Mendel University in Brno
Faculty of Business and Economics

Identification of Factors of Business Cycle Synchronization within the EU

DIPLOMA THESIS

Supervisor:

Doc. Ing. Petr Rozmahel, Ph.D.

Bc. David Irmann

Brno 2015

Acknowledgement

I would like to express my honest gratitude to my supervisor doc. Ing. Petr Rozmahel, Ph.D. for the supervision and guidance. His valuable advices, notes and constructive criticism were greatly appreciated and helped me to understand all the key factors of studied field.

Statutory Declaration

Herewith I declare that I have written my final thesis: "Identification of factors of business cycle synchronization within the EU" by myself and all sources and data used 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 Sb. On Higher Education as amended thereafter and in accordance with the *Guidelines on the Publishing of University Student Theses*.

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, 19th May, 2015 ……..

signature

Abstract

The objective of the thesis is to assess business cycle correlation and convergence in the European Union. The thesis also examines the effect of structural convergence, intra-industry trade intensity and other factors upon the above mentioned convergence of economic activities. For this purpose, the correlation analysis and panel data regression analysis are implemented. The results show positive influence of intra-industry trade intensity, whereas structural convergence indices report rather unstable and heterogeneous outcomes.

Keywords

OCA theory, business cycle synchronization, correlation analysis, rolling correlation, Augmented cross-correlation index, panel data regression analysis, intra-industry trade, structural convergence

Abstrakt

Cílem diplomové práce je posoudit synchronizaci a konvergenci hospodářských cyklů zemí Evropské unie. Práce zkoumá vliv strukturální konvergence, intenzity vnitroodvětvového obchodu a dalších faktorů na konvergenci ekonomických aktivit. K tomuto účelu je využita korelační analýza a regresní analýza panelových dat. Výsledky poukazují na pozitivní vliv vnitroodvětvového obchodu, naopak indexy strukturální konvergence vykazují spíše nestálé a heterogenní výstupy.

Klíčová slova

Teorie optimální měnové oblasti, synchronizace hospodářských cyků, korelační analýza, klouzavá korelace, Upravený index křížové korelace, regresní analýza panelových dat, vnitroodvětvový obchod, strukturální konvergence

Table of Contents

List of Figures

List of Tables

List of Acronyms

AUS	Austria
BEL	Belgium
BUL	Bulgaria
CRO	Croatia
CYP	Cyprus
CZE	Czech Republic
DEN	Denmark
EA	the Euro area
EA11	founding countries of the Eurozone
EST	Estonia
FEM	Fixed Effect Model
FIN	Finland
FRA	France
GDP	Gross Domestic Product
GER	Germany
GLI	Grubel-Lloyd Index
GRE	Greece
GVA	Gross Value Added
HHI	Herfindahl-Hirschman Index
HI	Herfindahl Index
HP	Hodrick-Prescott Filter
HUN	Hungary
IPI	Industrial Production Index
IRE	Ireland
ITA	Italy
KI	Krugman Specialization Index
LAT	Latvia
LI	Landesmann Index
LIT	Lithuania
LSDV	Least Squares Dummy Variable Model
LUX	Luxembourg
NACE	Statistical Classification of Economic Activities in the EU
NET	Netherlands
POL	Poland
POR	Portugal
REM	Random Effect Model
ROM	Romania
SITC	Standard International Trade Classification
SLV	Slovenia
SPA	Spain
SVK	Slovakia
SWE	Sweden
UK	United Kingdom

1 Introduction

By entering the European Union, namely the Eurozone, the member states are obliged to accept euro as a national currency at some point in the future. The question that arises here considers when to relinquish national currency and loose independent monetary policy which can take a form of remedy tool when it is needed, especially in times when business cycle disturbances occur. Furthermore, the country weighs under which circumstances it is beneficial to join the Eurozone. That might be seen as one of the reasons why the OCA (Optimum Currency Area) theory increased its popularity in the last two decades.

The OCA theory tries to answer the question which countries should form monetary union and which countries should keep their own national currencies i.e. in terms of benefits, what countries gain by relinquishing national currency and what countries loose. The answer is much more complex and complicated than the question is. By the time, economists and researchers have formulated several criterions which should be met by countries in order to form monetary union beneficial for all participants. As such criterions can be seen price and wage flexibility, mobility of production factors, the degree of economic openness and many more.

Business cycle plays an important role in this theory. What happens if asymmetric shock occurs in the monetary union, in other words, what happens if one country experiences economic growth whilst another country falls into a recession? One thing is obvious, common monetary policy cannot take place as it would be true in case of countries dealing with their own national currencies, as it follows, other more costly procedures would have to be implemented instead.

One of the presumptions for forming of monetary union is the business cycle synchronization. Synchronized cycles cannot account for all remedies, nevertheless, it is necessary condition for the creation of optimum currency area. Moreover, as soon as countries satisfy all the criteria of the optimum currency area, business cycles become synchronized to a great degree and economic shocks do not take a form of asymmetric disturbances, which is demanded situation.

The purpose of the thesis is to measure business cycle synchronization and convergence in the EU, and research for factors influencing business cycle synchronization in question. Subsequently, we would like to examine the impact of structural convergence, intra-industry trade intensity, common border with Germany and membership to EA11.

The development of the OCA theory is described at the very beginning of literature review, the comparison of benefits and costs takes place right after, and further review about recent business-cycle-synchronization studies concludes the literature part. Empirical analysis examines the question of what factors influence business cycle synchronization and to what extent. We assess the degree of business cycle synchronization via correlation analysis which is based on both the rolling window and Augmented cross-correlation index. Structural indices are chosen and further examined. The panel data regression analysis estimates the impact of chosen variables upon the overall synchronicity in the EU. At the very end of the thesis, the methods are discussed and the conclusion is communicated.

2 Objectives

Objectives of the thesis act in accordance with the OCA theory criteria. The aim is to assess the degree of business cycle correlation and convergence in the European Union and identify factors influencing co-movement of economic activities. In particular, the thesis should examine whether there is a positive effect of structural convergence, intra-industry trade intensity and other variables such as the distance from EU core and membership in EA11, all with respect to the criterion of increasing business cycle synchronization of countries forming or attempting to form a monetary union.

Concerning general appearance of the objective above, we can formulate research questions more specifically as:

- "Does the structural convergence imply also correlation of business cycles?"
- "Does the increase in international trade intensity cause convergence of business cycles?"
- "Do measures as common border with the EU core (Germany) and membership to EA11 affect business cycle synchronization positively?

In compliance with the OCA theory, initial hypotheses might be formulated as:

- Structural convergence implies an increase in business cycle synchronization.
- The higher the mutual intra-industry trade intensity, the higher the business cycle correlation.
- Common border with the EU core causes the business cycles to synchronize.
- Membership to EA11 implies higher co-movement of economic activities.

In order to achieve all the objectives, the following methodology is applied.

3 Methodology

The thesis aims to investigate business cycle synchronization and convergence in the EU with respect to the structural convergence indices, intra-industry trade intensity and other factors. For that purpose, chosen methodology includes correlation analysis and panel regression analysis. As a first step, an adjustment of data was needed. Then all of the indices can be calculated and panel regression models can be estimated.

3.1 Data Adjustments

All data were obtained from Eurostat and OECD databases. Below, you can find the adjustments which took place in the specification of dependent variables:

- GDP (Gross Domestic Product), GVA (Gross Value Added) and IPI (Industrial Production Index) data were collected as seasonally adjusted and adjusted by working days. GDP and GVA were of quarterly frequency and IPI was of monthly frequency ranging from the year 1995Q1 to 2014Q2 and 1997M1 to 2014M6, respectively.
- GDP and GVA data were transformed into natural logarithms in order to get percentage points into the interpretation of results; IPI data were already obtained in percentage points and thus no transformation via natural logarithms took place.
- As a second stage, the Hodrick-Prescott filter was applied so we could dissect the cyclical component out of the GDP, GVA and IPI time series and thus we were able to obtain the growth cycle of each instrument of economic activity. As Hodrick-Prescott (1997) mentions, the time series is assumed to be:

$$y_t = g_t + c_t$$

where g_t is the growth component and c_t stands for the cyclical component (which is the desired growth cycle), both for time t=1, …, T. Then the estimation of growth component is done via the solution of constrained minimization problem written as:

$$Min_{\{g_t\}_{t=-1}^{T}} \left\{ \sum_{t=1}^{T} c_t^2 + \lambda \sum_{t=1}^{T} [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\}$$

where λ gamma stands for the smoothing parameter and is suggested to take the value 100 for annual data, 1600 for quarterly data and 14400 for monthly data as mentioned by Mise et al. (2005).

- Once the growth cycles were identified, we were able to implement the data into the pairwise correlation analysis. Such analysis was introduced from static and dynamic point of view. The static point of view refers to the correlation analysis which was based on the Pearson´s correlation coefficient calculated over the entire examined period. As Sharma (2012) states, Pearson´s correlation coefficient ranges in the interval <-1, 1>.

  Dynamic point of view refers to the rolling correlation approach and Augmented cross-correlation index. Rolling correlation approach is based on the rolling window of Pearson´s correlation, namely, 5-year rolling window for GDP and GVA data due to the quarterly frequency, and 3-year rolling window for IPI due to the monthly frequency. Augmented cross-correlation index stands for the alternative measurement of correlation between two regions. The formulas is:

$$AO\rho_{ij,t} \equiv \frac{1}{2} log \left[\frac{1}{1 - \left[1 - \frac{1}{2} \left[\frac{(d_{j,t} - \bar{d}_j)}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(d_{j,t} - \bar{d}_j)^2}} - \frac{(d_{i,t} - \bar{d}_i)}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(d_{i,t} - \bar{d}_i)^2}} \right]^2 \right]} \right]$$

where $AO\rho_{ij,t}$ stands for the Augmented cross-correlation index of countries *i* and *j* in the time *t* mentioned in Artis-Okubo (2011), $d_{j,t}$ and $d_{i,t}$ stand for the growth rates of countries *i* and *j* in the time *t*, $\bar{d}_j$ and $\bar{d}_i$ are the average growth

rates of countries *i* and *j* in the time range of T observations[1]. The interval for Augmented cross-correlation index is (-∞, ∞).

Worth mentioning, that only dynamic correlations (rolling correlation and Augmented cross-correlation index) were implemented into the regression analysis. Regression analysis is based on the quarterly data and for that purpose the IPI monthly correlations were transformed into quarterly correlations.

After dependent variables were specified, the analysis of independent variables took place. The data were not adjusted in a special way:

- Grubel-Lloyd index and Herfindahl index are based on the export and import monthly data (expressed in euros). For the purpose of regression analysis, we needed quarterly data to obtain and therefore the monthly results were transformed into quarterly by simple averaging.
- Krugman index stemming from the employment data was originally calculated out of quarterly data, which was desired frequency.
- The original input data for Landesmann index were values of GVA (in euro) with quarterly frequency and no adjustments were needed.
- All indices range within the scope of 2000Q1 to 2014Q2.

3.2 Panel Data Regression Model

Panel regression helps us to create models which detect and explain dependencies among chosen variables. The regression models are constructed for various aggregation levels such as EU sample consisting of 17 EU countries, EU core and non-EA countries. The model estimations of panel data are based on balanced panel, worth mentioning, panel regression can be conducted as Fixed Effect Model (FEM) or Random Effect Model (REM) . To decide what approach should be implemented we have tested the below mentioned models with Hausman test. Based on the outcomes received, the Fixed Effect Model will be used.

[1] In our examined sample, there is a time range of t=1 up to T (the last observation in time). In our case the time range is within the period of 2000 and 2014. Considering GDP and GVA, data were obtained of a quarterly frequency and that is the range of 2000Q1 to 2014Q2 counting for T=58 observations, while IPI was of a monthly frequency ranging from 2000M1 to 2014M6 and thus counting for T=174 observations.

The panel data regression has the following structure:

- Dependent variable, which is the business cycle correlation of country in question with the EA (economic activity expressed by GDP, GVA and IPI) measured by the rolling correlation (abbreviated as rw) and Augmented cross-correlation index (referred as aXcorr).
- Independent variables such as Grubel-Lloyd index (GLI), Herfindahl index (HI), Krugman index (KI) and Landesmann index (LI).
- Two dummy variables standing for the membership in the EA11[2] (D_{EA11}; 0 – the country was not the member of EA11, 1 – the country was member of the EA11), and common border with Germany[3] (D_{ComBor}; 0 – country does not have common border with Germany, 1 – country has common border with Germany).

Now, we can approach towards the specification of full models[4] for the **EU sample**:

- Pooled regression

  Naïve regression where intercepts, slope constants and error term are all constant across the time and space. Formula of pooled regression is:

$$corr(y)_{it} = \beta_0 + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

  where β_0 is the common intercept, GLI_{it}, HI_{it}, KI_{it} and LI_{it} are structural indices of country *i* in time *t*[5], D_{ComBor} is the dummy variable for common border and D_{EA11} is dummy variable for membership in EA11.
- Fixed effects model (country effects) – LSDV[6] model

---

[2] Dummy variable reflecting EA11 membership was chosen in order to examine whether there is any influence of a fact that the country was founding member of the Eurozone.

[3] Common border with Germany was chosen in order to examine whether geographical aspects influence the business cycle synchronization within the EU. Germany stands for the strongest economy in the EU and that is why it is present as a benchmark country here.

[4] We have placed natural logarithms (ln) to each and every structural index, which modifies the interpretation of results as follows: if the growth rate (percentage change over the previous period) of structural index increases/decreases by 1% then the business cycle synchronization will increase/decrease by the value of β.

[5] Code tables for each time period *t* and country *i* can be found in Appendix N.

[6] Least-squares dummy variable model is abbreviated as LSDV model. In this thesis the term LSDV model is used interchangeably with the FEM (Fixed effect model).

Country effects refer to a situation in which slope coefficients are constant, intercepts vary across individuals. The model can be written as:

$$corr(y)_{it} = \alpha_1 + \alpha_2 D_{2i} \dots + \alpha_{17} D_{17i} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

where α_1 became the benchmark intercept for all the other dummy variable intercepts and, simultaneously, it is the constant for country effect of D_{1i} (country 1). D_{2i} is equal to 1, if the observation belongs to country 2, 0 otherwise; D_{3i}=1, if the observation belongs to country 3, 0 otherwise; the value of dummy variable D_{17i} equals to 1, if the observation belongs to country 17. As long as we use dummy variables, this model can be called the least-squares dummy variable model.

