Monetary Union. Hence, there will be just one central monetary policy for all countries of the area.

Based on Mongelli (2002) the OCA theory includes *flexibility of labor force and other factors of productions, flexibility of wages and prices, openness of economy, diversification of a production and consumption, similarity in inflation rates, and fiscal integration and political integration*. Using this theory as a benchmark for the candidate countries to enter the monetary union is considered as a very eligible way due to variety of conditions that help us to choose the most suitable group of countries that will be able to adjust potential asymmetric shocks smoother and easier and will definitely benefit from it. Therefore this theory offers us an alternative to verify and assess whether the candidate country will benefit from a membership or not. Ergo, this point brings us to a question how to detect the most suitable group of countries, the homogeneous group, to create the monetary union. One of the options that was used in Europe by Dimitri Boreiko (2002), M. J. Artis and W. Zhang (2001) and in East Asia by Saifuzzaman Ibrahim (2008) was an implication of cluster analysis of the OCA criteria. Based on the analysis the authors created a “core group” and “periphery groups” of the areas. This diploma thesis will expand and enhance these findings. Furthermore, Frankel and Rose (1996) had elaborated this theory before and came up with a crucial and very discussed result which states that the countries might fulfill the OCA criteria ex-post. The authors found a correlation between economic cycles and intensity of a trade within the OCA countries. This foundation brings a positive effect on being in the monetary union.

This diploma thesis will elaborate Frankel’s and Rose’s (1996) way of looking at the OCA theory in time by using cluster analysis. I will try to find out the existence of clusters in the European Union economics and examine them within a time.

2 Objectives

As was mentioned, the OCA is one of the well known and used theories for elaborating monetary integration nowadays. This theory can be very helpful for assessment of candidate countries that are trying to find an optimal way to join a currency union. This diploma thesis is inspired by a paper work of M. J. Artis and W. Zhang (2001) and also by a paper work of Dimitri Boreiko (2002). Both paper works elaborated the OCA criteria on the European countries via cluster analysis but with different countries in a data set. M. J. Artis and W. Zhang (2001) examined in their paper work just the original members of the Euro zone without adding CEECs (Central and Eastern European Countries). However, D. Boreiko (2002) did the analysis on readiness of just CEECs to enter EMU. This diploma thesis will expand these two studies and will examine the OCA criteria of 25 EU countries via cluster analysis.

Hence, the main objective of this diploma thesis is to examine the OCA criteria via Cluster Analysis and identify an existence of the “core group” and “periphery groups” within countries of the EU in a time.

Furthermore, the endogeneity of a monetary integration process means that all OCA conditions do not have to be fulfilled ex-ante, after the entering the monetary union but they can be fulfilled ex-post. In economical science there are two positions to this theory. The first is a position of the European commission (1991) that supports an idea of endogeneity of monetary integration process. The clarification is following, intra-industry trade leads to similar specialization patterns and integration leads to more equal economic structure and simultaneously less asymmetric shocks. The second is a position of Krugman (1993) who stated that a common currency creates more asymmetric shocks. *According to Krugman, integration will lead to clustering between the countries because countries will take an advantage of economies of scale - agglomeration effect.*

3 Literature review

On 31st of December 1998 were fixed eleven currencies in the European Union which created good condition and specific area for elaborating the significance of various concerns about monetary unification – especially elaborating the OCA theory on the economies of European countries. Even Mongelli called this integration process as a “laboratory conditions” for examining OCA theory. Besides, the working papers that have been elaborated this topic so far suggest that Euro zone might not fulfill all OCA criteria (Mongelli, 2008). This chapter describes the main features of the OCA theory and furthermore lays out weaknesses, limitations but also and advantages. Afterwards the findings and results from different scientific working papers and studies will be described in order to provide sufficient background for a practical part.

“EMU will have a very pervasive impact on the working of the economy. Many different mechanisms will come into play and interact.”

“One Market, One Money” (1990)

3.1 The OCA theory and its progression

It has been more than 50 years since Robert Mundell came up with the optimum currency area theory (1961) that has been elaborating by many economists afterwards. Mundell was considered as a father of this theory and his research on this topic was awarded by Nobel-price in 1999. Although, the theory was collectively created by two well know economists McKinnon (1963) and Kenen (1969). Some of the insights had been presented before by Friedman (1953) and Meade (1957).

According Mongelli (2008) an optimum currency area (OCA) can be defined as “*the optimal geographical area for a single currency, or for several currencies, whose exchange rates are irrevocably pegged. The single currency, or the pegged currencies, fluctuate jointly vis-à-vis with other currencies*”. Mundell (1961 in Ricci 2008) defines the OCA as “*a currency area for which the cost of relinquishing the exchange rate as an internal instrument of adjustment (i.e. within the area) are outweighed by the benefits of adopting a single currency or a fixed exchange rate regime*”. Ergo, the area is defined freely by sovereign countries that choose to take part in the currency area in order to benefit from it.

Before we start to examine this theory it is important to mention that a lot of economists like Mundell, Baldwin or McKinnon agreed that it is very hard to define whether country will benefit from the common currency or not. Hence, this theory has limitations that are described in the next chapter.

The OCA theory describes following criteria that should be fulfilled in order to benefit from it. Baldwin and Wyplosz (2008) single out *three economic criteria and three political criteria*. The first criterion is *mobility of factors of productions including labor* defined by Mundell 1961. It deals with minimization of asymmetric

shocks¹ within monetary union. Another two economic criteria are the *diversification in production and consumption* defined by Kenen (1969) and the *degree of economic openness* defined by McKinnon (1963). The political criteria deal with political aspects. These criteria (Solidarity, Transfers and Unity of objectives) say whether the countries that share the common currency are willing to help each other when asymmetric shocks occur. Baldwin and Wyplosz (2008) describe basic logic of the OCA theory in the following figure 1.

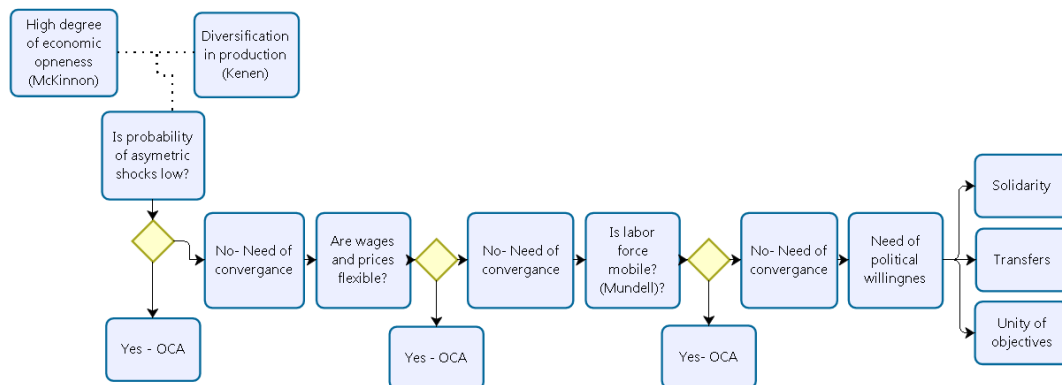


Figure 1 The basic functioning of the OCA criteria

Source: Author's adjustment from Baldwin and Wyplosz 2008

The first and important question when we start elaborate sharing a single currency is following. Is a probability of asymmetric shocks between countries that are willing to share a single currency high? If an answer is negative costs from entering the monetary union are low. Furthermore, Kenen (1969) noted that countries with high diversification of goods that are traded will face to asymmetric shocks with very lower probability². Another important question is related to flexibility of prices and wages. If wages and prices are not flexible, there is a need of convergence. Baldwin and Wyplosz (2008) noted that if there is a low diversification in production the wages and prices are not flexible in the same time, there is a high potential risk that countries sharing a common currency will find very hard to fight expected asymmetric shocks. Next question is related to ability of the countries to force these asymmetric shocks. Mundell's criterion says that if the wage flexibility is not sufficient, the labor mobility decreases impacts of asymmetric shocks. Even if this answer is negative and labor mobility is not sufficient, the need of political willingness in form of transfers from federal budget, unity of objectives and solidarity is needed to keep the monetary union alive.

¹ Financial Times Lexicon online 2015 defines asymmetric shock as an economic event that affects one economy or part of an economy more than another.

²A level of diversification in consumption and production, different variety of occupations/jobs reduce the potential asymmetric shocks. Ergo, the country's output is becoming less dependent and in the same time more diversified which diminishes the needs of exchange rate adjustments.

However, during the time, the theory was elaborated and advanced several times and some criteria have been added. Nowadays, Mongelli (2008) defines these 8 criteria: **price and wage flexibility, mobility of factor of production including labor, financial market integration, degree of economic openness, diversification in production and consumption, similarities of inflation rates, fiscal and political integration**. All the criteria are described in the following table one. *Hence, by applying these OCA criteria between the countries, the usefulness of nominal exchange rate is reduced.* Mundell (1961) and McKinnon (1963 in Ricci 2008) noted that the more open country is the less effective is the exchange rate. The reason is because wages and prices are expected to quickly neutralize the change in the exchange rate. Conversely the more open country is the higher risk of foreign shocks can be expected. However, the theory has also weaknesses and limitations that that were pointed out during an elaboration of the theory in its stages of evolution (*pioneering stage, reconciliation stage, reassessment stage and empirical stage*) will be elaborated in following chapter, Mongelli (2002). In 70s and 80s after the pioneering stage was defined new so called “meta criterion”, that is focused *on business cycle synchronization*. This meta criterion includes an impacts of criteria defined in the very beginning of the OCA theory, Mongelli (2002). Rozmahel and Najman (2010) noted that if the currency union members enjoy long term business cycle synchronizations, the risk of asymmetric shocks decreases and afterwards a necessity of monetary and exchange rate policy decrease as well.

According to Mongelli (2002) the main features of the 60s were definitely Bretton Wood exchange rate regime, capital controls in many countries and also initial process of European integration. The *OCA theory was created based on debates between fixed and flexible exchange rate regimes* and comparison of the US and the European economies. These debates created a base for so called “criteria”, “prerequisites” or “characteristics”, which are described in following table.

Tab. 1 Description of the OCA criteria

Name of criteria	Description
Price and wage flexibility	According Mongelli (2008) if prices and wages are flexible between two countries that share a common currency, the flexibility helps to adjust potential asymmetric shocks – especially unemployment (the economy in the country is hit by recession) in one country and inflation (the economy in the country is hit by excessive expansion/growth) in another one. Hence, it will in turn decrease the need for nominal exchange rate adjustment (Freidman 1953 in Mongelli 2008).
Mobility of factors of production including labor	High level of mobility of productions factors between countries that share a high level of factor market integration reduces a need to change prices of real factors and nominal exchange rate as a reaction to disturbances (Mundell in Mongelli 2002). Furthermore according the theory of trade the mobility of factors of production magnifies efficiency and welfare. The country that is hit by recession and high unemployment will shrink its unemployment by mobility of workers to the country where is demand overhang on labor market, hence economy is back in the original equilibrium. However, the mobility is limited by the velocity of generation of direct investments and absorption by another one. Correspondingly, the labor mobility in a short run is low because of cost related to retraining and migration (Mongelli 2008).
Financial market integration	Ingram (1962 in Mongelli 2008) noted that integration of financial market is likely to shrink the need for exchange rate adjustments. This can protect short-term disturbances through capital inflow. High level of financial market integration is connected to high level of capital mobility. Hence in case of interest rate changes the capital flow is produced and that subsequently helps to adjust equilibrium back. That criteria decrease differences between long-term interest rates and increase accessibility of financing.
The degree of economic openness	McKinnon (1963) noted that if the country has the high level of economic openness, the lower cost on entering the monetary union is applied. Additionally with high level of economic openness, the more changes of international prices are transmitting to the domestic living cost. Hence, it would reduce exchange rate and money illusion for workers. Furthermore frequent use of devaluation is much more rapidly transmitted to the price of goods and adversing its intended effects. Mongelli (2008) in his publication noted

	that the economic openness should be evaluated also with the overall openness of a country to trade with the world, level of openness with countries that intend to share single currency, share of non-tradable against tradable goods and also services.
The diversification in production and consumption	A high level of diversification of consumption and production, different variety of occupations/jobs, subsequently in export and import, reduce the potential shock specific to any particular sector. Ergo, diversification diminishes needs for changes in nominal exchange rate adjustment (Kenen in Mongelli 2008).
Similarities of inflation rates	Fleming (1971 in Mongelli 2008) noted that if countries have the same inflation preferences, similar and low over time, trade also remain fairly stable and this reduces a need for nominal exchange rate adjustment.
Fiscal integration	Creating a supranational budget that enables sharing fiscal transfers to countries that are hit by asymmetric shock could facilitate the adjustment process without a needs for changes in nominal exchange rate (Kenen in Mongelli 2008).
Political integration	According Mintz (1970 in Mongelli 2008) political will to create monetary union is one of the most important elements for the creation. Tower and Willett (1976 in Mongelli 2008) noted that success of monetary integration is defined by willingness of participant countries to make a compromise in terms of specific preferences like ability to make supranational macro-economical objectives or even creation of federation.

Source: Mongelli (2008)

3.1.1 Fragility of the OCA theory

The aim of this subchapter is to present arguments of economists who referred on boundaries of this theory. Right after the OCA theory was published and finished, several well-known economists pointed out on limitations and weaknesses of this theory, for example problem of inconclusiveness, difficulties to measure the criteria and problem of inconsistency of the criteria. These notes on the limitations and weaknesses emerged over time the theory was examined.

“It is arguable that the optimum-currency-area issue ought to be the centerpiece of international-monetary economics.”

Krugman, 1993

“The theory of Optimal Currency Area is, unfortunately, one of the low points of post-World War II monetary economics.”

Buiter, 2000

Ishiyama (1975 in Mongelli 2002) pointed out on the limitation of the criteria. Every country should evaluate costs and benefits from participating in the currency union, from the point of view of its self-interest and welfare. The point here is that differences in inflation rates result from different social preferences and different national demand policies.

Tavlas (1994) pointed out the “problem of inconclusiveness”. This problem describes that the OCA theory is short of unifying framework. Tavlas described this issue as a situation when country might be sufficiently open to trade with member countries and therefore the fixed exchange rate regime would be preferable or even monetary integration, of course just with the trading partners. Although the problem could arise when the same country demonstrates low mobility of factors of production, including labor, vis-à-vis the trading partners. This indicates that the flexible exchange rate regime would more appropriate in that case. Robson (1987) noted that it is difficult to measure some of OCA criteria.

Mongelli (2008) noted in his working paper that with hindsight, the importance of services in post-industrialized economies could not be foreseen in the early OCA theory. Furthermore, with hindsight in the early OCA theory the pervasive role of institutions in hindering labor market flexibility could not be predicted as well.

Additional limitation which was described by Tavlas (1994) is called “problem of inconsistency”. In that case some criteria might be inconsistent to another one. As was mentioned before for smaller and relatively open economies is better to us the fix exchange rate regime or even continue in monetary integration. However, the small relatively open economies are expected to be less differentiated in production comparing to big economies. Furthermore, McKinnon (1969) notes that “more differentiated economies are generally larger and have smaller trade sectors”.

Emerson at al. (1992) noted in the report “One Market, One Money” that we do not have “ready-to-use” theory for valuation of costs and benefits of EMU (Economic and Monetary Union) and this theory provides just an outline to define the optimum economic and monetary competencies for the EU. Additionally, Tavlas (1993) points out that “the OCA theory was assigned to “intellectual limbo³” between 1970 and 1980.

³Cambridge Dictionary online 2014 describes limbo as an uncertain situation that you cannot control and in which there is no progress or improvement.

3.1.2 The endogeneity hypothesis

According to Frankel (1999 in Mongelli 2002) this hypothesis predicts a positive link between a trade integration and income/output correlation between the country members. He set aside two main OCA properties as essential in assessing the net benefits from currency union. The first is the degree of openness (the extent of reciprocal trade among a group of member countries) and the second is the correlation of business cycles. Hence, countries sharing a high level of income correlation or openness, ideally both of them, will find beneficial to enter monetary union and share the single currency as it is illustrated on the figure 2.

The left side of the OCA line⁴ represents groups of countries (Sweden, UK, Denmark) or (Japan, EU, USA) where advantages from having a national monetary policy dominate by a common monetary policy. On the other side, the USA and the current member states of EuroZone are located on the right side, according Mongelli (2002) and Paul De Grauwe (2012). They are taking advantages from having a single currency and common monetary policy.