- Fixed effects model (time effects) – LSDV model

  Slope coefficients are constant, intercepts vary across time. Formula is written as follows:

$$corr(y)_{it} = \gamma_1 + \gamma_2 Dum_2 + \gamma_3 Dum_3 + \cdots + \gamma_{58} Dum_{58} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

  where γ_1 became benchmark intercept for all other dummy variable intercepts and it is the constant for the time period 1; Dum_2 equals 1, for the observation in the period 2, if not then 0; Dum_3=1, if the observation is in the time period 3, 0 otherwise; the value of dummy variable Dum_{58} equals to 1, if the observation belongs to the time period 58.

- Fixed effects model (time and country effects) – LSDV model

  Slope coefficients are constant, intercepts vary across time and individuals. Formula takes the form of:

$$corr(y)_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \cdots + \alpha_{17} D_{17i} + \gamma_1 + \gamma_2 Dum_2 + \gamma_3 Dum_3 + \cdots + \gamma_{58} Dum_{58} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

  where $corr(y)_{it}$ has its alternations in the form of $corr(rw_{GDP})_{it}$, $corr(rw_{GVA})_{it}$, $corr(rw_{IPI})_{it}$, $corr(aXcorr_{GDP})_{it}$, $corr(aXcorr_{GVA})_{it}$ and $corr(aXcorr_{IPI})_{it}$.

  For instance $corr(rw_{GDP})_{it}$ stands for the pairwise correlation index of GDP calculated by rolling window between country *i* with the EA in time *t*, an-

alogically, $corr(aXcorr_{GDP})_{it}$ is the pairwise correlation index of GDP calculated by Augmented cross-correlation index between country *i* with the EA in time *t*.

Analogically, the full models of the **EU core** take the following form[7]:

- Pooled regression

$$corr(y)_{it} = \beta_0 + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

- Fixed effects model (country effects) – LSDV model

$$corr(y)_{it} = \alpha_1 + \alpha_2 D_{2i} \dots + \alpha_6 D_{6i} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

- Fixed effects model (time effects) – LSDV model

$$corr(y)_{it} = \gamma_1 + \gamma_2 Dum_2 + \gamma_3 Dum_3 + \cdots + \gamma_{58} Dum_{58} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

- Fixed effects model (time and country effects) – LSDV model

$$corr(y)_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \cdots + \alpha_6 D_{6i} + \gamma_1 + \gamma_2 Dum_2 + \gamma_3 Dum_3 + \cdots + \gamma_{58} Dum_{58} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{EA11} + \beta_6 D_{ComBor} + u_{it}$$

Regarding the sample of **non-EA countries**, the full model specifications[8] can be written as:

- Pooled regression

$$corr(y)_{it} = \beta_0 + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{ComBor} + u_{it}$$

- Fixed effects model (country effects) – LSDV model

$$corr(y)_{it} = \alpha_1 + \alpha_2 D_{2i} \dots + \alpha_5 D_{5i} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{ComBor} + u_{it}$$

- Fixed effects model (time effects) – LSDV model

[7] D_{EA11} was not included due to the fact that all examined countries belong to EA11.

[8] D_{EA11} was not included due to the fact that all examined countries were not members of in EA11.

$$corr(y)_{it} = \gamma_1 + \gamma_2 Dum_2 + \gamma_3 Dum_3 + \cdots + \gamma_{58} Dum_{58} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{ComBor} + u_{it}$$

- Fixed effects model (time and country effects) – LSDV model

$$corr(y)_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \cdots + \alpha_5 D_{5i} + \gamma_1 + \gamma_2 Dum_2 + \gamma_3 Dum_3 + \cdots + \gamma_{58} Dum_{58} + \beta_1 lnGLI_{it} + \beta_2 lnHI_{it} + \beta_3 lnKI_{it} + \beta_4 lnLI_{it} + \beta_5 D_{ComBor} + u_{it}$$

Once all models were estimated, the backward elimination process is applied in order to omit redundant (insignificant) variables. 10% level of significance was chosen as a limit for the rejection of insignificant variables.

The software was used for all computations, namely Microsoft Excel for quantification of correlation indices, structural indices, data adjustments and creation of input data for regression analysis software. Gretl was used for the panel data regression analysis and HP filter applications.

4 OCA Theory As a Theoretical Framework for the Business Cycle Synchronization

This chapter reviews fundamentals of the OCA (Optimum Currency Area) theory and cost-and-benefits of monetary integration, whilst current studies of business cycle synchronization can be found as a concluding part.

4.1 What Is the Optimum Currency Area Theory (OCA) Telling Us?

Baldwin (2014) introduces the Optimum Currency Area as a theory attempting to answer the following question: Which countries should share the common currency? As Baldwin continues, moreover, the usage of the term "optimum" might be misleading as long as the OCA theory compares benefits and costs of sharing common currency rather than finding optimum situation. Once the comparison is done we can formulate the OCA criteria which should be fulfilled in order to make the monetary union beneficial.

As a founder of Optimum Currency Area (hereafter referred as OCA) theory is considered Robert Mundell (1961). De Grauwe (2014) points out that the theory was also significantly developed by McKinnon (1963) and Kenen (1969) describing under which circumstances countries would find it either beneficial or costly to peg their currencies and operate in the fixed exchange rate. Mundell (1997) highlights that there are two terms linked with general fixed exchange rate i.e. currency areas and monetary unions. Currency areas are characterized by one currency being pegged to another one, whereas monetary union is defined as common currency being shared by all members. Mundell also distinguishes between currency areas with single or multiple currencies involved. However, most economists use these two terms interchangeably as this thesis will.

4.1.1 Development of the OCA Theory

According to Mongelli (2002) the OCA theory development can be divided into 4 main phases which are briefly described below. The following chapter, dealing with

the phases more in detail, is based on Mongelli (2002), Tavlas (1993) and Tower-Willet (1976) unless noted otherwise.

The Pioneering Phase (1960´s to early 1970´s)

The pioneering phase was initiated by Mundell (1961). This work and also seminal contributions of other authors, as Mongelli (2002) points out, brought the first light upon the OCA theory, continuing that we can find some weaknesses of this period as for example OCA was lacking presence of unified framework, so far the clear empirical content of OCA features was missing. Below you can find the list which covers all criteria that were to be fulfilled for successful constitution of monetary union.

- **Price and wage flexibility** – as Friedman (1953) mentions if prices and wages are flexible enough at the time of asymmetric shock, adjustment mechanism will more likely lead these countries of currency area towards the equilibrium. In case that prices and wages are not flexible, loss of flexible exchange rate can be seen as a cost (Kawai, 1987).
- **Mobility of factors of production including labour** – This Mundell´s (1961) criterion states that at the time of disturbances, flexible relocation of production factors helps facilitate transition towards equilibrium. Overall mobility is rather the matter of long-run than short-run due to the migration and retraining costs (while talking about labor), and due to the capacity to induce and implement direct investments (in case of capital). Baldwin (2013) argues that the culture, language, institutional differences and differences in products are considered as impediments to mobility dynamics.
- **Financial market integration** – Ingram (1962) says that deeper financial market integration implies faster capital flows (lending) of countries positively affected by shock to those negatively affected by asymmetric disturbances. Moreover, just slight shift of interest rate will induce adjustment mechanisms, making resources to be allocated more effectively and shrinking differences in long-term interest rates.
- **The degree of economic openness** – McKinnon (1963) distinguishes between tradable and non-tradable goods. Former one refers to goods which can enter to the foreign market, whereas the latter one is defined as goods which do not enter foreign market. Mutual ratio between these two items determines the degree of openness. The higher the degree of economic openness is the more suitable fixed exchange rate regime would be for the particular country.

- **The diversification in production and consumption** – Higher diversification in production and consumption decreases the impact of asymmetric disturbances. That implies that countries with high diversification will find joining currency areas as beneficial, whereas countries with less diversified production and consumption should keep flexible exchange rate (Kenen, 1969). As Puiu (2011) adds, principle of diversification is widely used in insurance, which results in risk sharing within the industry.
- **Similarities of inflation rates** – Fleming (1971) noted, as long as inflation rates are similarly low and stable among particular countries there will be positive impact upon mutual trade decreasing the need for flexible exchange rate regime.
- **Fiscal transfers** – According to Lacina (2007), fiscal transfers are supposed to be based on central redistribution of national budgets. In other words, considerable part of the national budgets should be shared on the monetary union level (supra-national level). This would enable central authority to redistribute fiscal transfers in accordance with the need of countries which were either negatively or positively hit by asymmetric shock. Former country would receive financial aid at the expense of latter one. Baldwin (2013) extends this area with the question of moral hazard. What if the monetary union suffers not from the random shocks (hitting different countries) but rather from shocks hitting just one country repeatedly. Than the rest of the monetary union might find it costly to absorb such shocks.
- **Political integration** – Political integration belongs to building stones of the criteria-list mentioned above. Participation in monetary union is rather political decision than economical. Political authorities must be firstly willing to relinquish their competences to supra-national level (Lacina, 2007).
- **Solidarity** – Puiu (2011) noted that also solidarity should be considered as an important criterion for OCA theory. Regarding solidarity, once the union interests are in disagreement with national interests, member countries should abandon national interest in the name of common policies.

The Reconciliation Phase (1970´s)

Mongelli (2002) introduces the Reconciliation phase as follows, s second wave of researches extended the OCA nature by findings comparable with one another, formulation of new meta-characteristics and sorting out of gains and losses. For our

purposes, below you can find just some of the contributions which are directly linked with idiosyncratic disturbances.

McKinnon (1963) postulates that similarity of shocks is seen as a seminal criterion. McKinnon distinguishes between shocks having its origin in the monetary union or outside of the monetary union. Further description uses the case of two countries willing to form monetary union. One country is defined as low-inflation and second country is being under the influence of domestic supply and demand shocks. Once these two countries integrate monetarily, the latter country obtains stable prices of foreign products imported from former one keeping all the benefits from mutual monetary integration and supporting the value of money.

Mundell (1973) developed further some of the OCA theory characteristics, claiming that asymmetric shocks are less influential since members of monetary union are strongly interconnected via private financial channels. Mitigation of impact caused by asymmetric shocks can be administrated through diversification of the wealth portfolio, origin of income and foreign reserves.

The Reassessment Phase (1980´s till early 1990´s)

In the early 1980´s the OCA theory experienced a period of stagnation. As Mongelli (2002) continues, the development led the OCA theory to be revaluated in terms of its fundamental building stones i.e. more weight was put on the benefit-side contrary to cost-side approach present in the previous phases, relinquishing of national currency implies relatively smaller costs. This period can be seen as the period of criticism of OCA theory, in the end turning into the new theoretical paradigm, so called, "new theory of OCA". Furthermore, the dynamics of Reassessment Phase was spun by the European Economy report "One Marker, One Money" (1990) which discovered that the current OCA theory cannot be applied on future theoretical needs of the EMU.

Relinquishing of independent monetary policy was perceived as the main cost since Mundell (1961). Once the Phillip´s curve was recreated to reflect that wages are negotiated in real terms rather than in nominal terms, the inflation become to be perceived as anticipated, and overall monetary instruments seemed to be ineffective in the long run real terms, from this point of view the monetary policy loses its effectiveness and its abandonment implies lower costs (than estimated) stemming out from forming of the monetary union.

De Grauwe (2009) recalls that there were also other substantial areas which were the part of cost side in the "old" OCA theory, in other words prerequisites negatively affecting net benefits from joining currency area. Among these we can find differences between the countries (differences in the institutional framework in the labor market, various legal systems and financial markets, growth rates), credibility issues and openness of countries. These areas were reconsidered during the "new theory of OCA" era bringing up that resulting costs will not have such a severe impact as it was estimated at the earlier stages of the OCA theory.

The Empirical Phase (recent history)

Within this phase which can be dated from 1980´s till today, we can find numerous papers based on the empirical evidence focusing on the particular criteria of the OCA theory. Technical and econometric advancements, theoretical development and increased attention towards European integration process can be find as the main reasons for these papers being widely compiled.

Moreover, Mongelli (2012) noted that as the meta-characteristic of the OCA theory can be seen the similarity of shocks reflecting interlinkages between several OCA characteristics. The story behind states that if the supply and demand disturbances and velocity of adjustment mechanism are similar between countries which would like to constitute a monetary union, then resulting costs of relinquishing independent monetary policies will decrease. It implies, that high correlation of business cycles between these countries is highly preferred feature.

4.1.2 Endogeneity of the OCA Criteria

Empirical phase also rose the question what happens next once the country integrates monetarily, put differently, the ex post character (i.e. the endogeneity) of the OCA criteria was researched. In other words, endogenous OCA criteria imply that once the country integrates monetarily, these criteria will be satisfied afterwards even though they have not been satisfied before. Rozmahel (2008) noted that an attempt to formulate the answer was made by One Market, One Money (1990) and subsequently by Krugman (1993). Despite the fact that these two approaches contradict, both are dealing with the role of deeper economic integration, trade intensity and economies of scale.

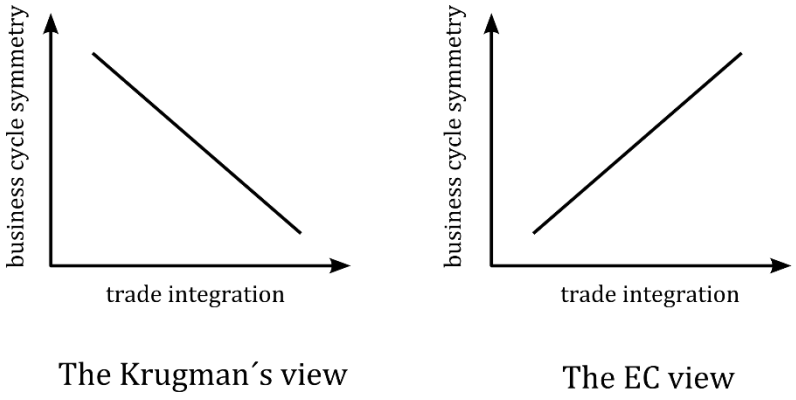
Let me get back to the question at the very beginning of this topic asking us what happens once the country in question joins the monetary union. The report

called **One Market, One Money (1990)** directed by European Commission states that asymmetric demand and supply shocks are less likely event due to the decrease in trade barriers increasing intra-industry trade among the member states. Intra-industry trade is the situation in which countries forming monetary union trade the same kind of products. De Grauwe (2009) describes intra-industry trade as a mutual relationship where Germans sell and buy cars from French people, and vice versa. When the negative demand shock appears, the demand for cars decreases correspondingly in both countries affecting the market in the same way, which is the nature of symmetric shock, which is also the requested feature.

Contrary, **Krugman (1993)** argues that deeper economic integration and increase in the trade intensity catalyze process of the regional industrial specialization due to the lack of trade barriers and subsequent effect of economies of scale. Krugman states: "…the stronger are intra-industry linkages …the lower are transportation/transaction costs" making "…the geographical concentration more attractive for each individual firm" (Krugman, 1993, p. 246). And thus, the presence of asymmetric shocks is highly probable. Krugman supported this statement by empirical evidence stemming from the research analyzing the regional specialization in the US. De Grauwe (2009) contradicts that Krugman´s hypothesis is not wrong in the nature of definition itself but rather it is seen as misleading in the estimation of its overall importance and reach. There might be some regional specialization effect with no dispute, but it will be most likely borders-blind meaning that the specialization effect will be present within particular region shared by two or more countries i.e. as a reaction to asymmetric disturbances, the possession of independent monetary policy (by countries in question) would have no effect.

Figure 1 graphically illustrates the **Krugman´s view and European Commission view**. The vertical axis stands for the level of symmetry of business cycles (output and employment), the horizontal axis stands for the level of trade intensity between countries that form monetary union. In accordance with Paul Krugman´s view, the relationship between these two variables is negative i.e. the deeper the trade integration is while increasing the trade intensity, the more asymmetric disturbances in terms of output and employment integrated countries face. The European Commission argues that if the trade intensity increases then the symmetry of shocks increases too.

Figure 1 Paul Krugman vs. European Commission



The Krugman´s view The EC view

Source: De Grauwe (2009), adjusted by author

Endogeneity – Empirical Studies

Several empirical studies, dealing with the endogeneity of the OCA criteria, have been published in late 1990´s. As a very substantial work is seen the study of Frankel-Rose (1998) and Fidrmuc (2001) analyzing the impact of trade intensity and its structure (intra vs. inter-industry trade) respectively.

Frankel-Rose (1998) suggested that the OCA criteria might be satisfied ex post and provided some seminal empirical background. The work assumed that by forming monetary union countries deepen trade interlinkages among them resulting into higher business cycle synchronization. By using panel of 20 countries and 30 years, they verified the initial hypothesis resulting into the statement that: "Continued European trade liberalization can be expected to result in more tightly correlated European business cycles, making a common European currency both more likely and more desirable." (Frankel-Rose, 1998, p.3). This paper also mentioned that the structure of the trade itself (inter vs. intra-industry trade) could influence the dynamics of the endogeneity, nevertheless the question of trade structure was not the main interest of Frankel and Rose. In contrast of this,

Fidrmuc (2001) tested the impact of trade structure upon the endogeneity of the OCA criteria. Grubel-Lloyd index is implemented in order to find out what is the impact of trade structure upon the business synchronization. The results are in favor of the intra-industry trade intensity and not in favor of bilateral trade volumes, contrary to findings of Frankel-Rose (1998).

4.2 Should We All Abandon National Currencies?

By the time the OCA theory has been developed, economists have been formulating costs and benefits of monetary integration. Its overall comparison should help us define whether the country should relinquish national currency and enter monetary union or whether to keep domestic currency and stay aside. De Grauwe (2009) highlights that benefits from abandoning national currency stem from microeconomic level whereas costs stem from macroeconomic level.

Worth mentioning, benefits and costs are not easily measurable, numerical quantification might be biased by researches attitude and therefore this thesis will limit itself to identify chosen benefits and cost just from the theoretical point of view. For illustration and clear depiction there will be used GG-LL model which helps to understand the point in question.

4.2.1 Benefits of Joining Monetary Union

De Grauwe (2009) noted that benefits can be characterized as gains in efficiency coming from both removal of transaction costs and risk elimination of exchange rate fluctuations.

- **Elimination of transaction costs and exchange rate risk** – refers to a mutual situation in which national currency is converted into foreign currency and vice versa, affecting all entities (firms, investors, tourists, authorities, banks etc) making transactions across the borders. De Grauwe (2009) mentions that this positive effect from joining monetary union is the most easily quantifiable one. European Commission estimates state that gains might be at the level from 13 to 20 billion euros a year.
- **Price transparency** – is basically bringing the prices into unified currency units. Consumers comparing prices can easily make decisions without necessity to reflect exchange rate fluctuations and risk, subsequently competition should increase due to this effect. Contrary to this De Grauwe (2009) states that price transparency mechanism is not necessarily present in Eurozone. Based on the studies that have been conducted on this phenomenon one can say that introduction of euro have not had such a positive direct impact as the theory expects.
- **Less uncertainty** – is connected with the risk associated with exchange rate volatility. Let´s assume that there are risk-averse individuals. Once the risk is

eliminated these individuals will be willing to invest more leading to, generally speaking, increase in welfare (De Grauwe, 2009).

- **Common currency as an international currency** - US dollar can be seen as an example of international currency playing important monetary role across the globe. When countries form a currency area big enough, this newly established common currency might become strong and powerful in terms of international relations and diplomacy. As Lacina (2007) points out, the euro became an important player in the field of international monetary system strengthening political and economic position of the EU in the world.

4.2.2 Costs of Joining Monetary Union

- **Loss of independent national monetary policy** - Mundell (1961) considers relinquishing of national currency to be the main cost of joining the monetary union i.e. country in question will not be able to use exchange rates or interest rates for recovery while being hit by asymmetric shock.

  This situation is further described via depicting two countries having balanced balance of payments, being in full employment and, simultaneously, being under the influence of asymmetric demand shock, that is to say, there is a change in preferences (demand shock) from goods of country A towards goods of country B. Following scenario takes into account the situation in which these two countries use flexible exchange rate regime and keep their national currencies. Then, such asymmetric shock causes unemployment pressures in the country A and inflationary pressures in the country B. Both countries are in disequilibrium and thus adjustments of exchange rate become satisfactory solution. Country A depreciates making their products more competitive and cheaper, and country B appreciates in order to decrease inflationary pressures.

  Once these two countries form monetary union, they lose independent monetary instruments. De Grauwe (2014) points out, there are another mechanisms which can stimulate movements towards the equilibrium, including wage flexibility and mobility of labor. Furthermore, Lacina (2010) suggests other mechanisms as fiscal transfers or change in the price level to help countries with adjustment process.

- **Changeover costs**- We can distinguish administrative, legal, hardware and psychological costs connected with joining monetary union.

As an administrative costs we can find, for instance, the introduction of supranational authority, transformation of prices within the market, dual prices before the transition is completed. In addition to that, once the exchange rate parity is not chosen wisely, this might lead to costs from being to competitive or not competitive in terms of competition among member states. Such imbalance will parish when the level of economic activity adjusts to the one prevailing among other member countries (Mongelli, 2002).

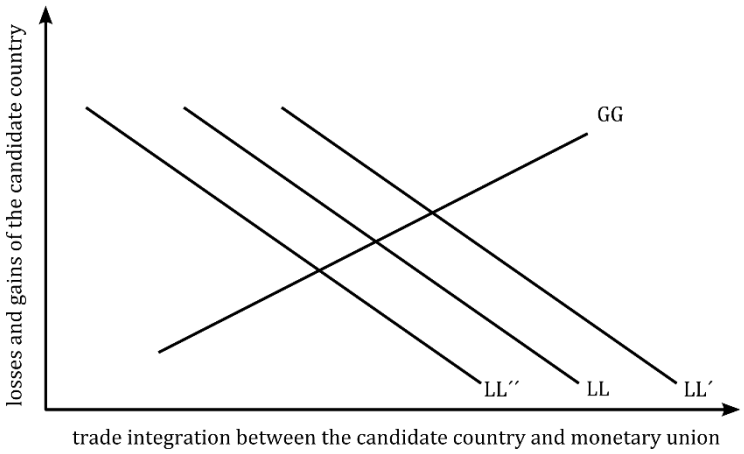
- **Cost from negative external shock** - Mongelli (2002) and Lacina (2007) noted that some countries of monetary union might prefer to run huge deficits turning into vast debt which, subsequently, might lead to monetization i.e. the international trust into the common currency (being an international currency) could be negatively affected.

4.2.3 The GG-LL Model

Krugman-Obstfeld (1994) considers the GG-LL model as a tool for measuring costs and benefits of joining monetary union. GG curve stands for benefits and LL for costs. The GG curve is upwards sloped representing the higher economic integration between the candidate country and monetary union is, the higher monetary efficiency gains are. The LL curve is negatively sloped stating that higher economic integration between the candidate country and monetary union results in lower costs from loss of national currency.

Rozmahel (2008) argues that the position of LL curve is determined by synchronization of business cycles and presence of disturbances. Rozmahel´s augmented GG-LL model derives LL´ and LL´´ curves. In case of small synchronization of business cycles and overall asymmetric shocks, the LL curve shifts to the right turning into LL´. In case of business cycles being synchronized at the high level and shocks are rather symmetric, the LL curve turns into LL´´ (see Figure 2). Stromberg-Kaller (2012) emphasized that the point of intersection of GG and LL (LL´, LL´´) curve depicts the critical level of economic integration. To the left of this critical point, costs are higher than benefits and to the right, gains are higher than losses. The candidate country should join the monetary union as long as the degree of economic integration is at least at the level of GG-LL (LL´, LL´´) intersection.

Figure 2 GG-LL Model: Gains and Losses Compared



Source: Krugman-Obstfeld (1994) and Rozmahel (2008)

4.3 What Do We Know About the Business Cycles?

The definition of business cycle can be taken from OECD Glossary (2001): "Business cycles are recurrent sequences of alternating phases of expansion and contraction in economic activity." The main attention towards business cycle analysis has started to be paid in the 20th century.

Rozmahel (2008) notes that the analysis of business cycle synchronization has been dominantly used for the assessment of economic convergences among candidate countries and member states of monetary union. This approach complies with the "new OCA theory" leading us to the assumption that the higher the business cycle correlations and convergences of countries forming monetary union are, the higher probability of gains being greater than costs (stemming out from the common currency) is.

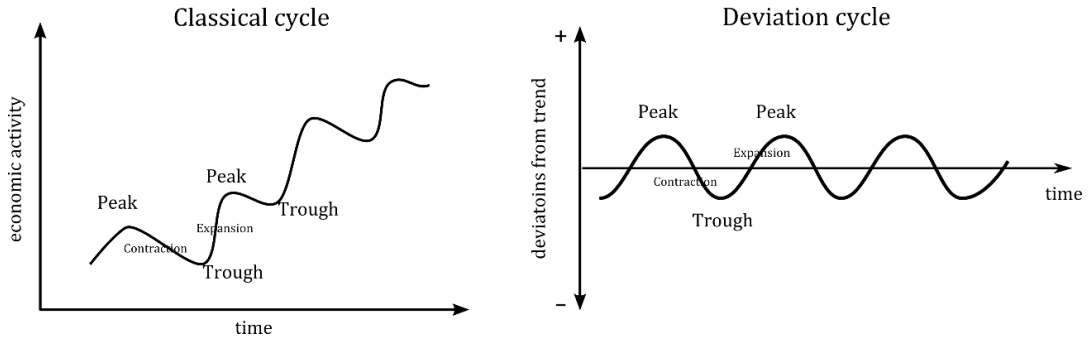
Hereafter, we will define two alternative practices commonly used for the estimation of business cycles nowadays i.e. classical approach and deviation approach. Behind the **classical business cycle** we can find the study of Burns-Mitchell (1946) defining the business cycle as a fluctuation of aggregate economic activity consisting of the expansion, recession, contraction and turning back into the expansion of a forthcoming cycle. The phases of business cycle differ from one another in terms of duration and amplitude. The cycle can span over 1 year up to 12 years.

Whereas the **deviation cycle** (also referred as growth cycle) was described by Lucas (1977) stating that the business cycle is to be seen as a cyclical deviation of an aggregate economic activity (output) fluctuating around its trend. Male (2010)

noted that this kind of analysis requires the trend to be excluded from the time series by application of some de-trending technique such as the Hodrick-Prescott (1997) filter commonly used nowadays. This technique requires a smoothing parameter to be set in respect to the cycle duration. Male stresses out that: "…it is this cyclical component which is considered to be the growth cycle." (Male, 2010, p.1) Fidrmuc (2004) perceives the Band-Pass filter from Baxter-King (1999) to be also suitable technique for dissecting the cyclical component.

Each business cycle consists of **turning points** i.e. the peak and trough. The peak-to-trough phase is called the recession or contraction. Long-lasting recession is called depression and can be accompanied by the deflation. The trough-to-peak phase is so called boom or expansion and is likely to be accompanied by inflation. Once we have clarified the terminology used, we should describe the state of economic activity regarding each of these phases. Peak is the point at which the economy fully utilizes capacity of its resources, there is also a high level of investments, demand, supply and low level of unemployment. After the peak is reached, inevitably, the recession comes. While being in the recession, dynamics of the economy slows down in hand with the negative expectations, the unemployment rate starts to increase, the level of demand, supply and investments decreases until the cycle reaches the trough. In this situation, the economy does not efficiently employ its resources turning into the high unemployment rate, low level of investments and demand. After trough there is the expansion in which economy experiences positive expectations, increase in the employment of resources, investments and demand.

Figure 3 Deviation and Classical Cycles Compared



Source: Reichlin 2004, adjusted by author

4.3.1 Business Cycle Synchronization in Context of Monetary Integration

The business cycle similarity studies have been vastly published and became an inherent part of the OCA criteria analysis. There are business cycle studies which examine the synchronization issue from many points of view. For instance such studies test various aspects in different areas around the globe with no respect to the common currency, or we can find studies implementing alternative methodology approaches in order to obtain new insights or, furthermore, compare the results with respect to methods previously used. Therefore, the review below brings just a brief insight into the problematics of business cycle synchronization.

The first decision making comes in terms of what business cycle the researcher is going to research. Regarding business cycle correlations, we need to distinguish between two approaches used for the identification of the business cycle itself. As mentioned previously, the distinction needs to be made between the classical business cycle (Burns and Mitchell, 1946) and deviation (growth) business cycle (Lucas, 1977). Studies as Bonenkamp (2001), Fidrmuc (2004), Rozmahel (2011) and Male (2010) note that such distinction is needed.

Furthermore, Bonenkamp (2001) concludes that while applying classical business cycle approach the peak occurs later than in case of growth cycle approach, simultaneously, becoming more and more asymmetric i.e. long period of expansion is substituted by a short recession. As Bonenkamp (2001) continues, classical cycles have some tendencies to pass away (disappear) if there is a presence of steadily growing trend. One can also detect some disadvantages of the deviation cycle such as the choice of technique approximating the trend. Fidrmuc (2004) adds that the deviation approach prevails in the current discussion.