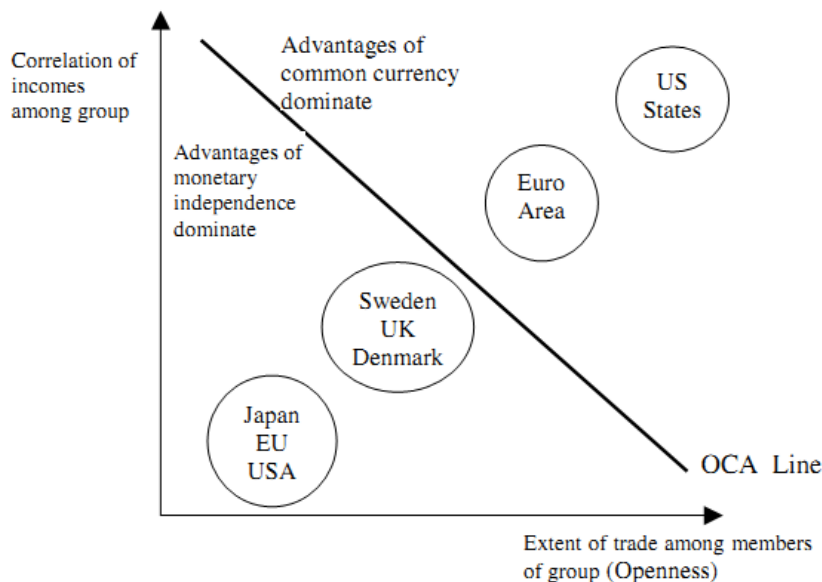


Figure 2 Benefits from forming the monetary union based on two key OCA characteristics

Source: Mongelli (2002)

⁴Frankel (1999) defines OCA line as a downward sloping line that represents trade-off between a combination of openness and correlation of income beyond which the advantages from the monetary union would dominate for a group of partner countries. Ergo, if the country is situated below the OCA line the disadvantages from being in the monetary union prevailed advantages thus is better to keep national monetary policy and conversely.

The endogeneity one more time

The basic idea behind this hypothesis is that countries that are considering entering a currency union, no matter what their motivation may be, may fulfill the OCA criteria ex-post even if they do not ex-ante. The authors of the hypothesis, Frankel and Rose (1997) in Mongelli 2002, suppose that the influence/impact of being in the monetary union will enable to fulfill the criteria ex-post.

This hypothesis elaborated two main OCA characteristic that had a positive impact on the endogeneity. The first criterion is the openness of economy and second is convergency of economic cycles. According to the authors, the monetary integrations will:

- reduce trading costs⁵ between the member states,
- eliminate exchange rate volatility,
- facilitate foreign direct investments,
- build a long-term relationship between the member states,
- promote reciprocal trade,
- facilitate business cycle synchronization among the countries sharing a single currency and
- promote economic and financial integration.

Mongelli (2002) explain this theory on the following pictures. We expect that the countries entering monetary union are initially in point 1 and form a “union” which is identical to the EU. Thanks to the union and its internal market (trade barriers will decrease) the trade integration and correlation of business cycle within the countries will rise. Ergo, the countries will gradually move to point 2. If the countries decide to create and enter currency area (which is EMU on the picture), the level of the trade integration between the countries and correlation of business cycle would rise again and the countries will find itself on the right side of OCA line.

However, M. J. Artis and W. Zhang (2001) pointed out that “at the present time, however, empirical support for the “endogeneity” view remains suggestive rather than conclusive”.

⁵ According De Grauwe (2012), The EC Commissions estimated these gains from elimination of transaction cost at a number 13 – 20 billion euros per year in 1990. Since EuroZone has now 18 members, we can expect bigger number.

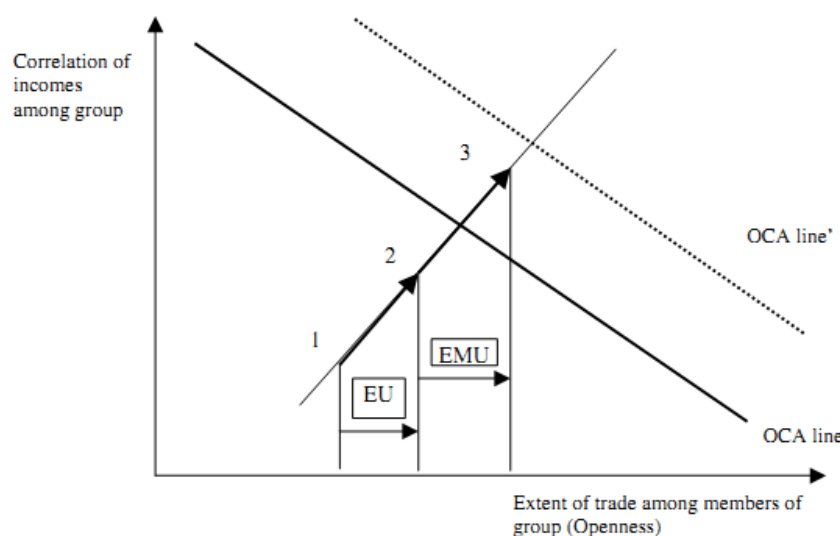


Figure 3 Process of endogeneity of OCA criteria

Source: Frankel and Rose in Mongelli (2002)

J. Fidrmuc elaborated in his paper works from 2002 and 2004 the endogeneity hypothesis of optimum currency area criteria that was stressed by Frankel and Rose (1998). He confirmed that “the convergence of business cycles relates to intra-industry trade, but finds no significant relation between business cycles and bilateral trade intensity”. The data sample consisted from the selected European countries. His results indicate that thanks to the high degree of intraindustry trade, the business cycles of accession countries and also the original member of EMU correlate with the German cycle much better. According to the results the growth of correlation of industrial production between (first observation period was 1991-1999 and the second was 1993-1999):

- *Germany and Hungary increased from 0,30 to 0,63,*
- *Germany and Poland increased from 0,23 to 0,45*
- *Germany and Slovenia was for the second period on the level 0,77,*
- *Germany and Czech Republic was for the second period 0,37,*
- *Germany and Finland increased from 0,39 to 0,69,*
- *Germany and Greece increased from 0,34 to 0,48,*
- *Germany and Spain increased from 0,84 to 0,92,*
- *Germany and Portugal increased from 0,59 to 0,56,*
- *Germany and Italy increased from 0,59 to 0,60,*
- *Germany and UK increased from 0,46 to 0,56,*
- *Germany and Sweden increased from 0,15 to 0,22,*
- *Germany and Denmark increased from 0,73 to 0,78,*
- *Germany and France increased form 0,87 to 0,91,*
- *Germany and Austria increased from 0,79 to 0,81,*

- *Germany and Netherlands decreased (as the only one but still keeps the sufficiently high correlation) from 0,59 to 0,56.*

His paper work also proves that selected CEEC countries have converged to the EU business cycle (especially Slovenia and Hungary) and also its trade integration sufficiently increased. Fidrmuc also stressed that the measurement period was not sufficiently long enough to conclude that business cycles are similar. Nevertheless, according to his expectation this trend can be expected even in the future due to increasing degree of intraindustry trade.

3.2 Elaboration of the OCA criteria

The cluster analysis is one of the well-known techniques in science for pattern recognition that is used to check the existence of homogeneity, similarities and dissimilarities of structures in a data set and subsequently to separate the data according the specific criteria (Hana Řezanková, Dušan Húsek and Václav Snášel, 2009).

This technique has already been used to estimate similarities in economic structure of the European and also Asian countries based on OCA criteria or Maastricht criteria by Dimitri Boreiko (2002), M. J. Artis and W. Zhang (2001) and Saifuzzaman Ibrahim (2008). In order to estimate the most relevant results the authors applied different cluster methods like *a group average cluster analysis, fuzzy cluster analysis or centroid cluster analysis*.

M. J. Artis and W. Zhang (2001) can be considered as pioneers thanks to their early paper work on an application of the cluster analysis to the OCA criteria in Europe. Afterwards Dimitri Boreiko (2002) expanded the Artis and Zhang's (2001) version to CEECs (Central and Eastern European Countries). In the pre-EMU period the economic policy that was applied by the most EU countries was oriented to meet Maastricht criteria for entry. However, a subject of convergence of the European countries has become an issue of controversy whether a convergence process is going to continue, stop or stagnate. Bjorksten and Syrjanen (1999) mentioned that "economic divergence within the euro area remains significant and do not appear to be diminishing". However, J. Fidrmuc (2002, 2004) confirmed a convergence of business cycles. In order to capture the arguments of the OCA theory in EMU the statistical correlation of the six main OCA criteria (business cycle synchronization, volatility of the real exchange rate, synchronization in the real interest rate cycle, trade openness, convergence of inflation and labor market flexibility) have been applied between the European countries and Germany, France or Eurozone as a referent object in the following studies.

Business cycle synchronization

In terms of measurement of business cycle synchronization a cross-correlation method has become popular and used among many economists. The cross-correlation of the cyclical components of monthly industrial production series was used by M. J. Artis, W. Zhang (2001) and also by Dimitri Boreiko (2002)

afterwards the Hodric-Prescott (H-P) filter was used as well to get cyclical component. P. Rozmahel and N. Najman (2011) used an alternative approach to measure business cycle synchronization which is Concordance index. P. Rozmahel and N. Najman (2011) also applied Christiano-Fitzgerald band-pass filter (BP) but also H-P filter. Another alternative method to identify shocks is a switching vector autoregressive (SVAR) technique which was used by Bayoumi and Eichengreen (1993) or by Korhonen and Fidrmuc (2004). This approach was also used by Saifuzzaman Ibrahim (2008) who measured a standard deviation of the difference of the logarithm of real GDP (as a proxy for output) between the candidate country and the respective reference country.

Volatility of the real exchange rate (RER)

In order to detect a volatility between Deutsche Mark (DM) exchange rate and the others currencies the standard deviation of the log-difference of real bilateral DM exchange rates was used, where deflation is accomplished using relative wholesale (producer) prices, M. J. Artis and W. Zhang (2001), Saifuzzaman Ibrahim (2008) and Dimitri Boreiko (2002).

Volatility of interest rate

This exercise is used to assume a harmonization of the real interest rates that may be interpreted as an indicator of coordination in monetary policy with Germany. Again the cross-correlation of the cyclical components of the real interest rate cycle with German one was used. The H-P filter was used to accomplish detrending (M. J. Artis and W. Zhang in 2001). Different approach was used by Saifuzzaman Ibrahim (2008) who applied the standard deviation of the difference in the logarithm of real interest rate between the candidate and the respective reference country. A deflation was accomplished by using CPI (Consumer Price Index).

Trade openness

In terms of transaction costs the countries that export and import a lot of goods or/and services between each other are supposed to be good candidates for creating monetary union. As a measurement for this criterion a bilateral trade intensity was used for any country i as $(x_{ig} + m_{ig})/(x_i + m_i)$, x_i represents export and m_i represents import where g is a sign for a destination of goods – Germany. This approach was applied by Saifuzzaman Ibrahim (2008), M. J. Artis and W. Zhang (2001) and Dimitri Boreiko (2002).

Convergence of inflation

This criterion was measured by simple inflation differential: $x_i - x_g$ where x_i is the real inflation of i country respectively to x_g which is the real inflation of reference object (Germany), M. J. Artis and W. Zhang (2001). The same approach was used by Saifuzzaman Ibrahim (2008), Dimitri Boreiko (2002). However, a different approach was used, structural VAR mode (vector autoregressive model), by Fidrmuc and Korhonen (2004).

Labor market flexibility

It has been argued several times that labor flexibility is much higher in the US comparatively to Europe, additionally this is one of the most important criterion of “old OCA theory”. To quantify it M. J. Artis and W. Zhang (2001) used a ranking measure of rigidity of labor markets which was collected from OECD data base. The indicator measures severity of employment protection legislation (EPL) – used to measure labor market flexibility in their study. This criterion was used just only by M. J. Artis and W. Zhang (2001). D. Boreiko (2002) did not apply this criterion because of lack of the data for CEECs.

3.2.1 Elaboration of the OCA criteria via cluster analysis of Western European countries

Artis and Zhang’s (2001) paperwork studied the status of the EMU countries by the time when euro was launched. The data sample of their paperwork consisted of fifteen European Countries (France, Italy, Netherlands, Belgium, Denmark, Austria, Ireland, Spain, Portugal, Switzerland, Sweden, Norway, Finland, Greece, UK) and three non European Countries (US, Canada, Japan) for the period 1979 – 1995. The principal motivation of their paper work was to find out, based on applying the OCA criteria, whether the EU-15 countries create wholly homogeneous group, that would be essentially ideal, or on the contrary a “core group ”that can be distinguished from others “periphery groups ”.M. J. Artis and W. Zhang (2001) applied the group average cluster method and also the centroid clustering on eighteen countries that defined five main clusters. The clusters are ranked from the countries that enjoy the best correlation with respect to Germany.

1. The Core Group {Austria, France, Netherlands and Belgium},
2. The Northern periphery group {Denmark, Ireland, the UK, Switzerland, Sweden, Norway, Finland},
3. The Southern periphery group {Italy, Spain, Portugal, Greece},
4. The North America group {the US, Canada},
5. The Japanese group {Japan}.

The following table 2 describes the results of particular criteria with respect to Germany for each country in the data set.

Tab. 2 Measurement of the chosen OCA criteria with respect to Germany, (1979 – 1995)

	Correlation in business cycle⁶	Volatility of the exchange rate⁷	Correlation in interest rate cycle	Trade (% of total trade)	Inflation differential (%)	Labor market flexibility⁸
France	0,683	1,118	0,334	16,853	2,365	12
Italy	0,459	1,732	0,207	18,467	5,744	18
Netherlands	0,730	0,582	0,587	26,181	-0,204	7
Belgium	0,634	0,864	0,529	21,353	0,835	15
Denmark	0,343	1,039	-0,015	20,303	2,037	3
Austria	0,745	0,907	0,216	38,525	0,432	14
Ireland	0,193	1,244	0,136	9,650	3,634	10
Spain	0,444	1,617	-0,141	12,623	5,177	17
Portugal	0,474	1,629	0,031	14,156	10,398	16
Switzerland	0,164	1,297	0,420	26,256	0,148	4
Sweden	0,289	1,835	-0,031	15,515	3,322	11
Norway	0,253	1,277	0,088	14,643	2,731	9
Finland	-0,075	1,769	0,095	13,284	2,279	8
Greece	0,235	1,710	n.a.	19,132	13,848	n.a.
UK	0,217	2,174	0,017	13,137	3,305	5
US	0,106	2,838	0,066	4,984	1,871	1
Canada	0,123	2,787	0,161	1,848	1,910	2
Japan	0,744	2,399	0,157	4,177	-0,856	6

Source: M. J. Artis and W. Zhang (2001)

The following two figures (4 and 5) describe the difference between the results from the group average clustering method and centroid clustering method. The first cluster that is depicted is the red one. The red cluster represents the core group which enjoys the best correlation with respect to Germany. The core group consists from the same countries in the both methods, which is good sign, however Switzerland reflects a phenomena in the centroid clustering method. The labor market is different from German one, business cycle is not in phase with the German cycle but Switzerland enjoys a large trade with Germany and sympathetic monetary policy that helped them to merger with the core group at the stage 14. The blue cluster represents the Northern periphery group which consists from the same countries in both methods. The only difference between the clustering me-

⁶ The cross-correlations of the cyclical components of monthly industrial production series; detrended applied by the Hodrick-Prescott (H-P) filter.

⁷ Standard deviation ($\times 10^2$) of the log difference in bilateral real exchange rate against deutsche mark

⁸The rank of Germany is 13. According to EPL the US, Canada, and the UK are among the least heavily protected and the Mediterranean countries (Italy, Spain, Portugal) are among the most heavily protected countries.

thods is an average distance between clusters which is lower in centroid method because of different position of Switzerland in the both methods. A feature that stands out here is that these economies measured by these 6 OCA criteria are much more similar within the group than between the groups. The green cluster represents the Southern periphery group which consists from the same countries in both methods as well. Furthermore the average distance between clusters is very similar in the first and second method. The last black cluster represents the North America group and Japan. This cluster is the less similar to Germany, although the composition of the cluster is the same in both methods. A feature that stands out is the high business cycle correlation between Germany and Japan, whereas the European countries like the UK, Ireland and the Scandinavian group (Finland's position is remarkably low) do not enjoy such synchronization.

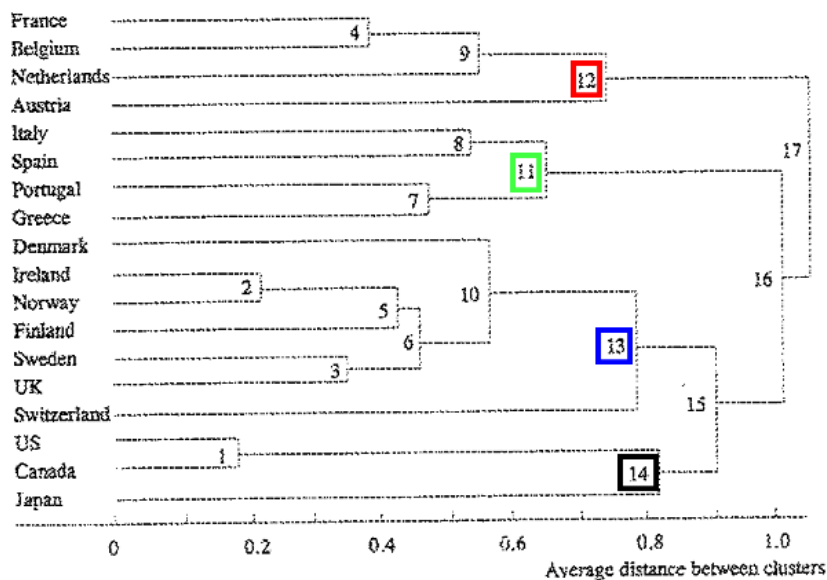


Figure 4 Merging process by group average clustering, (1979 – 1995)

Source: M. J. Artis and W. Zhang (2001)

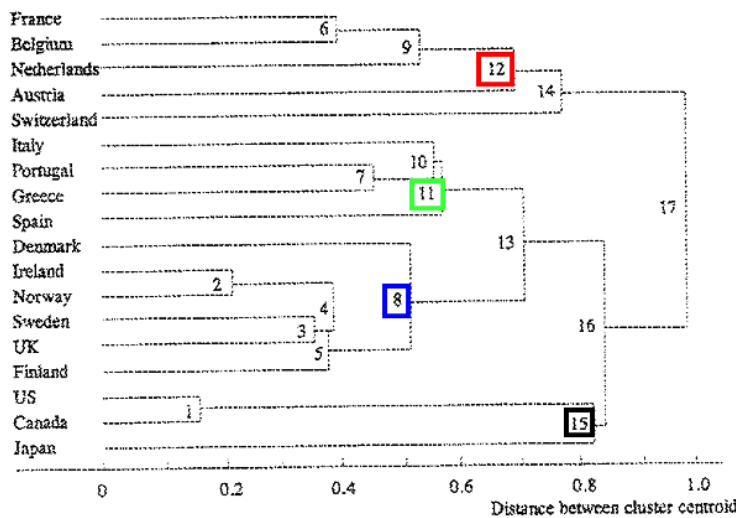


Figure 5 Merging process by centroid clustering, (1979 – 1995)

Source: M. J. Artis and W. Zhang (2001)

However this is not the only classification of the European countries into the groups or cluster that have been defined. Taylor (1995 in Artis and Zhang 2001) defined the core group that is ready for EMU from Germany, Netherlands, Luxembourg, Belgium, Denmark (if willing), Austria plus (tentatively) France. The group of four countries not ready for EMU was defined by Italy (tentatively), Spain, Greece, Portugal. He viewed Finland, Sweden, the UK, and Ireland as a group of countries that is left in between. Additionally, Bayoumi and Eichengreen (1997) defined the core group from Germany (center), Austria, Belgium, Netherlands excluded France but admitted Ireland and Switzerland, an OCA index method was applied as a measurement. Neither Taylor (1995) not Bayoumi and Eichengreen (1997) used cluster analysis.

3.2.2 Elaboration of the OCA criteria via cluster analysis of CEECs

Dimitri Boreiko, 2002, mentioned in his paper that he was inspired by Artis and Zhang results from 2001, therefore he decided to expand this research on CEE countries that were going to join the EU in 2004: Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. The main motivation of his paperwork was to estimate the readiness of the Accession Countries of Central and Eastern Europe for EMU by applying a fuzzy cluster analysis of membership for the period 1993-2001. Furthermore it was always argued that these countries satisfy the OCA criteria with respect to EMU and therefore it is beneficial to join. Dimitri Boreiko (2002) also mentioned that by joining the EMU the CEECs would enjoy lower risk premiums and simultaneously lower interest rates and as well lower transaction costs. Dimitri Boreiko (2002) examined readiness of CEECs countries based on just 4 OCA criteria: business cycles synchronization, volatility of the real exchange rate – RER, trade openness and inflation criterion. The methodology was very similar to M. J. Artis and W. Zhang (2001) that is

described in the chapter 3.2 simultaneously with other paper works. The particular OCA criteria results of the counties for the different time periods are depicted in the following table.

Tab. 3 OCA criteria and economic convergence of CEEC to the EMU

	Correlation in business cycles ⁹			Exchange rate volatility			Trade openness ¹⁰			Inflation differential ¹¹ (%)		
	1993-2001	1997-2001	1999-2001	1993-2001	1997-2001	1999-2001	1993-2001	1997-2001	1999-2001	1993-2001	1997-2001	1999-2001
Bulgaria	0,12	0,34	-0,32	4,45	3,53	0,48	0,45	0,48	0,50	159,1	218,2	5,00
Czech R.	0,20	0,50	0,52	0,97	1,16	0,71	0,59	0,63	0,66	6,3	4,0	1,70
Estonia	0,15	0,38	0,64	0,60	0,25	0,20	0,59	0,58	0,59	22,2	4,5	2,50
Hungary	0,52	0,60	0,84	0,85	0,68	0,62	0,64	0,69	0,70	14,8	10,4	7,90
Latvia	0,14	0,41	0,29	1,38	0,83	0,90	0,47	0,53	0,52	20,7	2,3	0,80
Lithuania	-0,32	0,04	0,05	2,00	1,42	1,53	0,40	0,44	0,46	60,2	1,5	-0,9
Poland	0,39	0,59	0,68	1,10	1,18	1,18	0,66	0,66	0,67	16,3	8,1	5,90
Romania	-0,12	0,06	0,33	3,04	3,54	1,48	0,55	0,60	0,63	86,8	66,0	40,0
Slovak R.	0,30	0,53	0,58	0,92	0,79	0,79	0,43	0,52	0,54	8,1	6,7	8,1
Slovenia	0,49	0,45	0,56	0,49	0,44	0,45	0,66	0,67	0,67	10,6	6,8	6,7

Source: Dimitri Boreiko (2002)

The data set from the table 3 displays a nice economic convergence to the EMU in mid-nineties. Boreiko Dimitri (2002) explained this convergence is a result of an economic restructuring and transition. These findings had been also confirmed before by study of J. Fidrmuc and F. Schardax (2000). We can notice that from the table number 4 during two periods from the beginning 3 clusters did not change its composition and were similar except Latvia that moved to the cluster of countries that enjoyed the best symmetry with respect to EMU: Czech R., Estonia, Hungary Poland and Slovenia. The analysis of the 3rd period 1997-2001 is highlighted by an improved performance of several countries – particularly Slovak Republic that moved from the worst performing cluster to the best performing cluster. D. Boreiko (2000) identified the group of the countries that are, base on the OCA criteria, more suited to join the EMU. The group consists from the countries of the 1998 Accession Group (Czech R., Estonia, Hungary, Poland, Slovenia) this was also confirmed by Rainer Schweickert studies from 2001 and 2002. Afterwards this group should be joined by Latvia and Slovakia over some period.

⁹ Although the estimates of Euro zone are available this exercise took German industrial production index as a reference. It is the same approach which was used by M. J. Artis and W. Zhang (2001).

¹⁰ An average for the period was used with reference to EU.

¹¹The Average for the period was used with reference to EMU.

Tab. 4 Evolution of CEEC clusters between 1993-2001 based on OCA criteria with respect to the EMU countries

	Business cycle correlation	Real exchange rate volatility	Trade openness	Inflation differential
1993-2001				
{Czech R., Estonia, Hungary Poland, Slovenia}	High	Low-Ave ¹²	High	Low-Ave
{Latvia, Lithuania, Romania}	Low	High	Ave	High
{Bulgaria, Slovakia}	Ave	High	Low	Mixed
1995-2001				
{Czech R., Estonia, Hungary Poland, Latvia, Slovenia}	High	Low-Ave	High	Low-Ave
{Lithuania, Romania}	Low	High	Low-Ave	Mixed
{Bulgaria, Slovakia}	Low	Mixed	Low	Mixed
1997-2001				
{Czech R., Estonia, Hungary Poland, Latvia, Slovenia, Slovakia}	High	Low-Ave	High	Low-Ave
{Lithuania, Romania, Bulgaria}	Low	High	Low-Ave	Mixed
1999-2001				
{Czech R., Estonia, Hungary, Slovenia}	High	Low	High	Low-Ave
{Poland, Slovakia}	High	High	Ave-High	Ave
{Lithuania, Romania, Latvia}	Low	High	Mixed	Mixed
{Bulgaria}	Low	Low	Low	Ave

Source: Dimitri Boreiko (2002)

Dimitri Boreiko results (2002) about readiness of CEECs to enter the EMU were considerably confirmed by results from paper work of J. Fidrmuc and I. Korhonen (2003). Fidrmuc and Korhonen (2003) examined a similarity of supply and demand shocks (these supply and demand shocks were obtained from 2 variables: output and inflation) between the Euro area and the CEECs. Their objective was to evaluate, based on similarity of supply and demand shocks, which of CEECs belong to the same optimum currency areas as the current members of the Euro zone. In order to examine the objective, they used two-variable (output and inflation) vector autoregressive models (VAR). The correlation of shocks was calculated with respect to Germany, France (these countries are considered as a "core" of the Euro area) and the Euro Area as a whole.

The results of Fidrmuc and Korhonen (2003) pointed out that some of the accession counties, especially Hungary, enjoy high correlation with the Euro area shocks, see table 5. The part of the best performing group countries with signifi-

¹² Average

cant correlation are also Estonia, Slovenia and Latvia. All these countries are also part the best performing group in Dimitri Boreiko (2002) paper work with an exception of Poland and the Czech Republic. On the contrary, Fidrmuc and Korhonen results from 2003 pointed out on low correlation of real GDP in the Czech Republic, Slovakia, Poland, and Lithuania with respect to the Euro area. According Fidrmuc and Korhonen (2003) results Estonia, Hungary, Slovenia and Latvia would be better off to join the Euro area club, but on the other hand Czech Republic, Slovakia, Poland, and Lithuania would not. In the following table 5 are presented results from Fidrmuc and Korhonen elaboration from 2003. Hungary is highlighted as the best performing country form the CEECs group. Furthermore, the Hungarian correlation with the Euro area is much greater than Greece or Portugal one.

Based on the GDP and inflation correlation Fidrmuc and Korhonen (2003) identified 2 groups of countries:

- *First group is composed form accession countries with low similarity of GDP and inflation {the Czech Republic, Lithuania, Poland, Slovakia, Turkey, Croatia, and few smaller OECD countries};*
- *The second group includes {Estonia, Latvia, Slovenia, Hungary and EU-15}.*

Moreover, based on result from this paper work Fidrmuc and Korhonen (2003) concluded that the EU countries or the Euro area are more homogeneous than the CEECs. The EU countries enjoy higher correlation coefficients and also smaller differences between them. Furthermore, CEECs has tended to regional grouping that created the Visegrad countries group (Slovakia, Poland, the Czech Republic and Hungary) or the Baltic States (Latvia, Lithuania and Estonia). Another important note according Fidrmuc and Korhonen (2003) is that Spain and Italy is moving from a periphery area to the core euro area.

Tab. 5 Correlation of GDP and Inflation for chosen EU countries (1991¹³-2000)

Country	GDP Growth			Inflation		
	Euro area	Germany	France	Euro area	Germany	France
Austria	0,64	0,57	0,66	0,48	0,85	0,74
Belgium	0,91	0,83	0,78	0,41	0,89	0,77
France	0,93	0,74	1,00	0,36	0,74	1,00
Germany	0,88	1,00	0,74	0,60	1,00	0,74
Italy	0,88	0,72	0,75	0,68	0,44	0,70
Netherlands	0,85	0,60	0,83	-0,23	0,03	0,06
Greece	0,42	0,49	0,68	0,06	0,71	0,79
Portugal	0,75	0,52	0,78	0,65	0,92	0,59
Spain	0,91	0,65	0,89	0,70	0,80	0,63
Finland	0,63	0,35	0,60	-0,21	-0,07	0,12
Sweden	0,59	0,42	0,62	0,23	0,62	0,85
UK	0,35	0,20	0,23	0,37	0,35	0,44
Ireland	0,69	0,33	0,40	0,47	0,05	0,31
Switzerland	0,76	0,53	0,78	0,47	0,74	0,74
Czech Rep.	-0,22	0,06	-0,42	0,20	0,74	0,56
Poland	-0,00	0,18	-0,31	0,13	0,47	0,75
Slovakia	-0,34	-0,17	-0,51	0,12	0,61	0,52
Hungary	0,83	0,86	0,73	0,04	0,48	0,78
Slovenia	0,35	0,45	0,29	0,45	0,71	0,77
Bulgaria	0,57	0,33	0,60	0,12	0,32	0,61
Romania	-0,03	-0,05	-0,11	-0,28	0,62	0,68
Estonia	0,35	0,42	-0,02	0,34	0,33	0,79
Lithuania	0,06	0,08	-0,15	0,29	0,46	0,86
Latvia	0,42	0,41	0,06	0,34	0,40	0,79
Croatia	0,11	0,19	-0,18	-0,58	-0,16	-0,15
USA	0,50	0,43	0,45	0,32	0,53	0,75
Turkey	-0,22	-0,14	-0,26	-0,11	0,06	0,20
Japan	-0,09	-0,05	-0,20	0,27	0,79	0,74

Source: J. Fidrmuc, I. Korhonen 2003 (modification by author)

The explanation of such positive and significant results of Hungary and Estonia can be explained by FDI (Foreign Direct Investments). These two countries have received obtained most FDI on a per capita basis and they have very intensive trade relation with the EU, indeed (Fidrmuc and Korhonen, 2003).

¹³ Because of unavailability to obtain more historical data set for CEECs, the measurement period for these countries started later, from 1993 for example for Slovakia or from 1995 for Poland or Lithuania.

Furthermore, Boone and Maurel (1998 in Fidrmuc and Korhonen 2003) in their working paper found a higher level of business cycle correlation for the assessing countries (Baltic countries were excluded) than for older members like Greece or Portugal. Boone and Maurel (1998) calculated a correlation coefficient between the cyclical components of industrial production and unemployment rates for the accession countries against Germany and the EU. Their results confirm the results of Fidrmuc, Korhonen (2003) that accession countries enjoy fairly good correlation, better than current members of Euro zone, with respect to Germany.

Another more present and interesting working paper focusing on Eurozone was composed by Rozmahel and Najman (2011). They analyzed business cycle similarity of Eurozone members and candidate countries by using a Concordance index (alternative approach). The concordance index technique measures the business cycle synchronization based on the identification of the phases of the cycle. "It specifies the proportion of time for which the countries have shared the same cycle phase" (Artis 2003 in Rozmahel and Najman, 2011). The phases of the cycle are modified into a binary series (1;0) where (1) indicates recession or (0) expansion in the cycle. From CEE countries authors chose Hungary, Poland, Slovakia, Slovenia and the Czech Republic due to its intensive economic and political relations and the comparable position at the beginning of transformation period in 90's. Germany, France, Austria, Portugal and the Eurozone were chosen as a core of the Euro zone.

According to the authors results Czech Republic and Slovakia appear to suffer from the output gap rather more than the Euro zone. Specifically, we can detect a significant deviation of Slovakian business cycle, because of higher economic growth from last years. Furthermore, authors concluded that the Eurozone countries enjoy higher classical business cycle concordance than new or candidate countries. Again, this paper work confirmed that Hungary and Slovenia show highly comparable business cycles to the Eurozone, whereas Slovakia¹⁴ is less synchronized with the Eurozone among chosen CEECs, see table 6.

¹⁴ Concordance index 0,55 - that means that the Slovakian economy shares the same phase of the Eurozone business cycle during a half of the analyzed period, which is not favorable result for a member of Eurozone due to higher risk of asymmetric shocks.