From the most global point of view, there are studies as Bagliano-Morana (2010) assessing the degree of co-movement among the countries of G-7 (Canada, France, Germany, Italy, Japan, the United Kingdom and the United States, the European Union was also included). For that purpose, there are applied methods such as large-scale factor vector autoregressive (FVAR) model, impulse response analysis and forecast error variance decomposition. The variables of co-movement include real GDP, the real oil price, the real stock market price index, the real effective exchange rate and others. The concluding part states that the source of business cycle synchronization are both common shocks and common transmission mechanism rather than spillover effects of individual shocks coming from abroad.

Cerqueira (2010) examines the world-wide synchronization since 1960. As highlighted, new alternative approach is applied in order to find out whether the results (provided by current literature) of world-wide business cycle synchronization are not biased due to the presence of extremes. Such extremes might deflect overall outcomes because of the usage of time windows. Hence, cross-correlation index bounded from <-1, 1> is applied. As the main source was used the data of Real Gross Domestic Income Adjusted for Terms of Trade Changes. Cerqueira (2010) created groups of countries based on the geography or development level. This paper is concluded by the statement of high international business cycle synchronization reflecting the deviations among the groups.

Studies of both Bagliano-Morana (2010) and Cerqueira (2010) focus on the business cycle synchronization in context of the OCA theory. On contrary to that, we can find numerous studies investigating the business cycle convergence with respect to the Optimum Currency Areas. Such studies are reviewed below.

The great number of concurrent studies apply correlation analysis for the assessment of business cycle synchronization, and that might be one of the reasons why Rozmahel (2011) uses concordance index and compares received results with the more traditional correlation approach. The paper concludes these two approaches result in significantly different outcomes i.e. the correlation analysis results in relatively low correlation of business cycles between the Eurozone and EU periphery, in contrast, the concordance analysis does not detect significant differences at all.

When speaking of alternative approaches, the paper of Cerqueira-Martins (2009) derives a cross-correlation index which possesses of several advantages compared to the traditional over-time correlation approach. As the main advantage is seen the capability of capturing time variability, which is due to the fact that the cross-correlation index is computed on the year-by-year basis rather than over the entire period. Artis-Okubo (2011) adjusted this cross-correlation index in terms of the domain. Cerqueira-Martins´ cross-correlation index is bounded in $(-\infty, 1>$, which results in asymmetric outcomes, whereas Artis-Okubo applied Fisher transformation in order to get the index bounded in interval of $(-\infty, +\infty)$. Such index is later referred as the Augmented cross-correlation index preserving the same advantages as original index but having symmetric range. As long as this index reflects time variability, simultaneous application of panel data is highly beneficial.

Lehwald (2012) asks the question whether the introduction of Euro changed the synchronization of business cycles in the core as well as on the periphery of the

EU. For this purpose, the period was divided into pre-Euro and Euro period. As a methodological tool there was implemented Bayesian dynamic linear factor model. The results go along with the statement that the business cycle synchronization within the EU was already to a great degree in the pre-Euro period. Once the Euro was introduced, the co-movement of business cycle has tended to further increase in case of core countries and decrease in terms of periphery, which goes against the implications of endogeneity mentioned in Frankel-Rose (1998). Lehwald continues that the increase in co-movement of business cycles was fostered by the development of world-wide business cycle tendencies. This statement complies with findings of Cerqueira (2010).

Besides the analysis of business cycle synchronization inside of the certain region or group of countries, there are studies which attempt to identify particular factors determining such correlations i.e. the cause of business cycle synchronization is examined. While researching the same question Lehwald (2012), Gaechter-Riedl (2014) employed year-by-year correlation index[9], independent variables were trade intensity, specialization index, fiscal difference index and dummy variable for EMU membership. As an econometric method was chosen dynamic panel method, which is the panel model containing lagged[10] dependent variable as a regressor. On contrary to Lehwald (2012), Gaechter-Riedl (2014) concludes that, with respect to the trade-intensity, introduction of common currency in the EU brought an increase in business cycle synchronization among the countries forming monetary union. Furthermore, such finding strengthens the idea of endogeneity.

Conraria-Soares (2009) analyzed the business cycle synchronization via implementation of alternative method, so called the wavelet analysis. Schleicher (2002) states that wavelets allow researchers to observe and examine data at different scales and, concurrently, data can be detected in time and frequency domain, which is very specific and unusual way of data transformation. It enables researchers to examine data from more general point of view as well as in detail. As Conraria-Soares (2009) continues, the paper examines the business cycle of EU core countries and, subsequently, tests whether other countries converge to the core or not, if yes at what frequencies. Such wavelet analysis, and wavelet filter particularly, provides another option to dissect the cyclical component from time series. Briefly concluding, business cycles of all EU countries converge except of Portugal.

[9] Year-by-year index is in fact the Augmented cross-correlation index of Artis-Okubo (2011) stemming out from Cross-correlation index of Cerqueira-Martins (2009)

[10] The lag was chosen at the level of 1.

Determinants of convergence are examined in Beck (2013) where one can find empirical evidence on the impact of structural convergences upon the business cycle synchronization. The cyclical component of the real GDP is detected by the Baxter-King (1999) filter due to its capability of neglecting high and low frequency components which can be caused by the monetary policy. Bilateral correlation is applied for the assessment of business cycle synchronization. Among structural indices we can find Krugman Specialization Index, pairwise trade intensity, bilateral population product and others. Estimation is done throughout the extreme bounds analysis (EBA) and OLS method. Accordingly to this paper, higher structural convergence can better imply similar reaction to economic disturbances.

Beck (2014) applied new data in hand with panel data regression and received following outcomes:"… lack of trade barriers and common currency have a positive impact on business cycles synchronization. Unfortunately, they also have strong positive impact on specialization, which leads to lower portion of intra-industry trade in overall trade and further structure divergence." (Beck, 2014, p.46). The paper concludes that the Krugman´s view is present, which might become a threat for the business cycle synchronization in the future.

Besides all above mentioned varieties, Issifov (2014) examines the impact of global value chain upon the business cycle synchronization in the euro area and CEE (Central and Eastern Europe). Cross-border production chain, accounting for a large share of products exported from CEE countries to the Euro area, is a substantial channel for spreading shocks between these two regions, regarding the short run point of view. Such output fluctuations are caused by industry-specific shocks and inventory adjustments. From the long run point of view, however, the future business cycle development of CEE countries is more dependent on the global demand rather than on the Euro area. As a concluding remark, both regions are highly synchronized and if there is any common demand and/or supply shock, it is transmitted via global value chain. Further common inventory adjustments strengthen the business cycle synchronization.

As a determinant of business cycle co-movements, Asteriou-Moudatsou (2015) tests the mutual foreign direct investments (FDI) in connection with the bilateral trade intensity. The data for 21 EU countries were regressed via the panel regression of fixed and random effects. As the results show, the business cycle synchronization is not directly fostered by the foreign direct investment. On contrary to that the international trade encourages the business cycles to synchronize, however, just in case of traditional EU15 countries and, simultanously, in the pre-crisis period solely.

Above mentioned studies deal with the business cycles synchronization in a specific way, either the methodology or determinants of influence or dataset vary over each sample. That is why there are discrepancies among the concluding outcomes. Rozmahel (2011) finds out that studies dealing with the business cycle synchronization lack common methodological and conceptual background and thus the results of such studies may differ eventually, which was proved to be true in the brief review above. This thesis reflects current development in the business cycle synchronization area and employs as best determinants, methods and datasets as the researcher is aware of.

5 Convergence of Business Cycles in the EU

As the literature research mentions, business cycle synchronization became an inherent part of the OCA criteria and thus the analysis of business cycles within the particular area is of a great interest paid by researchers. The goal of the thesis goes along with these intentions. The aim is to analyze the synchronization of economic activities among member states of the European Union, and identify the aspects influencing the business cycle synchronization itself. Business cycle is extracted based on the deviation cycle approach. Dissecting of the cyclical component and simultaneously obtaining the deviation/growth cycle is performed via Hodrick-Prescott filter. Based on these presumptions, the analytical part is divided into two main chapters i.e. **the correlation analysis** researching the level of business cycle synchronization in the EU, and **the regression analysis** identifying aspects of influence.

5.1 To What Level Are Business Cycles Synchronized in the EU?

In this chapter we introduce correlation analysis from a few stand points, with the main focus on the GDP, GVA and IPI correlations among the EU countries such as for instance Finland, France, Germany, Slovakia, Spain (the group of EA countries) and Czech Republic, Denmark, Hungary, Sweden, United Kingdom (the group of non-EA[11] countries).

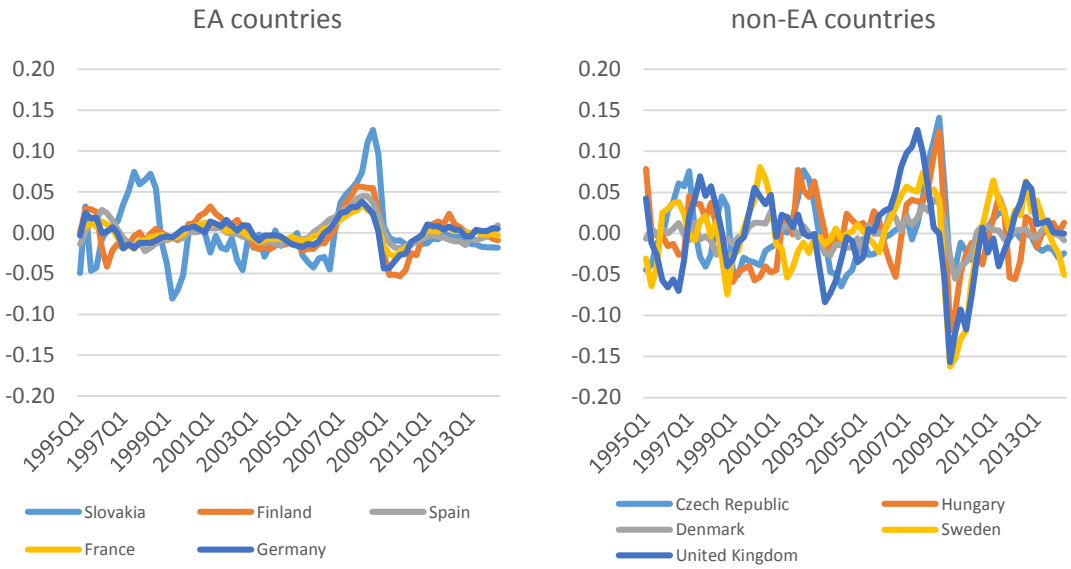
At the very beginning, we introduce **business cycles** with respect to GDP, GVA and IPI. Secondly, there are **analyzed pairwise (mutual) cross-correlation relations** of countries within the EU, as well as **correlations of an individual country with the euro area**. These relations do not reflect the evolution of the correlation itself i.e. the time aspect is neglected. Later, we approach towards the analysis of indices reflecting the time i.e. we analyze the correlation with its dynamics when implementing methods such as **rolling correlation** and **augmented cross-correlation index.**

[11] EA stands for the Euro area.

5.1.1 Identification of the Business Cycles

Before we approach to the correlation analysis itself, the development of GDP, GVA and IPI cycles is to be assessed below. The data of GDP, GVA were transformed into the natural logarithms so we can count on percentage points as a measurement. Then the Hodrick-Prescott filter was used as a de-trending technique providing us with the cyclical component of the time series i.e. the growth cycle[12]. Regarding IPI, these values were already obtained in per cents and thus the natural logarithms were not applied, just the Hodrick-Prescott filter was used.

Figure 4 GDP Growth Cycles of Chosen EA and Non-EA Countries (quarterly data: 1995Q1-2014Q2)[13]

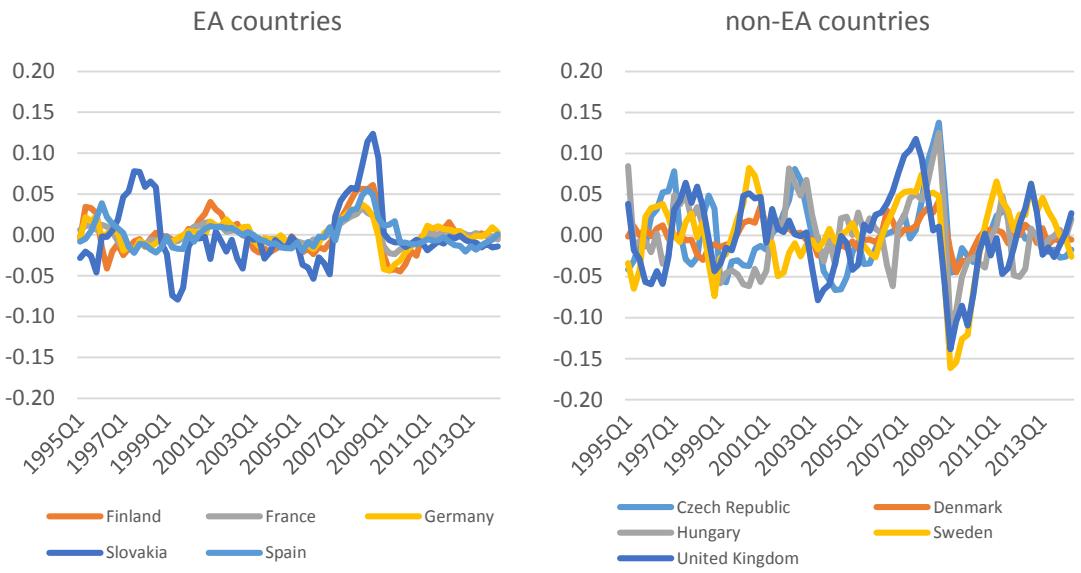


Source: Eurostat, author´s calculations

[12] Literature review mentioned two ways of extracting business cycles such as classical approach and growth/deviation approach. Hereinafter we talk about the growth cycles solely and thus the term business cycle and growth cycle are used interchangeably.

[13] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix A. The division of geographical regions is based on the United Nations classification.

Figure 5 GVA Growth Cycles of Chosen EA and Non-EA Countries (quarterly data: 1995Q1-2014Q2)



Source: Eurostat, author´s calculations

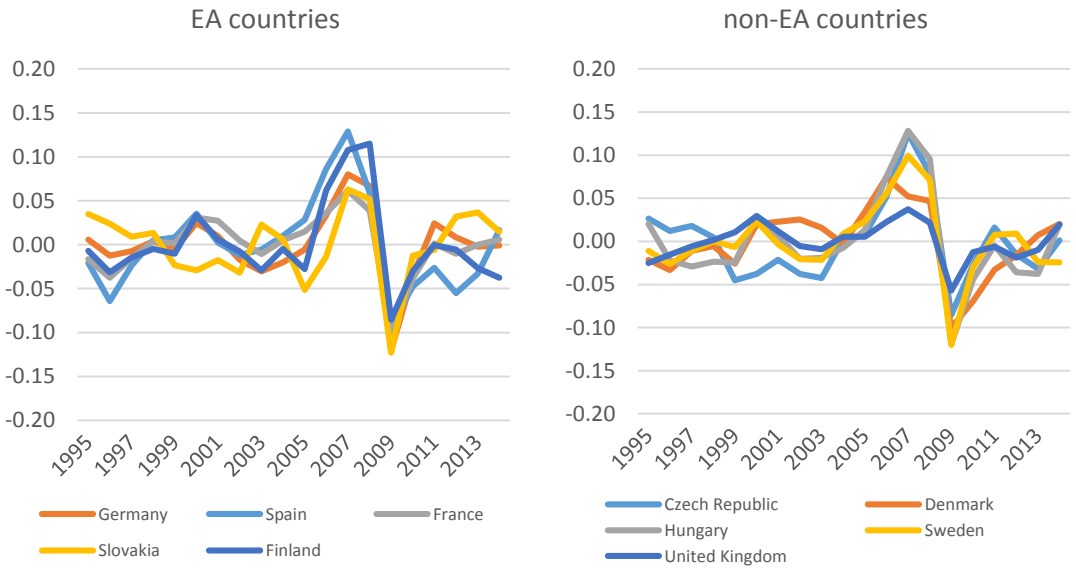
Figures 4 and 5 depict the evolution of Gross Domestic Product and Gross Value Added of chosen countries in time. Both EA countries and non-EA countries experienced a significant drop in 2008 which turned into a recession period reaching its trough around 2009 and 2010. The GDP and GVA development of EA countries seems to be much more stable, consistent and moderate compared to the non-EA countries. When taking into account the EA countries, in 1996-1997 and 2003-2004 the economic activity slowed down. Before the last economic crises begun the growth cycles had reached the peak being at the highest level within the examined period.

In terms of the consistency, the only exception is Slovakia which wasn´t the part of the Eurozone back then. In the pre-crisis[14] period Slovak business cycle significantly deviates from Eurozone countries. The performance of Slovakia seems to be rather similar to the non-EA countries, which actually Slovakia was till 2009. Since Slovakia joined EMU, the development of selected macro indices is much more similar to the EA countries. Post-crises period in the EA countries is to be homogeneous and moderate, Slovakia included.

[14] Pre-crisis and post-crisis are the abbreviations of the period before and after the crisis emerged, respectively.

Non-EA countries report quite heterogeneous development of GDP and GVA. Besides the last crises period, the economic activity of Denmark, Czech Republic and Hungary slowed down in 1998 and 2004, Hungary experienced recession also in 2006. The drop can be seen also in the case of the UK and Sweden in 1997 and 2000. Nevertheless, Sweden was able to recover after the latter one faster than the UK. Looking closer at the pre-crises period in the graph, one can notice that these two countries experienced troughs and peaks earlier in the time compared to the other countries. Worth mentioning, GDP and GVA development of Denmark is much more similar to the EA countries. Czech Republic and Denmark were affected by the global crises much less than the rest of the non-EA sample. Let us conclude this paragraph with the statement that GDP and GVA have been shaping in pretty much the same way taking into an account the overall appearance of charts.

Figure 6 IPI Growth Cycles of Chosen EA and Non-EA Countries (annual data: 1995-2014)



Source: Eurostat, author´s calculations

Figure 6 illustrates an evolution of Industrial Production Index from 1995 to 2014. While development of GDP and GVA can be characterized as quite similar, the IPI differs from them considerably. Contrary to previous analysis of GDP and GVA, the development of the IPI between EA countries and non-EA countries does not vary at a high degree. Both series are rather homogeneous and moderate in time. Naturally, the most visible peak occurred in 2007-2008 before the crises emerged. Subsequent recession reaches its trough in 2009. In 2012 most of the above mentioned countries

experienced another decline in the economic activity which is not of the crises dimensions.

As an exception in the IPI series can be seen Czech Republic and Slovakia. The value of Czech and Slovak IP index was almost constantly declining since the beginning of the examined period till 1999. Before Slovakia reached the fore mentioned peak in 2008, the country went through another significant contraction in 2004, which is not the case of the Czech Republic. Czech Republic experienced a minor contraction in 2001, and since 2003 had been constantly growing till the country reached before-crisis-peak in 2007.

When considering the contraction caused by the crisis, the most moderate impact upon the IPI can be observed in the UK which values of the peak and trough were the most conservative ones i.e. the UK experienced stable development of the IPI with the absence of strong deviations in contrast to the other countries from our sample. This might imply that the more rapid and anomalous the growth is the deeper recession takes place. To prove this statement there would be a need of further research, which is not the goal of this thesis.

5.1.2 Pairwise Cross-Correlations within the EU

Below you can find the cross-correlation table consisting of pairwise results for the particular pair of countries. Table 1 shown below describes just the sample of examined countries (for the full-length table please see Appendix B). X-axis refers to the certain country of EU28 which is about to be called the benchmark country, Y-axis depicts the EU countries lagged by ±4 time periods. All input data of GPD were transformed to the natural logarithms, in order to dissect the cyclical component the Hodrick-Prescott filter was applied, the dataset ranges from 1995Q1 to 2014Q2 for each and every country. Usage of the Hodrick-Prescott filter implies that we are about to deal with the deviation cycles.

Table 1 GDP Cross-Correlation Indices of Selected EU Countries (HP filter, quarterly data: 1995Q1-2014Q2)[15]

Lagged country	Benchmark country: EA		AUS		CZE		FIN		FRA		GER		GRE		HUN		LUX		SPA		SWE	
	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag	correlation	lag
EA	x																					
AUS	0.86***	1	x																			
CZE	0.67***	-1	0.56***	-2	x																	
FIN	0.81***	0	0.81***	0	0.44***	1	x															
FRA	0.91***	0	0.95***	0	0.57***	1	0.85***	0	x													
GER	0.91***	0	0.88***	0	0.51***	1	0.85***	0	0.90***	0	x											
GRE	0.27**	-4	-0.21*	3	0.40***	-4	-0.12	-1	0.23**	-4	-0.28**	4	x									
HUN	0.5***	-1	0.31***	-1	0.51***	0	0.42***	0	0.34***	0	0.44***	-1	0.08	4	x							
LUX	0.78***	2	0.86***	1	0.46***	3	0.67***	2	0.84***	1	0.75***	1	-0.25	-4	-0.33***	-4	x					
SPA	0.84***	0	0.84***	-1	0.61***	1	0.65***	-1	0.84***	-1	0.76***	-1	0.55***	4	0.29***	-1	0.78***	-2	x			
SWE	0.55***	1	0.59***	1	0.40***	-4	0.60***	2	0.66***	1	0.61***	0	-0.28**	-4	0.34***	2	0.64***	0	0.41***	2	x	
UK	0.6***	2	0.66***	2	0.37***	4	0.78***	2	0.70***	2	0.62***	1	-0.23**	-4	0.38**	2	0.53***	1	0.57***	3	0.64***	0

Source: Eurostat, author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

The lags were incorporated into the analysis in order to identify whether there are some countries which can theoretically serve as a forecast countries of future development in the EU. Based on the data in the Table 1 we can state that Luxembourg and United Kingdom can be seen as those forecasting countries. When taking into account Luxembourg, this country has simultaneously the highest average correlation coefficient with other countries and most of the lags positive. This might imply that what happens in Luxembourg (or eventually the UK) in terms of GDP development will sooner or later happen in the rest of EU with respect to the level of correlation coefficient.

Traditionally, high positive business cycle synchronizations can be seen among EA11 countries, furthermore, EA has the highest correlation coefficients with France (0.91***), Germany (0.91***), Netherlands (0.87***), Austria (0.86***), Spain (0.84***) or Finland (0.81***).

From the geographical point of view, also Baltic states i.e. Estonia, Latvia and Lithuania are highly correlated with each other (correlation coefficients are higher than 0.83***). Benelux countries also dispose of high correlations (correlations are greater than 0.75***) but not so high as in case of Baltic states.

[15]Cells of the table contain the maximum correlation coefficient in terms of absolute values. The results can be found in the following format: the correlation coefficient, the significance of that coefficient and the corresponding lag.

Taking into account countries as Denmark, Finland, Ireland, Sweden and UK, we can also find higher synchronicity than the EU average is, with respect to both the EU level and the national level.

Another group of countries to be compared is the Visegrad Four (hereinafter V4) consisting of Czech Republic, Poland, Slovakia and Hungary. Here we can see that these states do not generate such high correlations in absolute values as in case of fore mentioned countries, on the other hand these correlations are reaching mostly above-average levels regarding the average outcomes of each country in question. This implies that among V4 countries we can find higher business cycle correlations in terms of the average of individual states, nevertheless these results can be seen rather as the average values in terms of the EU.

Based on the data we can conclude that the countries on the periphery of the EU namely Greece, Italy and Portugal have quite low correlations among each other i.e. correlations are ranging between 0.17 and 0.32***. Also in terms of their national results these outcomes are below-average values except of Greece. Spanish values around 0.5*** with other countries on the periphery might be seen as an exception, nonetheless, this number is below-average in terms of Spanish correlations with the rest of the EU, which supports the statement that business cycles among peripheral countries on the south are not synchronized to a high degree.

Greece is the country which has the lowest correlations with other member states. Greece also generates the highest number of negative significant correlation coefficients meaning that there is some significant asynchrony in business cycles among certain states and Greece. All of these outcomes are accompanied with the low level of significance.

Based on the cross-correlation Table 1 we can derive general statistics which is summarized in the Table 2 (for the full-length table please see Appendix C).

Table 2 General Statistics of the Cross-Correlation Coefficients[16]

	EU28		EA	AUS	CRO	CZE	FIN	FRA	GER	GRE	HUN	ITA	LAT	LIT	LUX	MAL	NET	POL	ROM	SLO	SWE
average	0.58		0.69	0.64	0.67	0.52	0.65	0.68	0.62	0.13	0.30	0.44	0.67	0.58	0.56	0.50	0.61	0.57	0.60	0.61	0.39
count of average+	221	60.6%	22	21	23	8	21	21	17	2	0	7	21	14	14	8	19	15	17	19	14
count of 0.7+	86	23.6%	12	12	16	1	11	12	9	0	0	3	12	6	9	0	11	0	3	4	0
count of 0.8+	32	8.8%	6	8	2	0	6	8	6	0	0	0	4	2	2	0	6	0	0	1	0
count of 0.9+	3	0.8%	2	1	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0
max	0.95		0.91	0.95	0.87	0.72	0.85	0.95	0.9	0.55	0.51	0.71	0.87	0.9	0.86	0.69	0.87	0.69	0.78	0.85	0.67
min	-0.65		0.27	-0.2	-0.65	0.27	-0.12	0.23	-0.28	-0.3	-0.35	0.22	0.36	0.25	-0.33	0.26	0.27	0.34	0.42	0.4	-0.65
std. deviation	0.24		0.17	0.25	0.28	0.10	0.21	0.20	0.24	0.30	0.27	0.14	0.14	0.16	0.28	0.10	0.18	0.09	0.11	0.12	0.38

Source: Eurostat, author´s calculations

Let us approach towards the analysis of general statistics which stems out from the cross-correlation Table 1. The average value of cross-correlation coefficient in the EU28 reaches the level of 0.58. More than 60% of all correlations are above the average. Nevertheless, as we can see the numbers rapidly decrease as the lower limit of the criteria increases i.e. for instance the coefficients higher than 0.80 can be found just in 32 cases, which is 8.8% of the total sum of pairwise indices.

To get the overall picture of the business cycle correlations within the EU itself and its member states, we can examine the Table 2 more in the detail. Each row, except of min and max, highlights the 5 highest values (blue bold text) and alternatively the 2 lowest ones (red bold text) in some cases. France has the highest average correlation within the EU28, followed by Latvia, Croatia and Finland. France also reaches above-average correlations with 21 member states, being second right behind the Croatia counting for 23 above-average correlations. Among the most consistent countries in terms of deviations we can find Czech Republic, Malta, Poland, Romania and Slovenia. From different point of view, these countries belong to the average countries in terms of the overall correlations. Greece and Hungary are those countries which have poor performance in terms of the average correlation, number of average+ correlations and standard deviations.

[16] Criteria explanation:

- *average* stands for the average cross-correlation index of the certain country;
- *count of average+* imply the number of findings which are greater than the EU average;
- *count of 0.7+, 0.8+* and *0.9+* refer to the number of findings which are greater than 0.7, 0.8 and 0.9 respectively;
- *max* and *min* are the maximum and minimum values which are generated by the country in question.

5.1.3 Pairwise Cross-Correlations of Chosen EU Countries with the Eurozone

In this chapter we measure linear dependences (correlations) between an individual member state and EA i.e. below you can find an assessment of business cycle synchronization of a particular country and the Eurozone.

The time series is divided into 3 main sub-ranges and that is the span of 1995Q1-2014Q2, 1995Q1-2008Q2 and 2008Q3-2014Q2 corresponding to the full range, pre-crisis and post-crisis period respectively. The analysis helps us to detect the impact of crisis upon the performance of GDP business cycle synchronization, later on we implement lagged correlations in order to assess whether there was any impact of the global crisis upon the velocity of business cycle correlation.

Both EA countries and non-EA countries are examined here so we can compare these two groups of countries with respect to the euro area. As in the previous chapter, correlation coefficients range in the domain of <-1, 1> and reflect the development of correlations without the time dynamics. All of the GDP data were transformed into natural logarithms. In order to filter out the cyclical component, GDP data were adjusted by Hodrick-Prescott filter.