Tab. 6 Cross concordance indexes of the growth business cycles of the Eurozone member and candidate countries (1996-2009), (HP filter, BP filter)

	AT	CR	GER	EUR	FR	HU	POL	POR	SK	SLO
AT	1	0,70	0,66	0,70	0,96	0,95	0,75	0,80	0,52	0,77
CR	0,66	1	0,93	0,86	0,66	0,68	0,59	0,64	0,57	0,79
GER	0,71	0,66	1	0,89	0,63	0,64	0,66	0,57	0,61	0,86
EUR	0,77	0,68	0,77	1	0,66	0,68	0,70	0,61	0,57	0,89
FR	0,89	0,66	0,64	0,70	1	0,91	0,71	0,77	0,48	0,73
HU	0,71	0,66	0,64	0,55	0,68	1	0,73	0,79	0,54	0,75
POL	0,75	0,73	0,71	0,52	0,71	0,82	1	0,63	0,73	0,48
POR	0,66	0,50	0,80	0,57	0,59	0,73	0,73	1	0,68	0,57
SK	0,61	0,77	0,68	0,55	0,61	0,86	0,79	0,73	1	0,57
SLO	0,80	0,79	0,66	0,82	0,70	0,66	0,66	0,66	0,66	1

Source: P. Rozmahel and N. Najman (2011)

Elaboration of the OCA criteria via cluster analysis in Asia

Another pioneer was Saifuzzaman Ibrahim (2008) who was also inspired by previous working papers on analyzing the OCA criteria via cluster analysis. He decided to examine a study of the Optimum Currency Area in East Asia by applying the Cluster analysis as well. So called, "ASEAN +3" was chosen as a data set for the examining the feasibility study. However not all of the ASEAN countries were part of the research but just core members were picked: Indonesia, Malaysia, the Philippines, Singapore and Thailand plus China, Korea and Japan as a reference country. Saifuzzaman (2008) examined these countries based on the same five OCA criteria which have been used and described before are *volatility in real GDP*, *volatility of real exchange rate*, *volatility of real interest rate*, *trade openness* and *convergence of inflation*. To expand paperwork he also observed adjusted Maastricht Treaty criteria (inflation rate requirements, interest rate requirements, exchange rate requirements, limitation on deficit and debt) to suit ASEAN +3 which comprises mainly by emerging economies. By using this study, the results suggested that AMU (Asian Monetary Union) is not an optimal monetary union due to the non-homogeneity of the economies. Saifuzzaman (2008) mentioned that it would be very difficult for the group to adopt a "one size fits all" policy for analyzed countries.

4 Methodology

In this diploma thesis a cluster analysis is proposed to capture the basic ideology of the OCA theory on the chosen European countries. The cluster analysis, a multivariate explanatory statistical technique, is used to capture similarities in the data set between the selected European countries and reference object. EMU and Germany were applied as the reference objects to measure similarities in variables between the chosen European countries. This diploma thesis considers Germany as a putative center of the EMU because of its significant political and economical impacts on the European countries. Germany was also used and considered as a center of EMU in studies from M.J. Artis and W. Zhang (2002) and Dimitri Boreiko (2002) or J. Fidrmuc and I. Korhonen (2004).

The data set is composed from 25 European countries: *Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Ireland, Greece, Spain, France, Italy, Latvia, Lithuania, Hungary, Netherland, Austria, Poland, Portugal, Romania, Slovenia, Finland, Sweden, UK, Norway, Switzerland and Slovakia*. It is important to mention that two of these countries, Switzerland and Norway, are not part of the EU (European Union) but just part of the EFTA (European Free Trade Area), which enables them to participate in the EU's single internal market without being EU (European Union) and EMU (European Monetary Union) members. Additionally, 8 selected countries from the data set (Bulgaria, Czech Republic, Denmark, Hungary, Poland, Romania, Sweden and UK) are part of the EU and in the same time not participating in the EMU, which means that they still use their national currency. The rest of the countries from the data set (Belgium, Estonia, Ireland, Greece, Spain, France, Italy, Latvia, Lithuania, Netherland, Austria, Portugal, Slovenia, Finland and Slovakia) are in the same time part of the EU and the EMU.

Cyprus, Luxemburg, Malta were excluded from the data set because of its specific statistical characteristic¹⁵, Croatia was also excluded due to lack of data during the measurement period. The groups of countries, clusters, that were subsequently identified, by applying the cluster analysis, were similar with respect to Germany/EMU. The variables that were applied to measure similarities are: *business cycle synchronization, trade openness, convergence of inflation and synchronization in real interest rate*. The others OCA criteria were not used due to lack of data and problems with autocorrelation when the dummy variables were used. The mobility of labor force which could be measured by EPL (Employment Protection Legislation) was not applied because OECD does not provide records for all CEEC countries in the data set¹⁶. Volatility of exchange rate was not applied as well. The reason is that 15 countries from our data set have already accepted euro as a common currency,

¹⁵ M. Meloun, J. Militký mentioned in the publication: *Statistical Analysis of Experimental data* that outlying objects should be excluded from data set because the cluster analysis is very sensitive to not significant objects.

¹⁶ From Baltic countries just only Estonia has a record on the employment protection that has been dated since 2008. Bulgaria, Romania provide no records. Slovenia provides records since 2007.

therefore the cross-correlation of volatility of exchange rate between these 15 countries that have the same currency would bias the output from the analysis. Because of limitations to obtain more historical data on bilateral trade intensity the data sample was chosen from 2000Q2 until 2013Q3¹⁷. There are three observation periods for the applying the cluster analysis. The main and the longest period is 14 years (2000-2013), which is divided in two sub-periods in order to see the changes of clusters in a time. Hence, the second observation period is pre-crisis period (2000-2008) and the third observation period is after the crisis period (2008-2013). The reason of splitting the data set is to detect differences in the clusters before and after the financial crisis. The year 2008 was chosen because GDP (Gross Domestic Product) in Europe started to decline significantly into the recession. This diploma thesis examined the countries via cluster analysis separately in three parts with an aim to indentify the “core group” and the “periphery groups” in the data set, as was stated in the chapter objectives of the thesis. The first part elaborates Western European countries (Belgium, Netherlands, France, Italy, Portugal, Austria, Denmark, Spain, Greece, Sweden, Finland, UK, Ireland, Norway and Switzerland) before and after the crisis. The second part elaborates CEE countries (Bulgaria, Hungary, Czech Republic, Slovenia, Estonia, Slovakia, Lithuania, Romania, Latvia and Poland) and its evolution during the same observation periods. The reason of creating these sub-groups is to see an evolution of clusters after the studies of M.J. Artis and W. Zhang (2002) and Dimitri Boreiko (2002). The last and third part examined all 25 European countries together (CEECs and Western European countries) during the same observation periods and additionally for whole period of 14 years. In order to do cluster analysis with 4 variables for all chosen 25 countries, technical adjustments have been done, which are described in this chapter, because not all the countries keep the same methodology of records for the period of measurement.

Business cycle synchronization

In terms of measurement of business cycle synchronization a cross-correlation¹⁸ of a cyclical component of monthly industrial production time series was chosen (Baxter and Stockman 1989). Since, this diploma thesis expands the M.J. Artis and W. Zhang (2002) and Dimitri Boreiko (2002) paper works, the similar approach was used in order to capture synchronization in business cycle phase. To get purely cyclical component of the time series the Hodrick-Prescott (H-P) filter was chosen to de-trend this time series. The cross-correlation was applied for all the coun-

¹⁷ Eurostat provides statistical data on bilateral trade intensity for majority of the member partners only since 2000. Specifically Poland and Slovakia have a record of bilateral trade intensity with respect to Germany since 2003, for that reason an average was used to feel the gap.

¹⁸ Correlation coefficient, as a resultant, indicates linear association between two variables (time series in this case) on the range $<-1,+1>$. Negative correlation represents an opposite direction of the time series, whereas a positive correlation indicates that the time series vary but in the same direction. (P. Rozmahel, N. Najman 2011).

tries (25 countries) with respect to Germany (considered as a reputed center of the EU) and also with respect to EMU (EuroZone 19). The data set for this variable was obtained from Eurostat. In order to identify the best symmetry in terms of correlation the monthly time series were used instead of quarterly. There are no records of industrial production index for Switzerland available neither on Eurostat nor OECD. Therefore the cross-correlation of the cyclical component of quarterly GDP growth rate was used with respect to Germany.

Trade openness

The bilateral trade intensity between the European selected countries and Germany/EMU is applied as a measurement for this criterion. For any country i as $(x_{id} + m_{id})/(x_i + m_i)$, x_i represents total export and m_i represents total import where d is a sign for a destination of goods – Germany or EMU. To expand and follow previous studies of M. J. Artis and W. Zhang (2001) and Dimitri Boreiko (2002) the same approach was also applied. The data for this criterion was obtained from Eurostat.

Convergence of inflation

Since the traditional OCA was created during the “fixed-price” economics, applying convergence of inflation as a criterion is regarded as appropriate. This criterion is measured by simple inflation differential: $x_i - x_g$ where x_i is the real inflation of i country respectively to x_d which is the real inflation in Germany, EMU. The same approach was used by Saifuzzaman Ibrahim (2008), Dimitri Boreiko (2002) and M. J. Artis and W. Zhang (2001). It is important to mention that convergence of inflation was the central theme of the Maastricht treaty, which is the reason why all countries of Euro zone keep the inflation lower comparing to the period before EMU. For all the countries HICP (Harmonized Index of Consumer Prices), was used. Source of the data is Eurostat but an exception is Switzerland which started to record HICP only since 2005. Therefore the data set for Switzerland is obtained from OECD, particularly CPI (Consumer Price Index) was applied with respect to Germany and with respect to OECD – Europe. For the period after the crisis the HICP for Switzerland was used because the data records were available.

Volatility of interest rate

Harmonization of the real interest rates is interpreted as an indicator of coordination in monetary policy with respect to Germany/EMU. Again, the cross-correlation of the cyclical components of the real interest rate cycle with Germany/EMU is used. The H-P filter is used to accomplish de-trending. A deflation was accomplished by using CPI (Consumer Price Index). However, for Bulgaria, Lithuania and Romania HICP (Harmonized Index of Consumer Prices) is used. The data set on short term interest rates statistic for all countries is obtained from OECD statistics except Bulgaria, Lithuania and Romania. The data set for Bulgaria, Lithuania and Romania was obtained from Eurostat. Since monthly data is not available for majority of the countries neither on OECD nor Eurostat, annually data were used.

In this diploma thesis the cluster analysis is proposed to examine the similarities and dissimilarities of economic structure which are defined by The Euclidean distance was applied to measure a dissimilarity coefficient of distance between two clusters. The Euclidean distance is considered as the most preferable one for Ward's method according to M. Meloun and J. Militký, 2004. Hierarchical clustering as a method was applied as the most appropriate one in order to see the hierarchical arrangement of countries. Specifically, Ward's Method was applied and a principal of this clustering method is minimization of heterogeneity of clusters. Before the cluster analysis is applied the standardization of the all variables in Statistica SW was accomplished due to differences in measurement for different variables. In order to detect a correlation between variables a cross-correlation matrix for each analysis was done in Statistica SW. When EMU was applied as a reference object an existence of a significant correlation was detected between the variables in merging process of Western European countries and also in merging process of all 25 countries together, therefore Germany was used as a new reference object for these merging. In terms of merging of CEE countries no significant correlation was detected when EMU was applied as the reference object, therefore EMU was used. All the calculations regarding the clustering were conducted in the statistical software Statistica SW. Furthermore, detection of the cyclical component by H-P is conducted in the statistical software Stata. The graphical results from hierarchical method are depicted in dendrograms (hierarchical arrangement of clusters) to see a distance between particular countries.

Cluster analysis is not a typical statistical test but it is rather considered as a "collection" of variety of algorithms that "put objects into clusters according to well defined similarity rules". This method is used when we do not have any a priori hypotheses, therefore statistical significance testing really not appropriate here even when p-levels are reported (Statistica SW - Text book, 2015).

Tab. 7 Summarization of methodology

OCA Criterion	With respect to	Calculation
Business cycle synchronization	Germany/EMU ¹⁹	Cross-correlation of the cyclical component of monthly industrial production time series ²⁰
Trade openness	Germany/EMU	Arithmetical average of bilateral trade intensity for the period is used
Volatility of interest rate	Germany/EMU	Cross-correlation of the cyclical components of the real interest rate is applied
Inflation differential	Germany/EMU	Simple inflation differential between Germany/EMU and all the countries is applied

Source: Own elaboration

¹⁹ Germany was used as the reference object in merging process of the Western European countries and also in merging process of all 25 countries together. EMU was used in merging process of CEE countries.

²⁰ For Switzerland the cyclical component of quarterly GDP growth rate was used.

5 Practical part

This chapter provides a complete summary of results from the cluster analysis calculated in program Statistica SW. Firstly, the data set which was used for calculations is described in the beginning of every subchapter, separately. Secondly, the results from the cluster analysis are divided into three groups: the Western countries group than CEECs group in order to see an evolution and follow up the Dimitri Boreiko (2002) and M. J. Artis and W. Zhang (2001) studies and in the last subchapter is described clustering of all the countries, CEECs and Western countries, together.

The cluster analysis is conducted for specific periods described in the methodology. The aim of creation of the clusters is to detect dissimilarities/similarities between countries and its evolutions. If a distance between the clusters and within the clusters decreases in time (from period 2000-2008 to 2008-2013), based on this study, we can verify an increasing similarity between in our data set.

5.1 Merging process of Western European countries

Firstly, when EMU was applied as a reference object an existence of a significant correlation between four variables was detected, thus a new reference object, Germany, was applied in this measurement. However, even in case of Germany an existence of correlation was detected in the first measurement period (Trade openness and Correlation of real interest rate cycle) but the level of significance was low, therefore all the variables were applied in the cluster analysis for the purpose of the study, despite this low deviation (0,040) from the reference value (0,05), see the following table.

Tab. 8 Correlation matrix of OCA criteria (Merging process of Western European countries)

<i>Pre-crisis period (2000-2008)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Business cycle synchronization	1,000	0,303	0,270	0,478
Trade Openness	0,303	1,000	-0,358	0,534
Inflation differential	0,270	-0,358	1,000	-0,199
Correlation of real interest rate cycle	0,478	0,534	-0,199	1,000
<i>Period after the crisis (2008-2013)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Correlation of real interest rate cycle	1,000	0,238	0,157	0,281
Trade Openness	0,238	1,000	-0,030	0,258
Inflation differential	0,157	-0,030	1,000	0,486
Correlation of real interest rate	0,281	0,258	0,486	1,000

Source: Own elaboration

Tab. 9 Criteria by Optimal Currency Area calculated for Western European countries with respect to Germany

Country	Business cycle synchroni- zation			Trade openness			Inflation differential			Correlation in real interest rate cycle		
	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013
Belgium	0,357	0,306	0,399	0,196	0,201	0,183	0,042	0,031	0,049	0,744	0,912	0,619
Denmark	-0,002	0,049	-0,053	0,123	0,132	0,113	0,013	0,000	0,029	0,839	0,798	0,893
Greece	0,132	-0,069	0,282	0,068	0,050	0,034	0,087	0,139	0,033	0,285	-0,597	0,482
Ireland	0,096	0,179	-0,003	0,041	0,073	0,063	0,026	0,123	-0,106	0,514	0,752	0,347
Spain	0,165	0,330	0,046	0,097	0,105	0,088	0,084	0,129	0,026	0,833	0,882	0,797
France	0,435	0,340	0,532	0,146	0,147	0,146	0,008	0,016	-0,003	0,918	0,928	0,949
Italy	0,357	0,261	0,424	0,122	0,127	0,117	0,049	0,047	0,054	0,891	0,909	0,896
Netherlands	0,238	0,153	0,306	0,195	0,194	0,196	0,041	0,043	0,045	0,774	0,673	0,936
Austria	0,211	0,226	0,199	0,297	0,304	0,289	0,027	0,013	0,042	0,931	0,931	0,950
Portugal	0,288	0,256	0,340	0,106	0,115	0,100	0,052	0,112	-0,006	0,820	0,790	0,867
Finland	0,207	0,245	0,176	0,100	0,109	0,091	0,027	-0,032	0,093	0,450	0,163	0,708
Sweden	0,238	0,123	0,345	0,099	0,099	0,097	-0,006	-0,001	-0,007	0,262	0,367	0,220
UK	0,099	-0,096	0,281	0,082	0,085	0,079	0,048	-0,001	0,126	0,505	0,579	0,522
Norway	-0,024	-0,017	-0,034	0,091	0,088	0,091	0,004	-0,014	0,022	0,332	0,570	-0,065
Switzerland	0,164	-0,062	0,246	0,189	0,187	0,184	-0,084	-0,060	-0,122	0,473	0,838	-0,142

Source: Own elaboration

According to the results from the table 10 the linkage distance between the period has decreased from 8,86 (pre-crisis period: 2000-2008) to 7,77 (period after the crisis: 2008-2013). Based on this brief snap shot, it can be concluded that Western European countries are becoming more similar (more homogenous) based on the OCA criteria that were chosen. Additionally, from the figures 6 and 7 it is apparent that this group of countries have not changed significantly over time and keep the status quo with some exception that are described.

Pre-crisis period

Hence, based on the results from Ward's method and also weighted pair-group average that was applied as an alternative method (results from alternative method created almost the same clusters as Ward's method, see appendix A) four clusters are created for the pre-crisis period:

- {Belgium, France, Italy, Netherlands, Austria},
- {Ireland, Spain, Portugal},
- {Denmark, UK, Norway, Switzerland, Finland, Sweden},
- {Greece}.

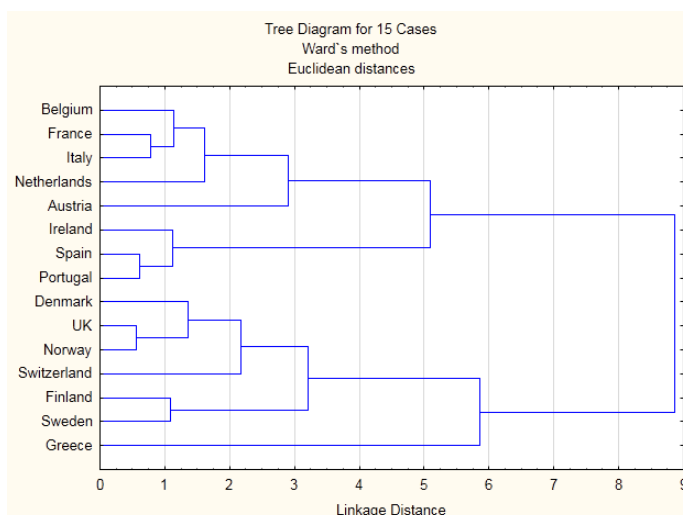


Figure 6 Merging process of Western European countries with respect to Germany (2000-2008)

Source: Own elaboration

The figure 6 evidently divides the countries into two big groups. The first half of the countries from the cluster analysis displays all the current members of the EMU (Belgium, France, Italy, Netherlands, Austria, Ireland, Spain and Portugal). Subsequently, the second part compresses the non-Euro zone countries (Denmark, UK, Norway, Switzerland and Sweden) with two exceptions: Finland and Greece. The first and very important finding is that the best performing and the most homogenous group, in both periods, consists from so called the "core group": Belgium, Netherlands, France, Italy and Austria. This cluster enjoys the lowest linkage distance 2,89 (see table 10) and countries in this cluster are very often considered

as the “core countries” by many economists that are described in the chapter literature review. Additionally, an interesting point according to the studies that have been elaborated over time is that Italy has converged from so called the “Southern periphery group” to the “core group” according to this result.

The second cluster (the first periphery group) consists from two Southern countries (Spain and Portugal) and one Northern country (Ireland). Spain and Portugal are very similar to each other with very low linkage distance 0,620 (see table 10 and figure 6). Both countries enjoyed above-average business cycle synchronization (Spain: 0,330 and Portugal: 0,256), high correlation of real interest rate cycle (Spain: 0,882 and Portugal: 0,790) and relatively solid trade openness with respect to Germany. Ireland reported a bit worst performance in all four criteria which reflect higher linkage distance (1,119). Nevertheless, all these countries created the cluster that is closest to the core group from the others.

The last and the biggest cluster (the second periphery group) consists from six, mainly the Northern countries (Denmark, UK, Norway, Switzerland, Finland and Sweden). Greece joined this cluster at the distance 5,869. All these countries reported not favorable results regarding business cycle synchronization (in case of Norway, Switzerland, UK and Greece even negative correlation) and the lowest trade openness (Greece: 0,050 or UK 0,085), however Switzerland is an exception within this cluster and enjoys solid trade openness 0,187 and conduct favorable monetary policy according to results from inflation differential (-0,060) and correlation of real interest rate cycle (0,838), which reflect on peculiar position of this country. All these Northern countries prefer a bit different preferences according to monetary policy which is reflected by lower inflation differential and also lower correlation of real interest rate cycle.

By looking at the data set for the cluster analysis, see table 9, we can notice a relatively solid correlation of real interest rate cycle for all the Western countries (exception are Greece -0,597 and Finland 0,163).

Period after the crisis

According to the results from Wards' method, see figure 7, and alternative method (see appendix A) three big clusters for the after crisis period can be defined:

- {Belgium, France, Italy, Netherlands, Portugal, Austria},
- {Denmark, Spain, Greece, Sweden, Finland, UK},
- {Ireland, Norway, Switzerland}.

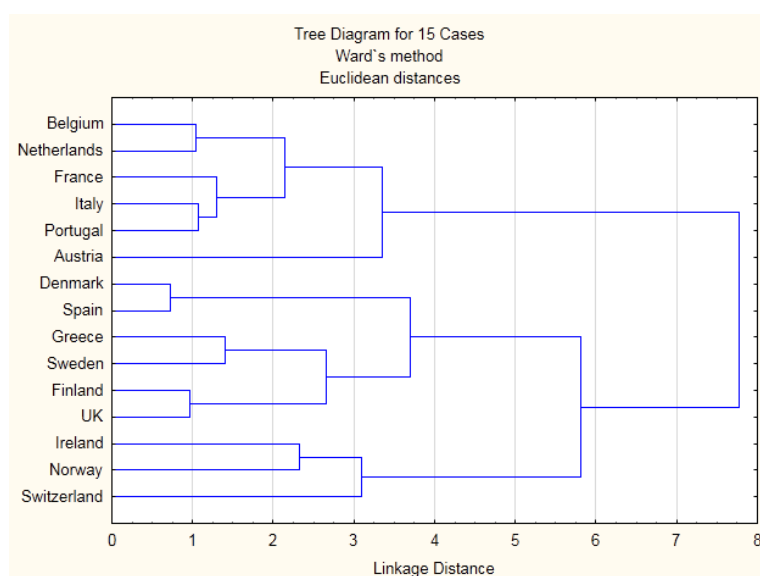


Figure 7 Merging process of Western European countries with respect to Germany (2008-2013)

Source: Own elaboration

This measurement has changed a composition of the clusters from the previous period but not significantly. The countries from the “core group” keep the same position and enjoy the best performance with respect to Germany. Additionally the core group has been expanded by Portugal. Portugal has enhanced its performance of the business cycle correlation (from 0,256 to 0,340) and enjoys a very low inflation differential and high correlation of real interest rate cycle which helped Portugal move to the “core group”.

From this point of view we can see the convergence of two Southern countries (Italy, Portugal) into the core group. Spain has not moved into this group because of its problems to boost economy and decrease very high unemployment rate (26 % in 2013, Eurostat) which might be the explanation of very low business cycle synchronization (0,046 between 2008-2013), whereas Portugal's and Italy's business cycle synchronizations are one of the highest for this period in the data sample (Portugal 0,340, Italy 0,424). An interesting point with respect to the Southern countries, with an exception to Greece, is that their performance of inflation differential and correlation of real interest rate cycles have improved, especially in case of Portugal.

The Northern periphery countries keep relatively the same position and are still considered, based on the results from the analysis, as the least similar group

from the data set according to the four criteria that were chosen. A potential exception can be Denmark and Finland. Denmark enjoys very high correlation of real interest rate (0,893 between 2008-2013) and low inflation differential (0,029 between 2008-2013), which moved Denmark with Finland to the second best performing cluster and very close to the core group. Finland has also significantly enhanced its correlation of real interest rate (from 0,163 to 0,708) with respect to Germany, which reflects on its position in the second best performing cluster comparing to Switzerland, Norway and UK. Switzerland that is in the last favorable cluster reflects again on its peculiar position because of solid trade openness 0,184 and conduct favorable monetary policy. For that reason Switzerland could be tentatively moved to more favorable cluster.

When we look at the whole time period 2000-2013 we can detect that the most influential criteria for the classification of the countries over time are the business cycle synchronization and correlation of real interest rate. Trade openness has not changed significantly in generally (particularly slightly decreased after 2008) for almost all the countries. Inflation differential remains low for almost all the countries which is connected to strict role of ECB to keep inflation stable, precisely defined: "a year-on-year increase in the HICP for the Euro area of below 2 % "(European Central Bank, 2015). Hence, the best performing countries or so called the "core group" (Belgium, France, Italy, Netherlands, Austria and Portugal (tentatively) reach the best results in correlation of real interest rate cycle and business cycle.

Tab. 10 Merging process of CEECs with respect to Germany, (Ward's method)

Cluster	Clusters joined	Linkage distance
Period 2000-2008		
14	{Norway, UK}	0,561
13	{Spain, Portugal}	0,620
12	{France, Italy}	0,785
11	{Finland, Sweden}	1,080
10	{Ireland, Cluster 13}	1,119
9	{Belgium, Cluster 12}	1,143
8	{Denmark, Cluster 14}	1,365
7	{Cluster 9, Netherlands}	1,607
6	{Cluster 8, Switzerland}	2,166
5	{Cluster 7, Austria}	2,898
4	{Cluster 6, Cluster 11}	3,210
3	{Cluster 5, Cluster 10}	5,098
2	{Cluster 4, Greece}	5,866
1	{Cluster 3, Cluster 2}	8,866
Period 2008-2013		
14	{Denmark, Spain}	0,7259
13	{Finland, UK}	0,959
12	{Belgium, Netherlands}	1,037
11	{Italy, Portugal}	1,078
10	{France, Cluster 11}	1,298
9	{Greece, Sweden}	1,404
8	{Cluster 10, Cluster 12}	2,149
7	{Ireland, Norway}	2,332
6	{Cluster 9, Cluster 13}	2,662
5	{Cluster 7, Switzerland}	3,102
4	{Cluster 8, Austria,}	3,350
3	{Cluster 6, Cluster 14}	3,699
2	{Cluster 3, Cluster 5}	5,813
1	{Cluster 2, Cluster 4}	7,770

Source: Own elaboration, Statistica SW

5.2 Merging process of CEECs

In contradiction to the previous subchapter the reference object was not Germany but EMU therefore the result of trade openness and business cycle synchronization have greater values comparing to the previous measurement where reference object was Germany. The existence of strong correlation between the variables was not proven despite the fact that in the second measurement can be seen a bit higher correlation between inflation differential and correlation of real interest rate, which is understandable based on the methodology of the calculation of real interest rate. Hence, the results from the analysis are considered as a significant and all the variables for the both periods were applied without any changes for the purpose of this study.

Tab. 11 Correlation matrix of OCA criteria (Merging process of CEECs)

<i>Pre-crisis period (2000-2008)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Business cycle synchronization	1,000	0,076	-0,211	0,150
Trade Openness	0,076	1,000	-0,029	-0,020
Inflation differential	-0,211	-0,029	1,000	-0,033
Correlation of real interest rate cycle	0,150	-0,020	-0,033	1,000
<i>Period after the crisis (2008-2013)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Business cycle synchronization	1,000	0,045	0,362	0,004
Trade Openness	0,045	1,000	0,030	0,119
Inflation differential	0,362	0,030	1,000	0,478
Correlation of real interest rate cycle	0,004	0,119	0,478	1,000

Source: Own elaboration

Tab. 12 Criteria by Optimal Currency Area calculated for CEECs with respect to EMU

Country	Business cycle synchroni- zation			Trade openness			Inflation differential			Correlation in real inter- est rate cycle		
	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013
Bulgaria	0,255	0,164	0,355	0,391	0,391	0,369	0,234	0,340	0,018	-0,290	-0,625	-0,079
Czech Republic	0,136	0,130	0,144	0,629	0,631	0,643	0,014	0,003	0,009	0,097	-0,081	0,246
Estonia	0,286	0,118	0,447	0,421	0,422	0,428	0,168	0,176	0,089	0,277	-0,199	0,523
Latvia	0,265	0,388	0,170	0,419	0,419	0,442	0,186	0,260	-0,039	0,144	0,188	0,132
Lithuania	0,001	-0,040	0,053	0,349	0,351	0,347	0,064	0,008	0,056	0,085	0,119	0,048
Hungary	0,279	0,123	0,411	0,503	0,503	0,482	0,248	0,295	0,198	-0,300	-0,894	0,715
Poland	0,377	0,362	0,405	0,483	0,484	0,479	0,062	0,032	0,095	0,104	0,273	-0,162
Romania	0,110	0,037	0,184	0,483	0,482	0,464	0,675	1,003	0,204	0,338	0,169	0,682
Slovenia	0,231	0,106	0,306	0,531	0,531	0,527	0,144	0,223	0,044	0,244	0,159	0,400
Slovakia	0,134	0,115	0,152	0,423	0,424	0,398	0,130	0,197	0,016	0,337	0,219	0,743

Source: Own elaboration

As it is obvious from the table 13 the linkage distance has increased from 4,955 to 5,498 which from the first point of view means that the CEECs have become more heterogeneous. However, when the weighted pair-group average method (alternative method) is applied for the same data set (see results in the Appendix A) the linkage distance has decreased from 3,747 to 3,028. The difference in these numbers can be explained by different calculation of linkage distances between the clustering methods. Ergo, the heterogeneity or homogeneity of the CEECs cannot be proved. When we take into account the business cycle synchronization and correlation in real interest rate cycles, see table 12, we can notice that these correlations have been increased for the majority of the countries. The inflation differential has been decreased as well. Therefore an inclination towards the homogeneity with respect to EMU would fit here. Additionally, first two clusters that compress the majority of the CEECs have also become more similar, clusters 5 and 6 have merged at the level 3,776 comparing to level from pre crisis period 4,076, see table 13. The composition of clusters is very similar whether is used the Ward's method or weighted pair-group average method which is a good sign.

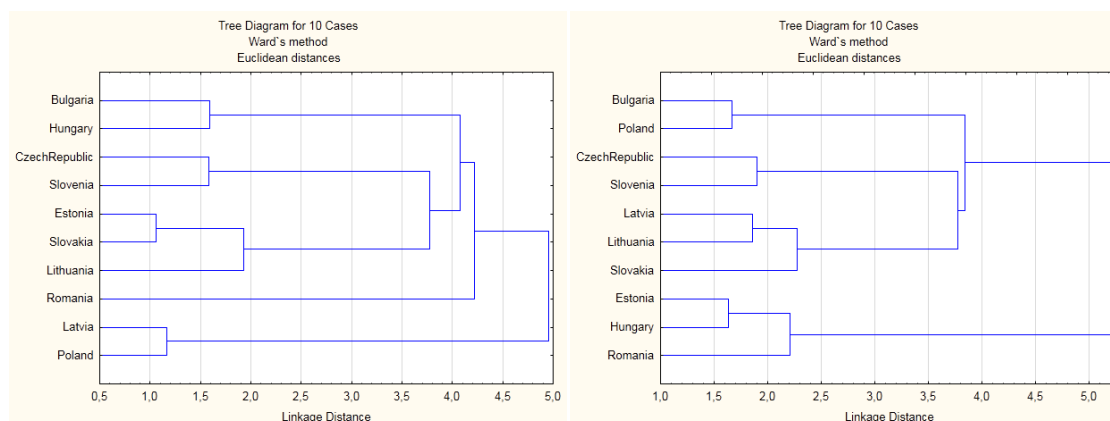


Figure 8 Merging process of CEECs with respect to EMU (2000-2008, 2008-2013)

Source: Own elaboration in Statistica SW

Period before the crisis

According to the results from the both cluster methods (see also appendix A), the four clusters can be defined for the pre-crisis period:

- {Bulgaria, Hungary},
- {Czech Republic, Slovenia, Estonia, Slovakia, Lithuania},
- {Poland, Latvia},
- {Romania}.

Period after the crisis

According to the results for the second period from the both cluster methods (see also appendix A), the three clusters can be defined:

- {Bulgaria, Poland},
- {Czech Republic, Slovenia, Latvia, Lithuania, Slovakia},
- {Estonia, Hungary, Romania}.

The table 13 describes the most similar countries within the data set from the first period, second period and also merging process, step by step. It is obvious from a first glance at the figures that the clusters have changed over time and we can see that this data set for CEECs is more divergent comparing to Western European countries and it is harder to define so called the “core group” of countries. However there are four countries particularly Bulgaria, Czech Republic, Slovenia and Poland that have kept very good position with respect to EMU over time which is noticeable from the figure 8 and table 13 for the both measurement periods.

Slovenia and Czech Republic are classified in the second best cluster and report excellent statistic in terms of trade openness. The classification of Bulgaria, in the first observation period, might be considered as a surprise because of not favorable results for monetary criteria (inflation differential was high: 0,340 and correlation of real interest rate cycle was negative: -0,079) and not so high trade openness (0,391) comparing to others. For that reason Bulgaria should be tentatively part of the less favorable cluster. Another surprising classification in the first observation period is Poland. The first look at the statistic, see table 12: business cycle synchronization (0,362), trade openness (0,484), inflation differential (0,032) and correlation of real interest rate (0,273) should suggest that Poland is a part of best performing group but according to the results from the cluster analysis was not, which is surprising. Nevertheless, in the second observation period Poland has kept its nice records with respect to EMU and classified into the best performing cluster with Bulgaria.