Figure 7 Pairwise Cross-Correlations of Selected Countries with the EA (GDP, HP filter, quarterly data: 1995Q1 – 2014Q2)

Source: Eurostat, author´s calculations

Figure 7 illustrates the GDP correlations of a certain country with the EA. Regarding the impact of crisis upon the business cycle synchronization, we can observe the

grey columns to be the highest ones regardless group of countries (EA countries and non-EA countries) i.e. higher correlations can be observed rather in the post-crisis period than in the pre-crisis period. As the exception can be seen the results of Spain which show higher GDP business cycle correlation in pre-crisis period than in post-crisis period. The crisis which hit the Europe around the year 2008 influenced the business cycle synchronization positively, most likely due to the fact that negative shock slowed down the economic activity throughout the whole EU28 turning into the recession in general, and thus we can see an increase in the linear dependence.

Table 3 Lagged Pairwise Cross-Correlations of Selected Countries with the EA (GDP, quarterly data: 1995Q1 – 2014Q2)[17]

GDP																				
1995Q1 - 2014Q2																				
LAG	EA countries										Non-EA countries									
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK	
-2	0.59	***	0.58	***	0.50	***	**0.50**	***	0.67	***	0.64	***	0.41	***	0.40	***	0.13		0.10	
-1	0.75	***	0.79	***	0.75	***	0.47	***	0.80	***	**0.67**	***	0.63	***	**0.50**	***	0.35	***	0.30	***
0	**0.81**	***	**0.91**	***	**0.91**	***	0.37	***	**0.84**	***	0.60	***	**0.73**	***	0.48	***	0.50	***	0.45	***
1	0.73	***	0.86	***	0.85	***	0.21	*	0.76	***	0.41	***	0.70	***	0.37	***	**0.55**	***	0.56	***
2	0.57	***	0.72	***	0.71	***	0.00		0.60	***	0.14		0.59	***	0.18		0.50	***	**0.60**	***
1995Q1 - 2008Q2																				
LAG	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK	
-4	0.21		0.13		0.25	*	0.27	**	0.20		0.46	***	0.10		**0.50**	***	0.01		-0.09	
-1	0.62	***	0.72	***	0.75	***	**0.36**	***	0.74	***	**0.62**	***	0.54	***	0.46	***	0.31	**	0.23	*
0	**0.76**	***	**0.89**	***	**0.90**	***	0.34	**	**0.86**	***	0.56	***	**0.67**	***	0.35	**	0.37	***	0.33	**
1	0.72	***	0.86	***	0.83	***	0.21		0.81	***	0.35	**	0.65	***	0.18		0.38	***	0.49	***
2	0.64	***	0.76	***	0.70	***	0.08		0.70	***	0.14		0.63	***	0.07		**0.40**	***	0.56	***
3	0.54	***	0.65	***	0.60	***	-0.01		0.58	***	0.01		0.56	***	-0.06		0.38	***	**0.57**	***
2008Q3 - 2014Q2																				
LAG	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK	
-1	0.75	***	0.68	***	0.54	***	0.38	*	0.56	***	0.33		0.52	**	0.22		0.33		0.33	
0	**0.94**	***	**0.96**	***	**0.94**	***	**0.51**	**	**0.71**	***	**0.75**	***	**0.87**	***	**0.75**	***	0.73	***	**0.62**	***
1	0.56	***	0.63	***	0.73	***	-0.05		0.18		0.34	*	0.61	***	0.52	**	**0.75**	***	0.61	***

Source: Eurostat, author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

Table 3 displays the lagged GDP cross-correlations. In the pre-crisis period Finland, France, Germany, Spain and Denmark indicate the highest correlation with the lag being equal to zero i.e. events affecting the business cycle synchronization of a country in question and the Eurozone occur almost simultaneously with respect to the correlation coefficient. Nevertheless, there are some other countries such as Slovakia, Czech Republic, Hungary, Sweden and the UK which report either positive or negative lags. For instance the positive lags of UK and Sweden at the level of 3 and 2

[17] The lag order was chosen at the level of 4 i.e. the correlation coefficients were computed with respect to the lag of ±4 quarters. For the table in full length please see Appendix D.

respectively mean that events affecting the business cycles occur in these countries 3 and 2 quarters before these events occur in the Eurozone, again with regard to the correlation coefficient 0.57 and 0.4 respectively. Analogically in case of the Czech Republic, negative lag of -1 means that the development of Czech business cycle is delayed by 1 quarter regarding the business cycle development in the Eurozone while considering the mutual level of correlation 0.62.

From the perspective of post-crisis period, we can see all the maximum values to be almost perfectly lined up. This implies that there is a change in the velocity of business cycle synchronization. Business cycle correlation between the Eurozone and certain country became positively synchronous with no respect to the membership in the group of either EA countries or non-EA countries, and moreover with no delays bearing in mind the corresponding level of correlation. This could be explained by a change in the speed of propagation mechanisms. Fore mentioned results are supported by the findings stemming out from the study conducted by the Czech National Bank (Česká národní banka, 2013).

Table 4 Lagged Pairwise Cross-Correlations of Selected Countries with the EA (IPI, quarterly data: 1995Q1 – 2014Q2)[18]

IPI											
1995Q1 - 2014Q2											
LAG	EA countries					Non-EA countries					
	FIN	FRA	GER	SVK	SPA	CZE	DEN	HUN	SWE	UK	
-1	0.83 ***	0.79 ***	0.85 ***	0.62 ***	0.64 ***	0.74 ***	**0.64** ***	0.79 ***	0.81 ***	0.69 ***	
0	**0.91** ***	**0.98** ***	**0.99** ***	**0.82** ***	0.91 ***	**0.89** ***	0.61 ***	**0.95** ***	**0.94** ***	**0.91** ***	
1	0.68 ***	0.82 ***	0.78 ***	0.73 ***	**0.92** ***	0.80 ***	0.39 ***	0.83 ***	0.78 ***	0.82 ***	
1995Q1 - 2008Q2											
LAG	FIN	FRA	GER	SVK	SPA	CZE	DEN	HUN	SWE	UK	
0	**0.86** ***	**0.96** ***	**0.98** ***	**0.76** ***	**0.91** ***	**0.83** ***	**0.45** ***	**0.94** ***	**0.88** ***	**0.83** ***	
2008Q3 - 2014Q2											
LAG	FIN	FRA	GER	SVK	SPA	CZE	DEN	HUN	SWE	UK	
0	**0.95** ***	**0.99** ***	**0.99** ***	**0.87** ***	**0.93** ***	**0.94** ***	0.82 ***	**0.97** ***	**0.97** ***	**0.96** ***	

Source: Eurostat, author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

Table 4 illustrates lagged pairwise cross-correlations based on the correlations of IPI (Industrial Production Index). The logic behind is the same as in case of GDP which is mentioned above. With regard to the pre-crisis period, we can see that the highest correlations are received with no lags i.e. correlation of industrial production is not delayed and all events occur simultaneously. Post-crisis period shows

[18] The lag order was chosen at the level of 4 i.e. the correlation coefficients were computed with respect to the lag of ±4 quarters. For the table in full length please see Appendix D.

similar outcomes as pre-crisis period in terms of the lags, which is the main difference regarding the lagged pairwise correlations of GDP. The only exception here is the Denmark which lags behind the Eurozone by 1 quarter. After the crisis emerged both GDP correlations and IPI correlations increased the overall performance.

5.1.4 Dynamics of the Business Cycle Synchronization within the EU

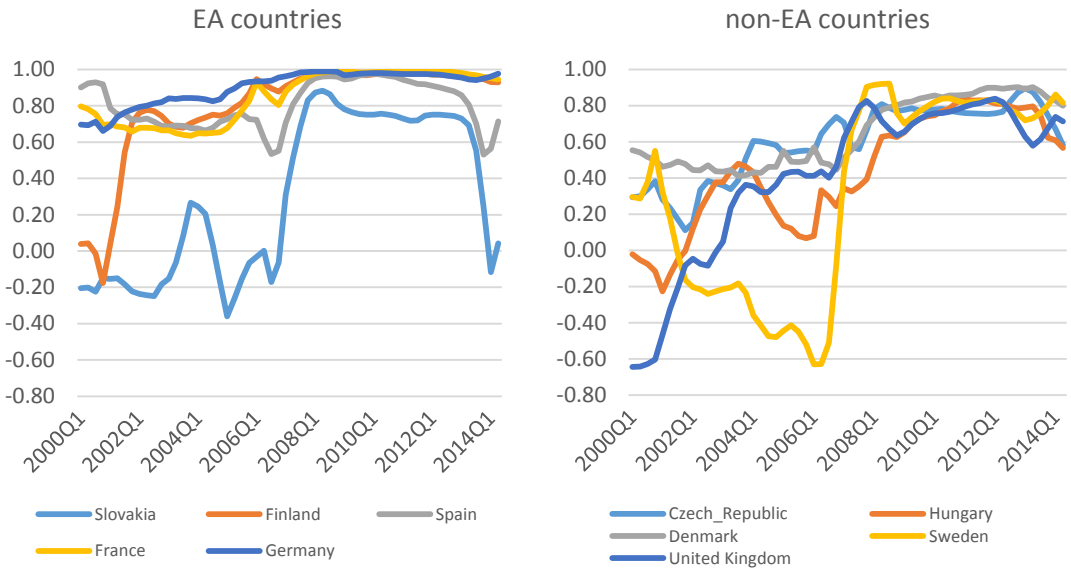
Previous sub-chapter dealt with the business cycle synchronization (correlation) from static point of view i.e. the development of business cycle was neglected and purely overall values were compared. The following analysis takes into account the dynamics of time. We incorporate two different ways of measuring business cycle synchronization with respect to the time. First method is commonly used among researchers and can be called the rolling correlation approach. Second method is the application of "Augmented cross-correlation index" which was introduced by Artis-Okubo (2011) based on the work of Cerquiera-Martins (2007). This index belongs to the group of alternative approaches for measuring the business cycle synchronization.

5.1.4.1 Rolling Correlation Approach

All of the input data of GPD and GVA were transformed to the natural logarithms so one can use percentage units instead of absolute values; IPI was already obtained in percentage units therefore natural logarithms did not take place in this case. In order to dissect the cyclical component the Hodrick-Prescott filter was applied for all three macroeconomic indices. Computation of the correlation coefficient is based on the 5-year rolling window for the GDP and GVA due to the quarterly data, and 3-year rolling window for the IPI due to the monthly data.

The correlation coefficients are ranging within the interval of <-1, 1> which has the same interpretation as in the case of previous chapter i.e. values close to -1 mean asynchronic business cycle correlation, and values close to 1 mean synchronic business cycle correlation. The main disadvantage of this method is that the dataset is reduced by the length of the rolling window and thus moving the starting point ahead. Another disadvantage is hidden in the nature of the rolling window itself, which is the smoothing out of exceptional/extreme quarters.

Figure 8 Business Cycle Synchronization with the EA Based on the 5-Year Rolling Window (GDP, quarterly data: 2000Q1-2014Q2)[19]



Source: Eurostat, author´s calculations

Figure 8 shows the business cycle synchronization of chosen countries with the benchmark country, which is the EA for now on. Let us divide these charts into two main periods i.e. pre-crisis (2000-2008) and post-crisis (2009-2014) period. Regarding EA countries, Germany is highly correlated with the Eurozone. This situation might be caused by the fact that Germany is denoted as the strongest economy in the EU and Eurozone. France, Finland and Germany have high and stable values in the pre-crisis and post crisis period. Spanish correlation coefficients were almost constantly declining in the pre-crisis period. Slovakia was not the member of the Eurozone in the pre-crisis period. Nevertheless, its values are below the EA and non-EA countries. Regarding the post-crisis period we can see that Germany, France and Finland keep the high correlations with the EA, Spain begun to slowly decline in 2010. This declination was followed by the drop at the beginning of 2013 which was substituted by the recovery tendencies in 2014. Correlation of Slovakia with the EA was slowly declining since 2008 being followed by the severe drop in 2013, some recovery can be seen since the year 2014.

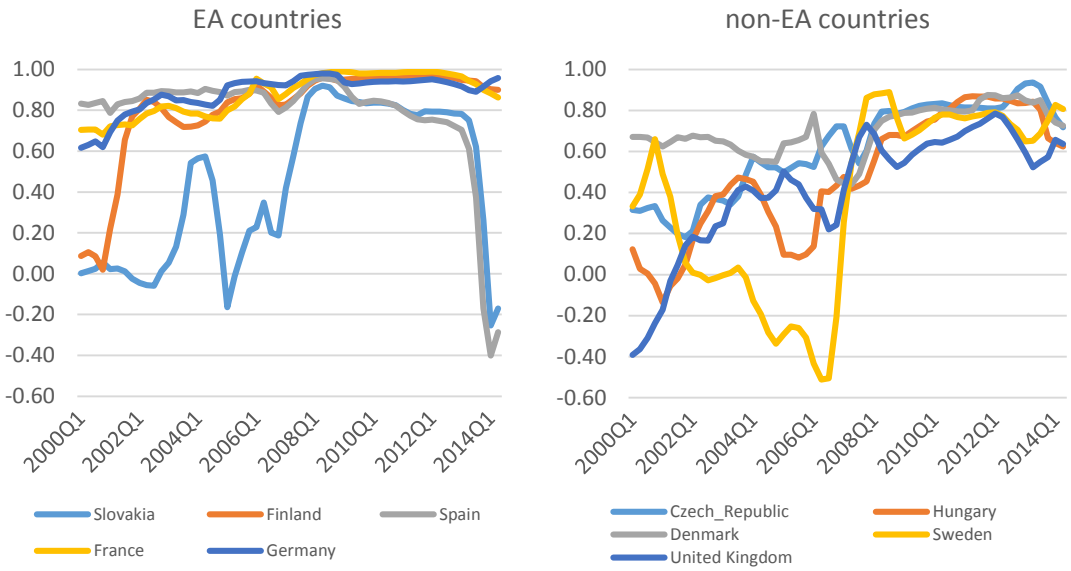
The case of non-EA countries differs in terms of the pre-crisis and post-crisis period, and also in the level of deviations. All of the countries, except of Sweden, have experienced positively sloped trend i.e. the overall business cycle synchronization

[19] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix E.

increases with no rapid elevations. The post-crisis period can be seen as a stable in terms of the development of GDP correlations i.e. deviating around the value of 0.8. Sweden is the only country from the sample in question which figures show constant declining tendencies till 2006, in contrast of that, the highest value was reached in the year 2008 i.e. Swedish correlation coefficient increased from -0.63 to 0.92 within two years, since the crisis begun the development of GDP correlations have been similar to those of the other non-EA countries.