Interesting point is an improvement of business cycle synchronizations for all the countries except Latvia. Nice example is Estonia whose correlation increased from 0,118 (pre-crisis period) to 0,447 (after the crisis period) or Hungary from 0,123 (pre-crisis period) to 0,411 (period after the crisis). And also others countries like Romania, Slovenia and Estonia significantly improved its business cycle synchronization with respect to EMU. However an only exception is Latvia, its correlation has decreased from 0,388 to 0,170. Trade openness have not changed significantly during measurement period and this criterion kept relatively the same values (on average has decreased by 0,006 between the periods). Inflation differential has changed over time too. Almost all the CEECs have decreased its inflation differential, especially Bulgaria, Estonia, Slovenia, Slovakia, Latvia and Romania (see table 12). The inflation differential decreased for many countries because of its effort to fulfill the Maastricht Criteria. The correlation of real interest rate cycle has been also improved for Slovakia (Slovakia enjoys the highest correlation and one of the best improvement for this criterion: from 0,219 to 0,743), Slovenia (from

0,159 to 0,400), Romania (from 0,169 to 0,682), Estonia (from -0,199 to 0,523) and Hungary (from -0,894 to 0,715 another big improvement). The reason of this change is that Slovakia, Slovenia, and Estonia (some of the latest members of EMU) needed to fulfill the Maastricht criteria in order to enter EMU. Bulgaria is not part of EMU II but has pegged its currency to euro since 2007. Hungary is not part of ERM II but improved its performance comparing to the previous period. An explanation of improvement and adjustment of their monetary policy performance could be necessity to fulfill the Maastricht criteria (Slovenia, Slovakia, Estonia, Latvia and Lithuania) or coping the ECB (European Central Bank) decisions and implementing them at national level. Additionally all the countries have become members of the EU (all countries joined the EU in 2004 except Romania and Bulgaria, these countries joined the EU in 2007) which could influence better results of business cycle correlation, trade openness and performance of two monetary criteria. An example are Slovenia (in 2007), Slovakia (in 2009) and Estonia (in 2011) that joined the EMU what had an impact on higher correlation of the real interest rate cycle and level of inflation differential with respect to EMU.

With respect to the second classification of the clusters analysis (after the crisis) Estonia could be moved into the core group with Czech Republic, Slovenia, Poland and Bulgaria (tentatively) due to its positive performance: high business cycle synchronization, sufficient trade openness, high correlation of real interest rate and relatively low inflation differential. Furthermore, when we take into account just business cycle synchronization as the most often examined criterion and also trade openness, for whole period 2000 -2013, we can split countries into two big clusters:

- *cluster with higher correlation and openness {Poland, Hungary, Latvia, Slovenia, Estonia} and*
- *cluster with lower correlation and openness {Lithuania, Bulgaria, Slovakia, Romania, and Czech Republic}.*

Even this classification brings some tentative and ambiguous result. Czech Republic enjoys extremely high trade openness (0,629) but has a below average business cycle synchronization (0,136).

The clusters have been mixed up over time because the values of the criteria have also changed due to countries' preferences to enter the EU and afterwards EMU.

Tab. 13 Merging process of CEECs with respect to EMU, (Ward's method)

Cluster	Clusters joined	Linkage distance
Period 2000-2008		
9	{Estonia, Slovakia}	1,055
8	{Latvia, Poland}	1,164
7	{Czech Republic, Slovenia}	1,587
6	{Bulgaria, Hungary}	1,589
5	{Cluster 9, Lithuania}	1,931
4	{Cluster 7, Cluster 5}	3,772
3	{Cluster 4, Cluster 6}	4,076
2	{Cluster 3, Romania}	4,221
1	{Cluster 6, Cluster 2}	4,955
Period 2008-20013		
9	{Estonia, Hungary}	1,630
8	{Bulgaria, Poland}	1,670
7	{Latvia, Lithuania}	1,856
6	{Czech Republic, Slovenia}	1,904
5	{Cluster 9, Romania}	2,208
4	{Slovakia, Cluster 7}	2,271
3	{Cluster 4, Cluster 6}	3,776
2	{Cluster 8, Cluster 2}	3,989
1	{Cluster 4, Cluster 5}	5,498

Source: Own elaboration

5.3 Merging process of all the countries

When the EMU was applied as the reference object the same issue with the correlation occurred again. Particularly an existence of significant correlation, between the variables, in both periods of measurement was detected, therefore a new reference object, Germany, was applied for the cluster analysis for all the countries from the data set. However even in case of Germany an existence of correlation (negative correlation between correlation of real interest rate and inflation differential) was detected in the first measurement period and the last period (2000-2013). Since, the level of significance was close to the reference value (0,05) the cluster analysis was applied for this study despite this low deviation (0,04).

Tab. 14 Correlation matrix of OCA criteria (Merging process of all the countries)

<i>Pre-crisis period (2000-2008)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Business cycle synchronization	1,000	0,103	0,021	0,364
Trade Openness	0,103	1,000	-0,059	0,086
Inflation differential	0,021	-0,059	1,000	-0,476
Correlation of real interest rate cycle	0,364	0,086	-0,476	1,000
<i>Period after the crisis (2008-2013)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Business cycle synchronization	1,000	0,116	0,000	0,244
Trade Openness	0,116	1,000	0,040	0,046
Inflation differential	0,000	0,040	1,000	-0,082
Correlation of real interest rate cycle	0,244	0,046	-0,082	1,000
<i>Whole period (2000-2013)</i>				
	Business cycle synchronization	Trade Openness	Inflation differential	Correlation of real interest rate cycle
Business cycle synchronization	1,000	0,171	-0,101	0,303
Trade Openness	0,171	1,000	-0,001	0,010
Inflation differential	-0,101	-0,001	1,000	-0,440
Correlation of real interest rate cycle	0,303	0,010	-0,440	1,000

Source: Own elaboration

Tab. 15 Criteria by Optimal Currency Area calculated for all the countries with respect to Germany

Country	Business cycle synchroni- zation			Trade openness			Inflation differential			Correlation in real inter- est rate cycle		
	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013	2000- 2013	2000- 2008	2008- 2013
Belgium	0,357	0,306	0,399	0,196	0,201	0,183	0,042	0,031	0,049	0,744	0,912	0,619
Bulgaria	0,225	0,136	0,316	0,100	0,104	0,094	0,274	0,383	0,109	-0,381	-0,543	-0,327
Czech Republic	0,064	0,002	0,126	0,314	0,312	0,310	0,054	0,046	0,046	-0,004	0,124	-0,078
Denmark	-0,002	0,049	-0,053	0,123	0,132	0,113	0,013	0,000	0,029	0,839	0,798	0,893
Estonia	0,165	0,029	0,285	0,075	0,079	0,068	0,191	0,219	0,174	0,146	-0,119	0,239
Greece	0,132	-0,069	0,282	0,068	0,050	0,034	0,087	0,139	0,033	0,285	-0,597	0,482
Ireland	0,096	0,179	-0,003	0,041	0,073	0,063	0,026	0,123	-0,106	0,514	0,752	0,347
Spain	0,165	0,330	0,046	0,097	0,105	0,088	0,084	0,129	0,026	0,833	0,882	0,797
France	0,435	0,340	0,532	0,146	0,147	0,146	0,008	0,016	-0,003	0,918	0,928	0,949
Italy	0,357	0,261	0,424	0,122	0,127	0,117	0,049	0,047	0,054	0,891	0,909	0,896
Latvia	0,200	0,300	0,130	0,095	0,107	0,082	0,212	0,303	0,104	-0,029	0,195	-0,156
Lithuania	-0,039	-0,075	0,000	0,099	0,112	0,085	0,093	0,051	0,158	-0,109	0,081	-0,278
Hungary	0,229	0,093	0,335	0,232	0,247	0,216	0,282	0,338	0,203	-0,254	-0,868	0,576
Netherlands	0,238	0,153	0,306	0,195	0,194	0,196	0,041	0,043	0,045	0,774	0,673	0,936
Austria	0,211	0,226	0,199	0,297	0,304	0,289	0,027	0,013	0,042	0,931	0,931	0,950
Poland	0,237	0,254	0,230	0,189	0,126	0,225	0,107	0,075	0,120	0,031	0,256	-0,259
Portugal	0,288	0,256	0,340	0,106	0,115	0,100	0,052	0,112	-0,006	0,820	0,790	0,867
Romania	0,093	0,088	0,100	0,146	0,138	0,155	0,731	1,046	0,251	0,256	0,010	0,631
Slovenia	0,248	0,231	0,262	0,173	0,179	0,171	0,177	0,266	0,055	0,095	0,135	0,143
Finland	0,207	0,245	0,176	0,100	0,109	0,091	0,027	-0,032	0,093	0,450	0,163	0,708
Sweden	0,238	0,123	0,345	0,099	0,099	0,097	-0,006	-0,001	-0,007	0,262	0,367	0,220
UK	0,099	-0,096	0,281	0,082	0,085	0,079	0,048	-0,001	0,126	0,505	0,579	0,522
Norway	-0,024	-0,017	-0,034	0,091	0,088	0,091	0,004	-0,014	0,022	0,332	0,570	-0,065
Switzerland	0,164	-0,062	0,246	0,189	0,187	0,184	-0,084	-0,060	-0,122	0,473	0,838	-0,142
Slovakia	0,076	0,109	0,051	0,156	0,109	0,176	0,187	0,240	0,057	0,342	0,289	0,596

Source: Own elaboration

Before we start to elaborate the differences in clusters between these two periods we can discover the decrease of linkage distance from 10,120 (before the year 2008) to 8,730 (after the year 2008). This is not so significant but still notable decrease of linkage distance between these two periods which suggests that this group of 25 selected European countries is becoming more similar from the OCA criteria point of view. Additionally, the alternative method (weighted pair-group average, see in the appendix A) supports this decrease of dissimilarities between the data set.

It can be argued that the observation periods 2000-2008 (before the crisis) and 2008-2013 (after the crisis) might not be sufficiently long enough for measuring business cycle synchronization and might cause bit of bias results due to not so long observation periods. For that reason cluster analysis was applied also for whole period 2000-2013 at the end of this sub-chapter.

Pre-crisis period

According to the results from Ward's method and also weighted pair-group average that was applied as an alternative method (results from this method created very similar clusters as Ward's method, see appendix A), five clusters were created for the pre-crisis period:

- {Belgium, France, Italy, Spain, Portugal, Netherlands},
- {Ireland, Sweden, Poland, Finland, Latvia, Slovenia},
- {Bulgaria, Estonia, Slovakia, Greece, Hungary, Romania},
- {Czech Republic, Austria},
- {Denmark, Switzerland, Lithuania, UK, Norway}.

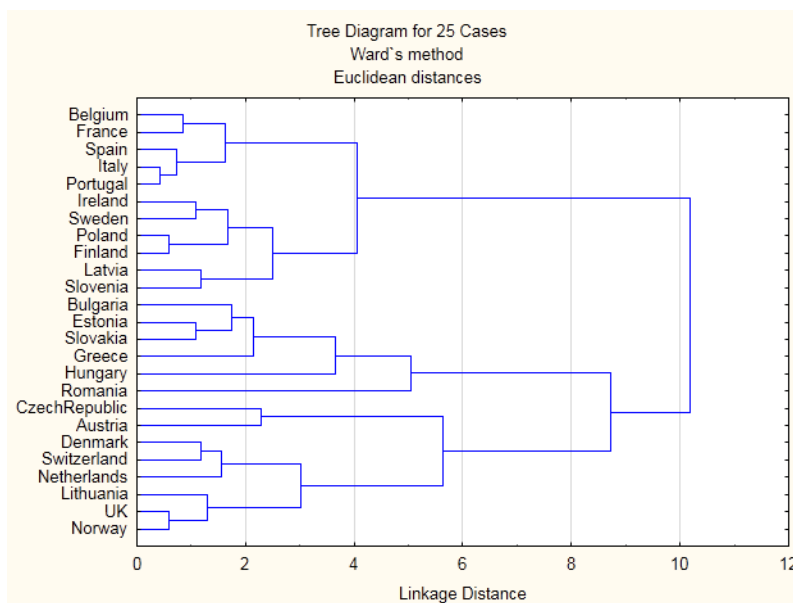


Figure 9 Merging process of all the countries from the data set with respect to Germany (2000-2008)

Source: Own elaboration

According to the results from the Ward's method and also the Weighted pair-group average method (see appendix A), five relatively medium clusters that are composed from comparatively the same number of countries are created. The most similar and also called the "core group" was created from: Belgium, France, Spain, Italy, Portugal and Netherlands. Based on the results from the Weighted pair-group average method Netherlands was classified into the "core group", whereas Ward's method did not classify Netherlands into the "core group". Therefore, according to the very good performance in terms of all the OCA criteria (see table 15), this country was classified into the core group. These differences in classifying might have occurred because of different calculation processes of clusters between the cluster methods. Additionally, the "core group" tentatively suggests the convergence of three Southern countries (Italy, Spain and Portugal) into the core group as well. This result can be a bit biased because we compare CEECs and Western European countries together via cluster analysis which is very sensitive statistical method according to M. Meloun and J. Militký (2004) and the data set is bigger, indeed. However we can still see that these Southern countries (Portugal, Spain and Italy) are much more alike to each other which is evident from the small sub-cluster that is created by them, see figure 9. This convergence of countries came up with a surprising result which is a classification of Spain into the core group. Spain enjoyed high business cycle synchronization (0,330) with a high correlation of real interest rate cycle (0,797). Inflation differential and trade openness kept the same stable and relatively high values. However this surprising categorization of Spain was just temporary because of not favorable performance after the financial crisis which is obvious from table 15 (business cycle synchronization has dropped by 0,284 and trade openness as well (from 0,105 to 0,088) additionally correlation of real interest rate cycle has slightly decreased as well.

Next cluster is mainly created from combination of the Northern countries (Sweden, Finland and Ireland) and some of the core countries from CEECs clustering (Poland, Latvia and Slovenia). These countries present a nice performance in terms of trade openness (specific case is Poland whose trade openness almost doubled from 0,126 to 0,225). Another reason of classification into the second best performing group is a high business cycle synchronization (Poland 0,254; Latvia 0,300; Slovenia 0,231, Ireland 0,179 or Finland 0,245) and relatively high trade openness but correlation of real interest rate is significantly lower comparing to the results from the "core group", see specifically in table 15, which is a reason for not classifying them into the core group. A peculiar case is represented by Ireland whose business cycle synchronization and trade openness are relatively low comparing to countries in the same cluster but Ireland enjoys high correlation of real interest rate.

The third cluster is composed from CEECs (Bulgaria, Estonia, Slovakia, Hungary and Romania) and Greece. This position of Greece proves its problems to catch up with original member countries of EMU because of its economical problems that are proved here. This third cluster has particularly problems with correlation of real interest rate cycle that was highly negative, especially in case of Hun-

gary (-0,868), Bulgaria (-0,543) and Greece (-0,597), additionally the correlation business cycles are relatively low and especially in case of Greece slightly negative (-0,069).

An interesting cluster was created from Austria and Czech Republic. When we take a look just on Austrian performance for this period it is obvious that this country belongs to the core group. Since Austria is on the border with Czech Republic that facilitate and deepen its business connections and additionally both countries enjoy the highest level of trade openness (Czech Republic: 0,312, Austria: 0,304) with respect to Germany.

The last and the least similar cluster (Denmark, Switzerland, Lithuania, UK, Norway) is created from the countries that have negative or very low business cycle synchronization (UK: -0,096, Norway: -0,017, Lithuania: -0,075 or Switzerland: -0,062), whereas correlation of real interest rate cycles are in case of Switzerland (0,838) and Denmark (0,798) very high which might be confusing from classification point of view. A position of Switzerland can be considered as a peculiar because of its high trade openness and also high correlation of real interest rate with respect to Germany.

Period after the crisis

Before we start to comment on decomposition of clusters and elaborate it, an interesting point is noticeable, especially in terms of CEECs. The point is that three out of four criteria (correlation of real interest rate, business cycle synchronization and inflation differential) has been improved (correlations has been increased and inflation differential has shrunk) for majority of these countries (outstanding examples are Estonia, Bulgaria, Greece, Italy, Hungary). The trade openness in generally has slightly decreased (an exception are definitely Poland whose openness almost doubled also Slovakia that increased its openness by 61 %). This slight decrease of trade openness was detected mainly in Western European countries which might be explained by lack of growth in the European countries after the crisis, whereas increase of trade openness in CEECs has been enhanced by entering the EU and taking advantages from European single market afterwards. This improvement reflects favorable position of CEECs in clusters on the figure 10. A brief glance on the results point out a decrease of linkage distance between these two periods which indicate that 25 EU countries are becoming more similar based on the four OCA criteria.

Clusters that have been defined according the Ward's method and also alternative method (see appendix A) are following:

- {Belgium, Netherlands, France, Italy, Portugal},
- {Czech Republic, Austria, Hungary, Romania},
- {Bulgaria, Poland, Slovenia, Latvia, Lithuania, Norway},
- {Estonia, UK, Finland, Sweden, Greece},
- {Switzerland, Ireland, Slovakia, Spain, Denmark}.