Both the EA countries and non-EA countries can be characterized by much stronger correlations with the Eurozone after the crisis emerged. This might have been caused due to the negative shock which was affecting the economic activities of countries within the EU, and thus there was a room for individual countries to catch-up with the EA average i.e. there was a negative shock which negatively affected EU countries forcing their GDPs to decline; the correlation measures the linear dependences, there can be found a similar downward movement in the GDP performance and that is why the correlation generates such high positive values. From different point of view, increase in the correlation coefficient of country in question does not necessarily mean increase in the economic performance of this country and vice versa. Nonetheless, the performance of national economies is not the criterion of the OCA theory that is to be examined here. The criterion in question is the degree of business cycle synchronization of countries joining or forming monetary union i.e. the important measure is the correlation itself not the activity of particular economy.

Figure 9 Business Cycle Synchronization with the EA Based on the 5-Year Rolling Window (GVA, quarterly data: 2000Q1-2014Q2)[20]

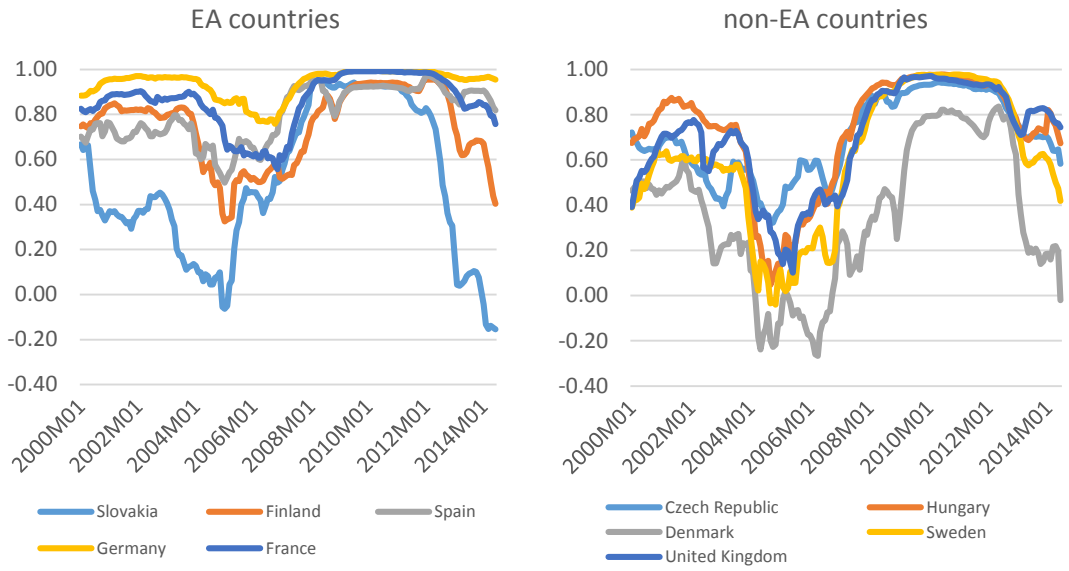


Source: Eurostat, author´s calculations

Figure 9 depicts the situation of GVA correlations of individual countries with the Eurozone as a benchmark. The overall development is rather similar to the development of GDP correlations. However, there are some differences that we should highlight. In case of Spain and Slovakia, severe drop of the year 2013 reaches far lower (negative) values than in the case of GDP. These values refer to asynchronous business cycle correlations which is not desired feature of countries forming monetary union. When taking into an account the non-EA countries we can see from Figure 9 that the development in question corresponds with the one of GDP i.e. constant increase in the business cycle synchronization, higher deviations among non-EA countries in comparison with EA countries and relatively steady development in the post-crisis period with no severe drops till 2014Q2.

[20] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix E.

Figure 10 Business Cycle Synchronization with the EA Based on the 3-Year Rolling Window (IPI, monthly data: 2000M01-2014M6)[21]



Source: Eurostat, author´s calculations

Figure 10 is illustrating the situation of IPI which is based on the monthly data. All of our sample countries report positive values at the very beginning of the examined period. Regarding EA countries, Germany reaches almost perfect business cycle synchronization with the EA, values range from 0.76 up to 0.99. In the pre-crisis period all of the non-EA countries experienced a downward sloping decline but kept the level in positive absolute values except of Slovakia, which is the special case here due to the non-EA-member status until 2009. The crisis and post-crisis period have much the same pattern i.e. the business cycle synchronization rapidly increases due to the fact that each and every country experiences the impact of negative shock turning into the recession.

One can notice that there is another similarity with the GDP and GVA development and that is the drop in the IPI of Slovakia reaching negative values at the level of -0.15 meaning that there is a negative synchronization of Slovakia with the Eurozone. Considering GDP and GVA correlations, the decrease of Slovakia was also accompanied with the decrease of Spain, which is not present in case of IPI. Instead, Finland is the country exhibiting a significant drop in the correlation coefficient.

Taking into account the non-EA countries, these countries deviate from the Eurozone more than countries forming monetary union. In the pre-crisis period most

[21] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix E.

of the countries were characterized by the downward sloping trend i.e. the trend of business cycle synchronizations had been decreasing between 2001 and 2005-2006. The country reaching the lowest value is Denmark, on the contrary, the country with the most moderate decline is the Czech Republic; that is the minimum value at -0.27 and 0.32 respectively. As soon as the crises took place, countries of the non-EA sample increased their correlations significantly while the first relevant deviations can be observed from 2012/2013 on. In terms of the business cycle synchronization with the EA, Denmark was lagging behind the rest of the non-EA countries, moreover, not achieving such high correlations as the others from the sample, and subsequently falling down considerably.

Looking at both charts from Figure 10, non-EA countries reach higher degree of deviation among each other, achieve lower values in terms of correlation coefficients in the pre-crises period, and when recovering from the crisis these countries leave the belt of high correlations (0.8 – 1) faster than EA countries.

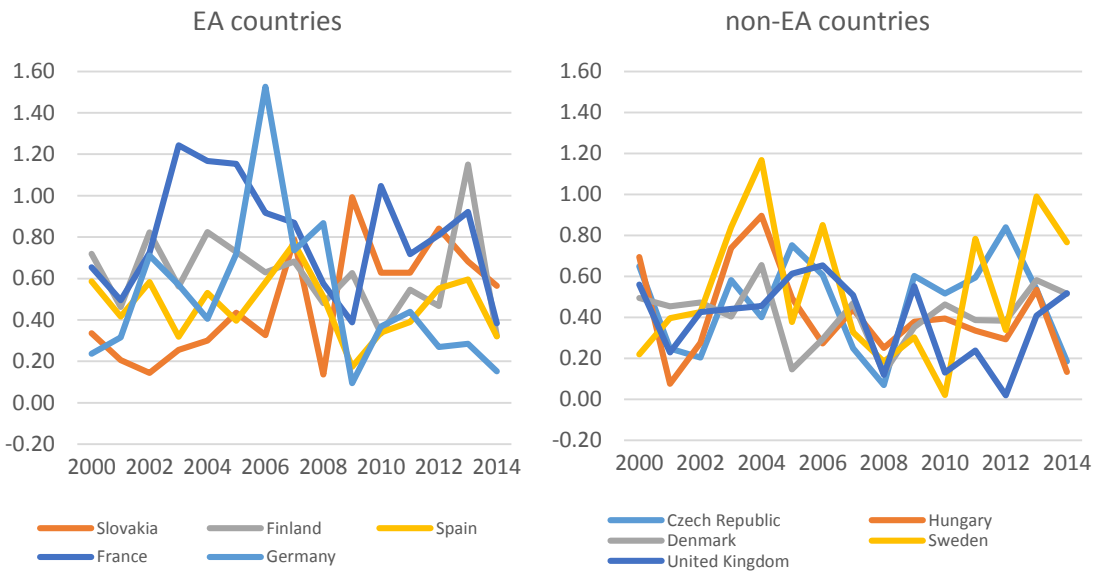
5.1.4.2 Augmented Cross-Correlation Index

In this sub-chapter we implement alternative techniques for measuring of business cycle correlations. Compared to the rolling correlation approach we can find this method as being capable of diminishing the weaknesses of rolling window. For our descriptive purposes all data in charts below were transformed into annual data[22].

Furthermore, this approach does not enable us to meaningfully present results in the absolute units since the range is bounded from $(-\infty, \infty)$, in addition to that we are not able to directly compare outcomes stemming out from the rolling correlation and Augmented cross-correlation indices due to the various domains. Nevertheless, the evolution of all indices can be analyzed via the comparison based on the relative performance.

[22] The simple averaging method was applied. Data with higher than annual frequencies appeared to be unreadable due to the small size of the charts. Worth mentioning, the original monthly and quarterly data were used for regression analysis i.e. the annual frequency is applied just throughout below mentioned graphs.

Figure 11 Business Cycle Synchronization with the EA Based on the Augmented Cross-Correlation Index (GDP, yearly data: 2000-2014)[23]



Source: Eurostat, author´s calculations

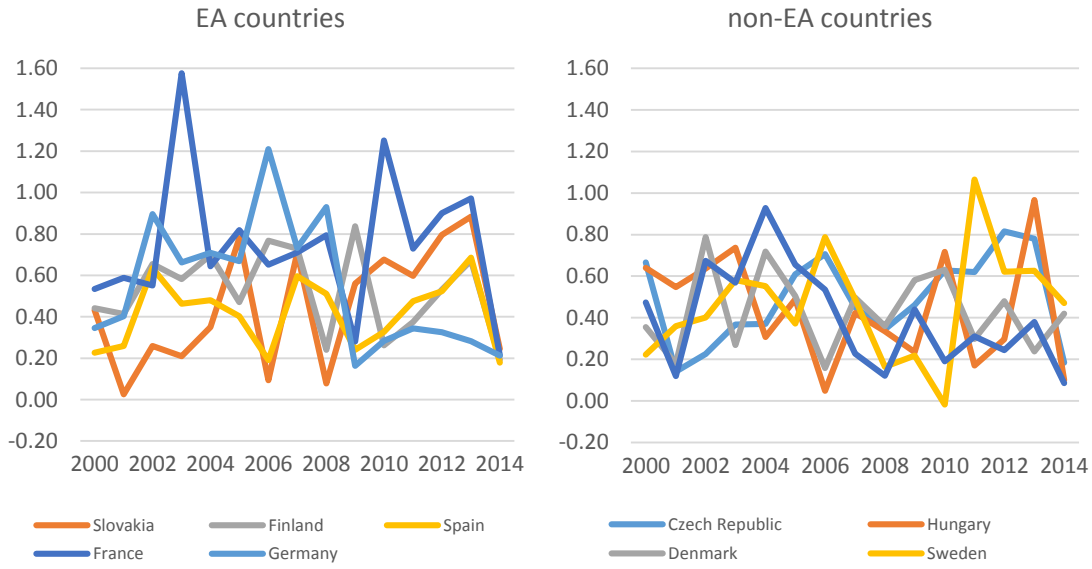
Figure 11 depicts the nature of GDP business cycle synchronization measured by the Augmented cross-correlation index. Generally speaking, France and Germany are above the correlation level of the other EA and non-EA countries in the pre-crisis period. The highest average performance is seen in the case of France. In spite of that fact, Germany reaches the highest level of business cycle synchronization in 2006 taking into an account all countries from the sample. Contrary to findings in the chapter dealing with the rolling correlations, since 2008 German correlation index remains as one of the lowest within the scope of EA countries.

Finland and Spain experienced most of their deviations in the range of 0.4 to 0.8 and 0.2 to 0.6 respectively. Surprisingly, Slovakia does not show significant deviations from other member states, as it was in the case of rolling correlation approach, in the contrast to that we can observe that Slovakia keeps positively sloped trend i.e. Slovakia constantly increases its general business cycle synchronization with the Eurozone. Worth mentioning, the correlation index of each and every country from the EA sample significantly decreased in 2008. In 2009 those indices bounced back from the bottom and showed an increase in the correlation with the EA. However, the year 2013 can be observed as a downturn year because all of the EA countries report some declining tendencies since that time on.

[23] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix F.

Regarding non-EA countries, countries show lower correlations with the Eurozone than EA countries. In case of Sweden we can observe higher correlations with the EA while performing in the similar way as France. Czech Republic, Denmark, Hungary and United Kingdom constantly deviate around the level of 0.4. Similarly to EA countries, the year 2008 is the turning point at which these countries restored a growth of correlation indices. Except of the UK, all the countries reached the post-crisis peak in the year 2012 (Czech Republic) and 2013 (Denmark, Hungary, Sweden), and since that time on there are declining tendencies. United Kingdom is the only country from the EA and non-EA sample which increases the business cycle synchronization with the Eurozone, considering the recent history i.e. the year 2013.

Figure 12 Business Cycle Synchronization with the EA Based on the Augmented Cross-Correlation Index (GVA, yearly data: 2000-2014)[24]



Source: Eurostat, author´s calculations

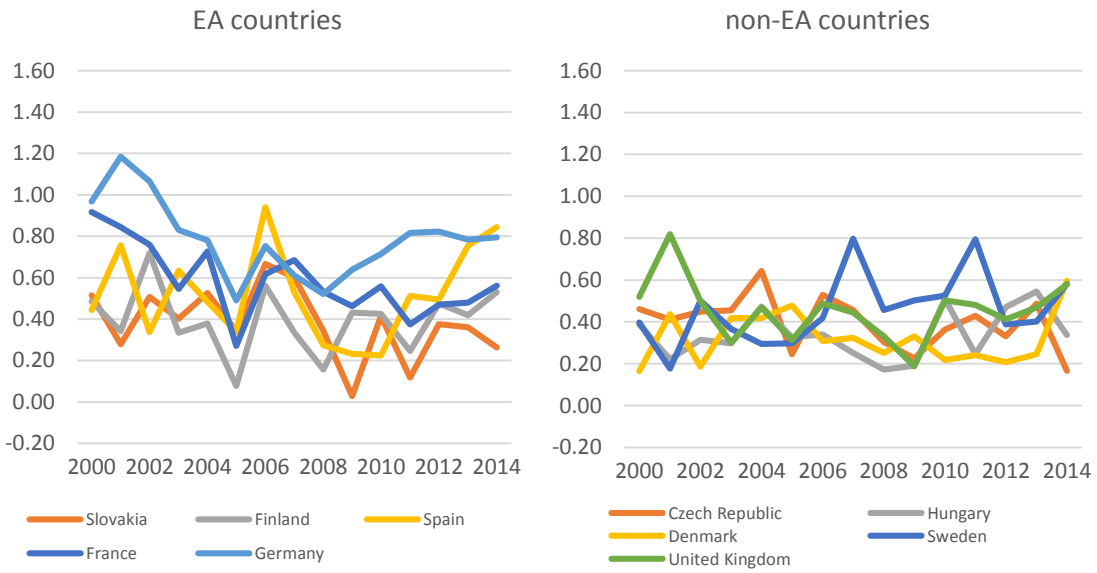
Figure 12 illustrates the development of business cycle synchronization based on GVA which has similar outcomes as charts based on GDP. EA countries report the lowest values in 2008 and 2009, non-EA countries from 2008 up to 2010. Regarding EA countries, France and Germany reach the highest values in general. Nevertheless, in the post-crisis period German reports low correlation coefficients, while France shows rather high values. Spain and Finland constantly deviate in the range of 0.2-0.6 and 0.3-0.8, respectively. Considering Slovakia, we can observe positive trend of

[24] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix F.

the business cycle synchronization with the EA from 2001 on. All of the EA countries report negatively sloped trends from 2013.