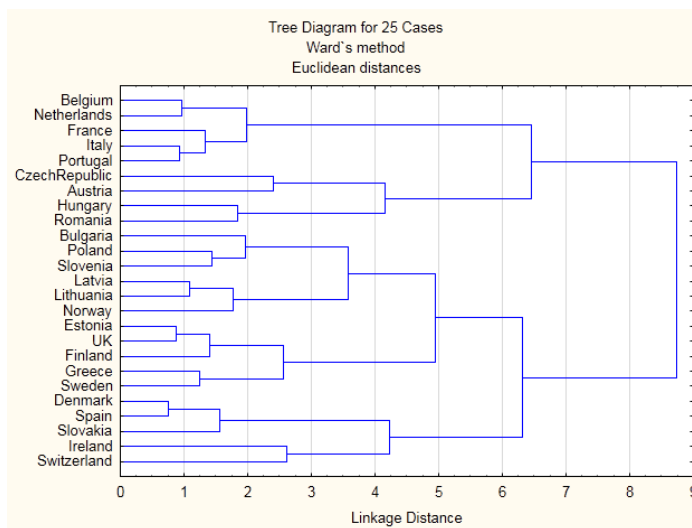


Figure 10 Merging process of all the countries from the data set with respect to Germany (2008-2013)

Source: Own elaboration

The results from the second observation period revealed pretty much expectable clusters with some exceptions. The “core group” is again created from the same countries but without Spain. Belgium, Netherlands, France, Italy and Portugal are the countries that were also depicted previously as the core group from the elaboration of Western European countries and from the previous measurement of all the countries. Since the CEECs were added into the aggregate data set the pre-assumption to be classified in the core group has decreased on average, because of bigger data base, which helped Portugal classify into the “core group” again. Due to Spanish problems to get over on its labor market problems and boost economy troubles this country fell into the least favorable cluster with the Northern countries.

The second cluster is created from countries (Czech Republic, Austria, Hungary and Romania) which in the previous period demonstrated not so good performance but thanks to improvements in term of correlation business cycles especially in case of Hungary (from 0,093 to 0,335), Czech Republic (0,002 to 0,126) these CEECs have been merged very close to the core group. Position of Austria is not surprising because of its good and stable performance and close business-relationship with Czech Republic, Germany and Hungary. Romania has significantly decreased inflation differential (from 1,046 to 0,251) and increased correlation of interest rate (from 0,010 to 0,631) which improved Romanian position in the analysis.

The next cluster is almost purely composed from the CEECs (Bulgaria, Poland, Slovenia, Latvia, and Lithuania) with an exception of Norway. That might suggest again a continuing convergence of these countries to the core group.

Last but not least favorable cluster (Estonia, UK, Finland, Sweden, and Greece) posses relatively high business cycle synchronization but low level of openness to

trade (0,068 in case of Estonia or 0,097 in case of Sweden) another problem is a low correlation of real interest rate cycle comparing to others which is on average 0,422.

The last cluster is created from Switzerland, Ireland, Slovakia, Spain, and Denmark. Surprisingly, three of these countries (Spain, Slovakia and Ireland) are part of EMU which should suggested that these countries should have been more similar to the core group. However, business cycle synchronization in terms of all these countries is significantly different, indeed in case of Ireland slightly negative (-0,003) which explains their position. Reasons for ambiguity come up when Switzerland with its high business cycle synchronization and trade openness was classified into this group, however slightly higher inflation differential and negative correlation of interest rate could be an explanation of this.

Results for the whole period

In order to get a clearer, brighter, long term perspective picture from clustering and also enhance previous cluster analysis that examined measurement period separately, this part compress much more observations (14 years) with respect to Germany. Based on the results from the Ward's method and alternative method (see figure 12) we can define three big clusters:

- {Belgium, Netherlands, France, Italy, Portugal, Switzerland, Austria},
- {Czech Republic, Bulgaria, Estonia, Latvia, Hungary, Poland, Slovenia},
- {Denmark, Spain, Greece, Ireland, UK, Finland, Sweden, Lithuania, Norway, Slovakia, Romania}.

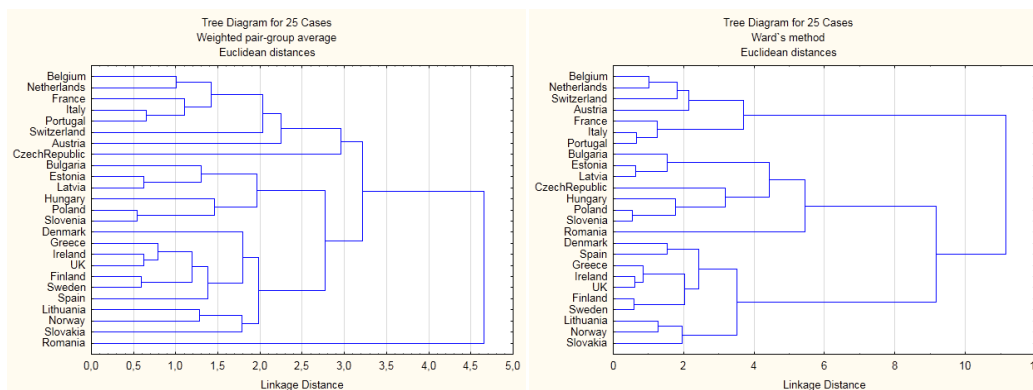


Figure 11 Merging process of all the countries from the data set with respect to Germany (2000-2013)

Source: Own elaboration

As we can see the first cluster is again defined by the same core countries as from the previous elaboration (Belgium, Netherlands, France, Italy, Portugal and Austria) and supplemented by Switzerland. Looking at the Switzerland performance for the whole period especially: trade openness which is high with respect to Germany (0,189), relatively not high inflation differential (-0,084) and sufficiently high business cycle synchronization (0,164) comparing to others, we can tentatively put

Switzerland into the core group. The classification of the Southern countries (Italy and Portugal) in this observation period proves a nice and high convergence (especially Italy) to the core group.

The second best performing cluster is composed from eight CEE countries (Bulgaria, Estonia, Latvia, Czech Republic, Hungary, Poland and Slovenia). This result points out on the fact that CEECs are becoming more and more similar to Germany and are converging to the core group more than the Northern and some Southern countries which define the last and least similar cluster. Romania is not part of this cluster because of its high inflation differential 0,731 and low convergence of real interest rate 0,256.

The least similar and in the same time the biggest cluster is created mostly from the Northern countries (Ireland, Denmark, UK, Finland, Sweden and Norway), two Southern countries (Spain and Greece) and three CEECs (Romania, Slovakia and Lithuania). This results, in generally, confirms problems and hesitations of Northern countries to join EMU and also struggling of Spain and Greece in EMU. Classification of Slovakia and Lithuania in the very last cluster is bit surprising, but reasonable because of not so good performance in term of OCA criteria. This confirms that Slovakia suffers from higher output gap and has different business cycle synchronization. However even more interesting would be to study its performance for the next years and see potential indication of convergence of these countries.

6 Discussion

According to the results from the cluster analysis it can be confirmed the finding of Fidrmuc and Korhonen (2003), which says that Western European countries (particularly the original Euro zone founders) are more homogeneous than the CEE countries. The Western countries enjoy higher business cycle synchronization, smaller inflation differential and higher correlation of real interest rate cycles. Furthermore, an identification of the “core group” was clearer and the group has been composed from the same countries during all observation period comparing to the CEE countries. When we also take a look at the another finding of Boone and Maurer (1998), it can be also confirmed that most of the CEE countries, particularly Hungary, Slovenia or Poland enjoy better results from the OCA criteria with respect to Germany and have been classified in superior cluster (observation period 2000-2013) than Greece, Spain or Ireland, which are current Euro zone members. This was also confirmed by Fidrmuc and Korhonen (2003). Additionally, it was argued in Dimitri Boreiko (2002) paper work that some CEE countries satisfy the OCA criteria better than some Western European countries, hence it can be confirmed according to the results gained from observation period 2000-2013 and 2008-2013 where majority of the CEE countries (Czech Republic, Bulgaria, Estonia, Latvia, Hungary, Poland, Slovenia and Romania) have been classified in the superior cluster than the Northern countries (Sweden, Denmark, UK, Ireland or Norway) and some Southern European countries (Greece and Spain). Furthermore, it is evident from classification before crisis, just only Poland, Slovenia and Latvia were classified into the second best cluster, whereas after the crisis seven CEE countries were classified into the second best cluster. This proves that CEE countries are becoming more similar to EMU and they are moving to the “core group”.

It can be also confirmed that Poland, Hungary, Slovenia, Czech Republic and Estonia are the countries from CEECs that are more suited to join EMU (Slovenia and Estonia are already part of Euro zone) as was also mentioned in Dimitri Boreiko paper work from 2002, whereas Fidrmuc and Korhonen (2003) pointed out that Czech Republic and Poland should not be part of this group which can be explained by using different method and observation period and different OCA criteria. We can also confirm Fidrmuc and Korhonen (2003) finding that Hungary enjoys the best synchronization of business cycle from CEE countries, this was also proven by Rozmahel and Najman (2011). It was also proven that Slovakia suffers from output gap, significant deviation from German and EMU business cycle because of high economic growth in last years, which was found by Rozmahel and Najman (2011), however Slovakian position in CEECs was relatively stable and high thanks to the high trade openness and improved correlation of real interest cycle and lower inflation differential. It would be very interesting to study evolution of Slovakia in following years in order to find out whether Slovakia is improving its business cycle synchronization with respect to EMU or not, which could be a sign for other countries from the Visegrad group that are not already part of EMU.

Looking at the results from the Western countries it can be agreed with M. J. Artis and W. Zhang (2001) who marked a position of Switzerland as a peculiar because of its high trade openness and also high correlation of real interest rate cycle with respect to Germany, which caused a classification of Switzerland into the best cluster for the whole measurement period (2000-2013), whereas classification of Switzerland before and after the crisis was not in superior cluster. Additionally, we can conclude that a composition of the “core group” is the same (France, Belgium, Netherlands and Austria) as was in J. M. Artis and J. Zhang (2001) paper work and it is getting bigger, which can be confirmed by joining Italy into this group and by Portugal. Portugal was classified into the “core group” in all observation periods only when the data set was expanded to 25 countries, by CEE countries, whereas the data set compressed just the Western countries Portugal did not classify into the “core group”. Hence, based on the results from clustering before and after the crisis we can agree on the convergence of Italy into the “core group” with Fidrmuc and Korhonen (2003), whereas we cannot confirm the convergence of Spain into the core group because of not favorable results after the crisis. However, Portugal can be tentatively considered as a country that is moving into the core group. Taylor (1995) defined the group that is ready for EMU from Germany, Netherlands, Luxembourg, Belgium, Denmark (if willing), Austria plus (tentatively) France, which proves the results from this analysis with an exception of Denmark, not part of the core group, whereas France was always strong and not doubtful member of the core group.

We can also agree with J. M. Artis and J. Zhang (2001) on the hesitation of Northern countries (particularly: Sweden, UK, Norway or Denmark) to adopt euro because of its not favorable position in this analysis. Additionally, it cannot be confirmed exactly the same classification of J. M. Artis and J. Zhang (2001) of Southern countries (Southern periphery) according to the results from this analysis. The southern periphery has been divided into two groups. The first group is converting or have already converted into the “core group” like Italy and Portugal and the second group of countries (like Greece and Spain – tentatively) that are converting to the less favorable cluster, which is composed from the Northern countries. The Northern countries have created the cluster that is the least similar to Germany in all observation periods. This confirms J. M. Artis and J. Zhang (2001) classification. However, Denmark was classified in pre-crisis and after the crisis period very close to the core group, as was also in the J. M. Artis and J. Zhang (2001) classification and Taylor (1995) classified (if willing) Denmark into the core group indeed, which refers to its very good results from correlation of real interest rate cycle with respect to Germany and low inflation differential. It would be interesting to observe the evolution of Denmark, precisely the business cycle synchronization in next few years, which could possibly tear off this country from the Northern periphery to the “core group”.

It is important to mention that working papers that have been done so far applied in their analysis different numbers of criteria, whether it was just a few OCA

criteria (synchronization of business cycle and or inflation differential) as it was in Fidrmuc and Korhonen (2003) and Rozmahel and Najman (2011) paper work or even more criteria (business cycle synchronization, volatility of the real exchange rate, correlation of real interest rate cycle, trade openness, inflation differential and labor market flexibility) as it was in J. M. Artis and W. Zhang (2001), Saifuzza-man Ibrahim (2008) or Dimitri Boreiko (2002) paper works. Ergo, the results from these paper works provide a bit different classification because of different OCA criteria that were applied and also different observation periods. Nowadays, it is not possible to apply all the criteria for all the countries. An example could be the volatility of the real exchange rate and the reason is that already 19 European countries have joined Euro zone, which would significantly shrink the data set to less countries that still have their national currencies. Another problematic criterion that could expand this analysis is the labor market flexibility, which is measured by EPL (Employment Protection Legislation) on OCED. However, not all the countries have records on OCED, for example Romania and Bulgaria, and the other CEE countries provided this record just since 2007. Hence, in order to include this criterion, the data set and observation period would have to be shrunk again. Thus, to expand the number of OCA criteria the number of states (data set) would have to be much smaller and additionally observation period could be shorter as well. From technical point of view another adjustment could be done by applying a different method of measurement of synchronization of business cycles and the convergence of inflation. The synchronization of business cycles could be measured by SVAR (Switching Vector Autoregressive) method instead of correlation of business cycles, which could bring different level of values for the business cycles results. The convergence of inflation could be measured structural vector autoregressive model instead of inflation differential. Additionally, the Christiano-Fitzgerald band-pass (BP) filter could be used as an alternative to Hodric-Prescott (H-P) filter. The Fuzzy cluster analysis can be use as an alternative analysis of CEE countries.

Additionally, in order to expand and complete this analysis the β -convergence and or OCA index could be calculated as well. The β -convergence analysis is used by the European Union to find with an aim to determine the convergence among European countries. The OCA index, constructed by Bayoumi and Eichengreen (1997), could also assess a suitability of the EU countries that are not part or EMU to enter the Euro zone. However, these analyses were out of the scope of this thesis.

7 Conclusion

The literature overview part was devoted to describing a theoretical composition of the OCA theory and also provided a summary of paper works and its results from different authors who elaborated OCA theory via cluster analysis. This part provided a very good background for conducting a practical part.

The practical part was divided into three parts with an aim to indentify the “core group” and the “periphery groups” in the data set, as was stated in the chapter objectives of the thesis. The first part elaborated Western European countries before and after the crisis. The second part elaborated CEE countries and its evolution during the same observation periods. The last and third part examined all 25 European countries together (CEECs and Western European countries) during the same observation periods and additionally for whole period of 14 years.

Western European countries, the first section of the practical part, defined one core group and three periphery groups during the observation period before the crisis. The parts of the core group were Belgium, France, Italy, Netherlands and Austria which was expected based on its geographical position and tighter economical and political connection since the end of the Second World War. The first periphery group was defined by three EMU countries Ireland, Portugal and Spain. The second periphery group was entirely defined by the Northern countries Denmark, UK, Norway, Switzerland, Finland and Sweden. Greece was the most dissimilar part of this data set and was the only member of the last periphery group. These results, in generally, confirms problems and hesitations of Northern countries to join EMU and also struggling of Spain and Greece in EMU. The biggest defect of the Northern countries is very low and in some cases negative correlation of business cycles with respect to Germany, for example Norway. Nevertheless, these Northern countries conduct favorable monetary policy with respect to Euro zone, particularly Denmark or Switzerland. The problems of Greece are very low trade openness, the lowest from the data set, very low correlation of real interest rate cycle and also low business cycle synchronization for the period of 14 years. The deviation of Spain has been caused by decreasing trade openness and much lower business cycle synchronization.

The observation after the crisis have not changed the position of the “core group” but mixed up a composition of the periphery groups that have shrunk from three clusters into two. The core group was expanded just by Portugal and kept the same members as before. The first periphery group was a combination of two Southern countries Spain and Greece and four Northern countries Denmark, Sweden, Finland and UK. The last periphery group was defined by Ireland, Norway and Switzerland. This results show that Portugal was able put itself closer to the core group during the economical problems after 2008, whereas Spain and Ireland did not achieve such a good results based on OCA criteria, even though Ireland has reported very good and solid macro-economical statistics as a GDP growth, unemployment and inflation since the end of the crisis. This joining of southern coun-

tries (Italy and Portugal) into the core group suggests a convergence Southern periphery into core groups.

The CEE countries in the second section did not contain such a clear “core group” of countries as the Western countries, therefore the core group was chosen from the first four best performing countries based on the analysis from both measurement periods. In the first observation period, the core group was defined by Bulgaria, Hungary, Czech Republic and Slovenia, whereas in the second period Hungary was classified in the less favorable cluster and Poland became a part of the best performing group with Bulgaria, Czech Republic, and Slovenia. However, to make an overall conclusion in terms of the core group both countries, Hungary and Poland, should be considered as a part of the core group because of its very good results in terms of trade openness and business cycle synchronization. The only two countries that kept its position stable, have not moved in the both observation positions, were Slovakia and Lithuania. These two countries kept very good results of the OCA criteria that were focused on monetary policy. Two Baltic countries, Estonia and Latvia, have swapped its position during observation periods, however both countries referred solid results in terms of all OCA criteria, particularly Estonia enhanced its results in all criteria which would tentatively suggest that this country should be of the core group. Romania was the only country that was classified in the bottom of the classification as the most dissimilar. It can be concluded that almost all the CEE countries have decreased its inflation differential, especially Bulgaria, Estonia, Slovenia, Slovakia, Latvia and Romania and also the correlation of real interest rate cycle has been improved especially for countries that are part of EMU, all in the second observation period. These two criteria have been improved for these countries because of its effort to fulfill the Maastricht Criteria.

The cluster analysis from merging process of all the countries provided very interesting results thanks to the bigger and more various data set. Belgium, France, Italy, Austria and Netherlands have proved its dominant and strong position in EMU and were again classified in the core group of this merging process in all observation periods. Portugal has been part of the core group again in all observation periods for this data set. Very interesting finding, according to four selected OCA criteria, is that CEE countries are becoming more and more similar to EMU than Northern European countries, which have been proved by classification of seven CEE countries (Czech Republic, Bulgaria, Estonia, Latvia, Hungary, Poland, Slovenia) right behind core group for the whole observation period (2000-2013) and also by classification of the same CEE countries after the crisis. The Northern countries, Greece and Spain kept the same position and have been again classified in the last cluster. The explanation of this better classification of CEE countries could be a tighter political and economical cooperation of CEE countries with the EU since entering the EU in 2004 and additionally, majority of the CEE countries have improved its business cycle synchronization, decreased inflation differential and improved correlation of real interest rate cycle which can be also explained by motivation of most of these countries to enter EMU (all Baltic countries, Slovakia, Slo-

venia already joined Euro zone). On the contrary the Northern countries kept its position with respect to the EU relatively the same and hesitate to do more economical and political actions that would enhance the performance. Additionally, business cycle synchronization of the Northern countries is in some cases (Norway) negatively correlated.

The business cycle synchronizations of CEE countries that have been part of the Euro zone during observation period (Slovenia, Estonia and Slovakia), measured with respect to EMU, point out on an existence of agglomeration effect in CEE countries. However, results of original EMU members were not so clear because six Western European members (Spain, Ireland, Austria and Finland) have not improved its business cycle synchronization. Hence, the agglomeration effect or specialization effect cannot be confirmed based on this, even though the evolution of the linkage distance has decreased after the crisis in case of Western European countries and also in case of the CEE countries.

8 Bibliography

- ARTIS. M. J., ZHANG W. *Core and Periphery in EMU: A Cluster Analysis*. Economic Issue. Vol. 6, Part 2.[online]. 2001. [cited. 2015-02-16] Available from www: <<http://www.economicissues.org.uk/Files/2001/201dArtis.pdf>>
- BALDWIN, R., WYPLOSZ CH. *Ekonomie evropské integrace*. 1. vyd. Praha: Grada, 2008, 478 s. ISBN 978-80-247-1807-1
- BAYOUMI.T. and EICHENGREEN B. *Ever Closer to Heaven?An Optimal Currency Index of European Countries*. European Economic Review, 41. [online]. 1997[cited. 2015-03-10] Available from www: Available from www: <<http://www.ecares.org/ecare/personal/sapir/evercloser.pdf>>
- BJRKSTEN, N., SYRJANEN M. *Divergences in the Euro Area: A cause for Concern?*.Bank of Finland. Discussion Papers 11/99.[online]. 1999. [cited: 2015-04-10] Available from www: <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1021280>
- BOREIKO. D. EMU and Accession Countries: Fuzzy Cluster Analysis of Membership. European University Institute. [online]. 2002. [cited. 2015-02-15] Available from www: <http://www.oenb.at/dms/oenb/Publikationen/Volkswirtschaft/Working-Papers/2002/Working-Paper-71/fullversion/wp71_tcm16-6161.pdf>
- DE GRAUWE, P. *Economics of monetary union*. 9th ed. Oxford: Oxford University Press, 2012, 1 v. ISBN 978-0-19-960557-6.
- European commission. *One market, one money: An evaluation of potential benefits and cost of forming an economic and monetary union*. Study of the Directorate-General for Economic and Financial Affairs [online].1990. [cit. 2014-05-05] Dostupné z www: <http://ec.europa.eu/economy_finance/publications/publication7454_en.pdf>
- FIDRMUC. J., SCHARDAX. F. *More Pre-Ins Ante Por-tas? Euro Area Enlargement, Optimum Currency Area, and Nominal Convergence*. Österreichische Nationalbank. [online]. 2000. [cited. 2015-03-12] Available from www:<http://www.oenb.at/dms/oenb/Publikationen/Volkswirtschaft/Focus-on-Transition/2000/Focus-on-Transition-2-2000/chapters/fidrmuc_schardax_ftr_200_tcm16-10415.pdf>

- FIDRMUC J., KORHONEN I. *Similarity of supply and demand shocks between the euro area and the CEECs*. Economic Systems. [online]. 2003, [cited. 2015-04-07]. Available from www: <http://ac.els-cdn.com/S0939362503000621/1-s2.0-S0939362503000621-main.pdf?_tid=3b439f74-dd31-11e4-8d02-00000aa b0f02&acdnat=1428416604_153f00b6093186cbd06a60f66c3b4877>
- FIDRMUC J. *The endogeneity of the optimum currency area criteria, intraindustry trade and EMU enlargement*. Contemporary Economic Policy. Volume 22, Issue 1. [online]. 2004. [cited. 2015-04-09]. Available from www: <<http://onlinelibrary.wiley.com/doi/10.1093/cep/byh001/epdf>>
- Financial Times. *Lexicon*, [online]. 2015. [Cited: 2015-01-25]. Available from www: <<http://markets.ft.com/research/Lexicon/Term?term=asymmetric-shock>>
- FRANKEL, Jeffrey A., ROSE, Andrew K. *The endogeneity of optimum currency area criteria*. Working paper. [online]. 1996. [cited: 2014-01-10]. Available from www: <http://www.nber.org/papers/w5700.pdf?new_window=1>
- LACINA, L., a kol.: *Měnová integrace: náklady a přínosy členství v měnové unii*. Praha: C.H. Beck, 2007. 538 s. ISBN 978-80-7179-560-5
- MCKINNON, R. *Optimum Currency Areas*. American Economic Review. [online]. 1963. [cit. 2014-01-20] Available from www: <http://www.experimentalforschung.vwl.uni-muenchen.de/studium/veranstaltungsarchiv/sq2/mckinnon_aer1963.pdf>
- MELOUN, M., MILITKÝ J. *Statistická analýza experimentálních dat*. Vyd.2., upr. a rozš. Praha: Academia, 2004, 953 s. ISBN 80-200-1254-0.
- MONGELLI, P. *European Economic and Monetary Integration, and the Optimum Currency Area Theory*. Working Paper Series. [online]. 2008. [Cited: 2014-01-13] Available from www: <http://ec.europa.eu/economy_finance/publications/publication12081_en.pdf>
- MONGELLI, P. „New“ Views On The Optimum Currency Area Theory: What Is EMU Telling Us? Working Paper Series. [online]. 2002. [Cited: 2014-01-15] Available from www: <<https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp138.pdf>>

- RICCI, Lucca A. *A Model of an Optimum Currency Area*, Research Department of IMF. [online]. 2008. [Cited: 2015-02-02]. Available from www: <http://www.economics-ejournal.org/economics/journalarticles/2008-8/version_1/count >
- ROZMAHEL, P., NAJMAN, N. *Index shody hospodářského cyklu České republiky a vybraných zemí střední a východní Evropy s eurozónou*. Acta univ. agric. et silvic. Mendel. Brun. [online]. 2010. [Cited. 2014-03-05] Available from www: <http://acta.mendelu.cz/pdf/actaun201058060407.pdf>
- ROZMAHEL, P., NAJMAN, N. *Business Cycle Similarity Measuring in the Eurozone Member and Candidate Countries: an Alternative Approach*. MENDELU Working Papers in Business and Economics 6/2011. [online]. 2011. [Cited. 2014-03-05] Available from www: <http://vyzsc.pef.mendelu.cz/cz/publ/papers>
- ŘEZANKOVÁ, H., HÚSEK D., SNÁŠEL V. *Shluková analýza dat*. 2., rozš. vyd. Praha: Professional Publishing, 2009, 218 s. ISBN 978-80-86946-81-8.
- SAIFUZZAMAN. I. *A Study of Optimum Currency Area in East Asia: a Cluster Analysis*. Journal of Economic Integration 23(4). [online]. 2008. [cited. 2015-02-15] Available from www: <<http://pakacademicsearch.com/pdf-files/ech/387/765-790%20Volume%2023,%20No%204,December,%202008.pdf>>
- SCHWEICKERT R. *Assessing the Advantages of EMU-Enlargement for the EU and the Accession Countries: A Comparative Indicator Approach*. Kiel Institute of World Economics. Working Paper No. 1080. [online]. 2001. [cited. 2015-03-12] Available from www: <https://www.ifw-kiel.de/ifw_members/publications/assessing-the-advantages-of-emu-enlargement-for-the-eu-and-the-accession-countries-a-comparative-indicator-approach/kap1080.pdf>
- SCHWEICKERT R. *The Integration of Accession Countries into EMU - Concerns about Convergence*. Intereconomics. [online]. 2002. [cited. 2015-03-12] Available from www: <<http://www.intereconomics.eu/downloads/getfile.php?id=206>>
- TAVAS, G.S. *The Theory of Monetary Integration*. Open Economies Review, Vol. 5 no. 2, pp 211-230. [online]. 1994. [cit. 2014-05-05] Available from www: <<http://link.springer.com/article/10.1007/BF01000489#page-1>>
- TAYLOR, C. *EMU 2000? Prospects for "European Monetary Union"*, Chatham House Papers, The Royal Institute of International Affairs. ISBN 978-1855673137

Appendix A

A Alternative method of cluster analysis

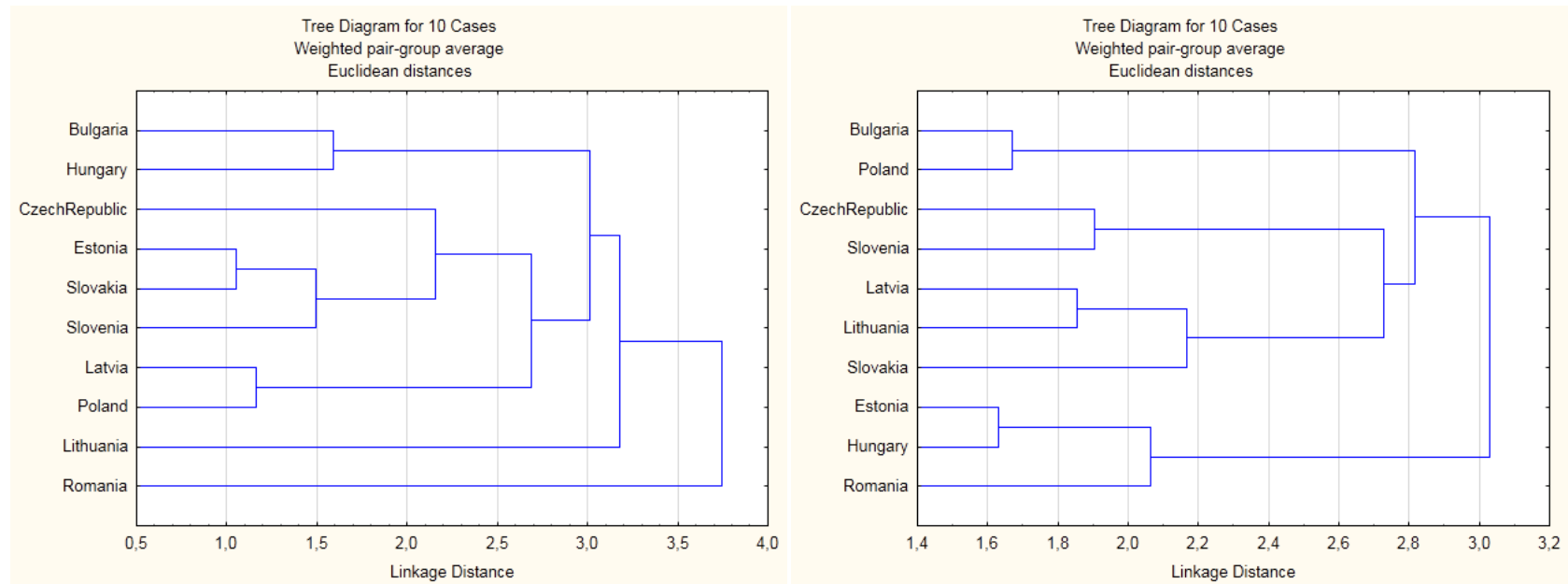


Figure 12 Merging process of CEEC with respect to EMU, Weighted pair-group average method (2000-2008,2008-2013)

Source: Own elaboration

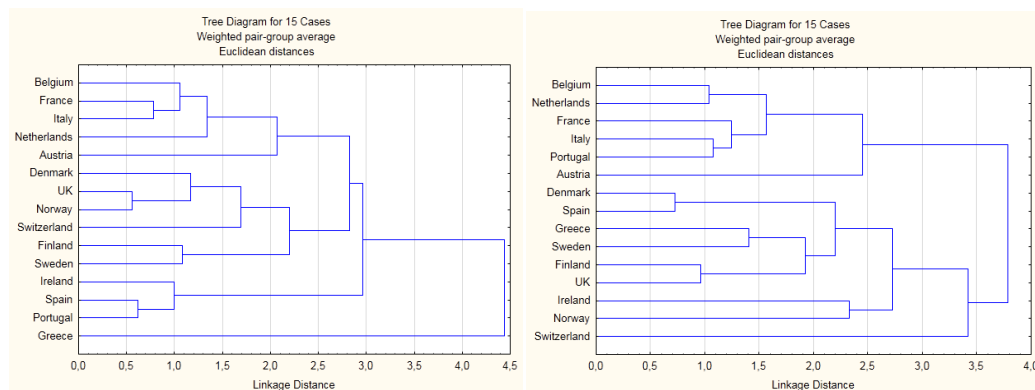


Figure 13 Merging process of Western countries with respect to Germany, Weighted pair-group average method (2000-2008, 2008-2013)

Source: Own elaboration

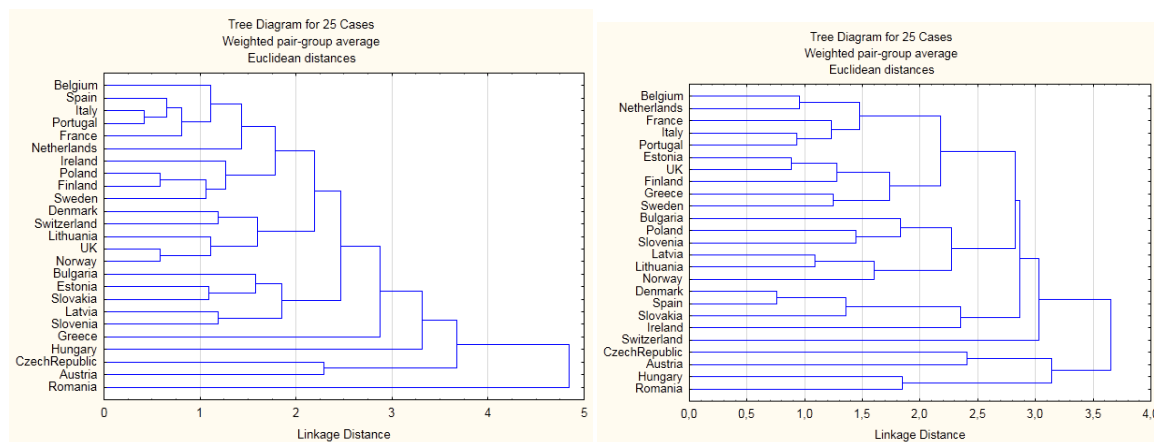


Figure 14 Merging process of all the countries with respect to Germany, Weighted pair-group average method (2000-2008,2008-2013)

Source: Own elaboration