Non-EA countries are at the slightly lower level of correlation in comparison with EA countries. We can see rather negatively sloped trends of business cycle synchronization in case of Denmark, Hungary and UK. Czech Republic and Sweden show relatively constant trend ranging in the belt of 0.2 and 0.8 (peaks of extremes excluded). Czech Republic and Hungary experienced severe drop in 2013, Sweden and the UK also report the drop of correlation indices, nevertheless, not as severe as in case of former countries. The only country being positively affected by the year 2013 is Denmark i.e. Denmark has been increasing the business cycle synchronization since 2013.

Figure 13 Business Cycle Synchronization with the EA Based on the Augmented Cross-Correlation Index (IPI, yearly data: 2000-2014)[25]



Source: Eurostat, author´s calculations

Considering Figure 13, the EA and non-EA countries show us slightly different correlations of IP indices compared to results obtained in the analysis of GDP and GVA correlations. Regarding EA countries, Germany has the highest business cycle synchronization of the IPI having its maximum and minimum values on the higher level than the others. Germany and Finland reached the lowest level of correlation in

[25] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix F.

2005 and not right before/after the crisis emerged as in previous cases, furthermore, there can be identified downward sloping development till 2008. Since that time on, the trend is positively sloped.

France also reports the lowest correlation coefficient in 2005, nevertheless, the trend seems to be negatively sloped throughout the whole period i.e. the overall business cycle synchronization of France and Eurozone constantly decreases. Slovakia and Spain reached the lowest values in the year 2008, since that time on these two countries appear to be positively raising their correlation indices with Eurozone. Worth mentioning that since 2013 Spain has been exceeding the correlations of Germany and therefore became the country with the highest business cycle synchronization with respect to the examined sample of member states.

Taking into account non-EA countries, one can notice that correlation indices vary much less in time while ranging within the interval of 0.18 and 0.8. The only significant upward sloping trend can be observed in case of Sweden. Although the lowest values can be found in the year 2008, these are not of the size in terms of the EA countries dimensions.

5.2 What Factors Influence Business Cycle Synchronization and to What Extent?

Regression analysis is statistical process which enables us to detect relationships among certain group of variables in the model. The sense follows, what causes the business cycle synchronization to increase? Here, the factors affecting the business cycle synchronization are seen as regressors (independent variables), and the business cycle synchronization itself is seen as regressand (dependent variable).

In the previous chapter we have analyzed the overall appearance of business cycle synchronization in the EU, in other words, we have analyzed the dependent variable of our future econometric model. Once we choose some of the factors to be regressors in our model we are able to run regression analysis and estimate, by how much the business cycle synchronization changes once the independent variable changes i.e. what kind of impact these factors have upon the business cycle synchronization. Naturally, this chapter is introduced by the **analysis of chosen independent variables**, then we conduct a **panel regression** reflecting various levels of aggregation.

5.2.1 Structural Convergence Indices

Structural indices take place of independent variables in our future models. Among chosen indices we can find:

- Grubel-Lloyd index (intra-industry trade intensity)
- Herfindahl index (export specialization)
- Krugman specialization index (industry specialization index based on the structure of employment)
- Landesmann index (industry specialization based on the structure of a Gross Value Added)

5.2.1.1 Grubel-Lloyd Index

Grubel-Lloyd index (hereinafter as GLI) measures intra-industry trade intensity between two countries by quantifying the share of imports and exports of a particular commodity within the industry over the entire trade exchange i.e. GL index measures the share of intra-industry trade in the entire trade exchange. As the name suggests the index was developed in Grubel-Lloyd (1975). However, it contained some weak points which caused a bias under certain circumstances. Such bias was detected by Greenway-Milner (1983) and referred to the situation in which one country is a net exporter of one good and net importer of another good, simultaneously. And thus there was a need for an adjustment, which resulted in the following formula:

$$GLI_j = 1 - \frac{\sum_{i=1}^{n} |X_{ij} - M_{ij}|}{(X_j + M_j)}$$

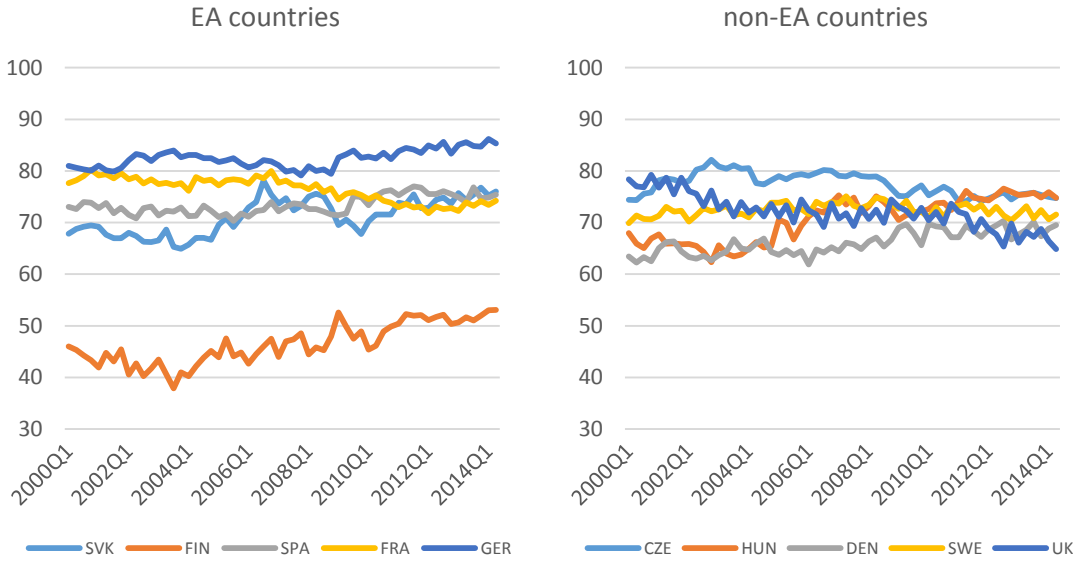
where *i* is a subgroup within the industry *j*, X_{ij} stands for the export of a commodity *i* in industry *j*, M_{ij} is an import of the commodity *i* in industry *j*, X_j stands for the total exports from industry *j* and M_j is the total imports from industry *j*.

As the implementation of this index became popular among researches, certain adjustments were made in order to meet the requirements of various studies. Based on Rozmahel et al. (2014) Grubel-Lloyd index can take the form of adjusted formula which reflects better the purpose of this thesis:

$$GLI_{ij,t} = \left[1 - \frac{\sum_k |X_{k,ij,t} - M_{k,ij,t}|}{\sum_k |X_{k,ij,t} + M_{k,ij,t}|}\right] \times 100$$

where $X_{k,ij,t}$ stands for the export of commodity k from the country i to country j, $M_{k,ij,t}$ denotes the import of commodity k from the country j to country i. As it follows, the country i is the certain country from our sample, and the country j is the benchmark country i.e. the evolution of Eurozone[26]. The higher the GLI is, the deeper the trade integration is. GLI index ranges within the interval of <0, 100> and the commodity distribution is based on the SITC lev.2.

Figure 14 Evolution of Grubel-Lloyd Index in Chosen Countries (quarterly data: 2000Q1 – 2014Q2, SITC lev.2)[27]



Source: Eurostat, author´s calculations

Figure 14 illustrates the situation of GLI development between the chosen country and Eurozone. All of the commodities go along with the division of SITC lev.2. Regarding EA countries, the share of intra-industry trade in the total trade exchange ranges within the belt of around 65-85%. The only exception is Finland with values ranging in the interval of about <38, 53>, which is significantly lower level considering both EA and non-EA countries. Germany is the country with the highest GL index from the sample. In terms of trends, all of the EA countries (except of France)

[26] In the Eurostat database abbreviated as EA.

[27] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix G.

report positively sloped trend leading us to the statement that the share of intra-industry trade increases as the time goes by. The opposite can be observed in case of France which trend of GLI declines meaning that France decreases the level of bilateral trade integration with the EA.

Taking into account non-EA countries, one can observe the GLI ranging from 62% to 82%, which is slightly lower level compared to the EA countries. In terms of trends, the UK reports negatively sloped trend, Sweden and Czech Republic oscillate around their neutrally sloped trends, Hungary and Denmark report positively sloped trend. Czech Republic reports the highest share of intra-industry trade being at the level of Germany (around 80%) until the crisis of 2008. Since then the Czech Republic had experienced a drop and its trend has remained constantly neutral, however, at the lower level than in the pre-crisis period.

Comparing both groups together, EA countries generate slightly higher numbers i.e. higher trade integration with the Eurozone. 4 out of 5 EA countries report positively sloped trend, which refers to the overall increase in the field of trade integration.

5.2.1.2 Herfindahl Index

Herfindahl index (hereinafter as HI) is used as a measurement of export concentration. Low et al. (1998) states that HI can be seen as a flow-weighted concentration index.

However, at the very beginning of its existence the index was used for measuring of market shares and market concentrations in order to detect monopoly. Based on the Hirschman (1980) the original Herfindahl index[28] can be described as the sum of the squares of all market shares while considering the market counting of n companies, and the market share of s_i belonging to i-th company. The formula can be written as:

$$HI = \sum_{i=1}^{n} s_i^2$$

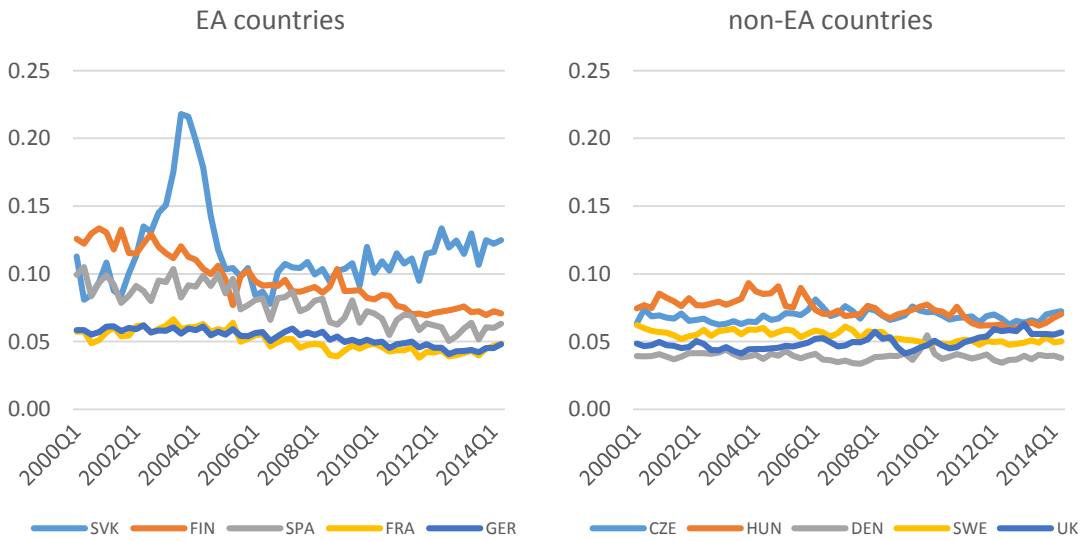
[28] Sometimes referred as Hirschman index or Herfindahl-Hirschman index (abbreviated as HHI). Naldi (2014) highlights that the name was inherited after two economists who developed this index independently on each other´s work. As Naldi (2014) continues, Albert O. Hirschman presented this index in 1945 and Orris C. Herfindahl in 1950.

Based on the study of La (2011), for export specialization purposes we can express Herfindahl index in the following form:

$$HI_{i,t} = \sum_k \left[\frac{x_{ik,t}}{X_{i,t}}\right]^2$$

where $HI_{i,t}$ stands for the Herfindahl index of country i in the time t, $x_{ik,t}$ denotes the export value of commodity k of country i in the time t and $X_{i,t}$ is the total export value of all commodities exported from country i. The resulting values range within the interval of <0, 1>. The higher the HI is, the higher export specialization particular country reports. Theoretical value of 1 means that the country in question exports just one commodity group. As in case of GLI, commodity groups are determined by SITC lev.2[29].

Figure 15 Evolution of Herfindahl Index in Chosen Countries (quarterly data: 2000Q1 – 2014Q2, SITC lev.2)



Source: Eurostat, author´s calculations

[29] SITC lev.2 stands for the Standard International Trade Classification of 2-digit level maintained by the United Nations. 1-digit level is divided into 10 sections, 2-digit level is divided into 76 sub-sections etc.

From the Figure 15[30] we can observe that the trend of export specialization either constantly decreases or seems to be rather constant in time. Exceptional values can be seen in case of Slovakia which reports positively sloped trend in terms of the export specialization i.e. Slovakia specializes more in the export of certain commodities and thus the vulnerability to asymmetric shocks increases. Whereas the other countries decrease the export specialization and thus decrease the vulnerability to potential asymmetric shocks, which is the desired situation. Regarding EA countries, the graph shows higher deviations and spread implying that non-EA countries seem to be less specialized in exports.

In case of EA countries, the value of exported commodities is spread to a greater extend. Denmark shows the lowest export specialization within the scope of both groups. Looking at the time series of the UK, we can observe the year 2008 to be a turning point, since that time on the export specialization of UK has been either slowly increasing or constant.

5.2.1.3 Krugman Specialization Index

Krugman specialization index (hereinafter as KI) is used for the assessment of industry specialization where all of the calculations are based on the level of employment within the particular industry. Palan (2010) summarizes the meaning of Krugman specialization index as: "…it calculates the share of employment which would have to be relocated to achieve an industry structure equivalent to the average structure of the reference group." (Palan, 2010, p.17)

Krugman specialization index takes the name after Paul Krugman, in Krugman (1993) we can find the definition of KI as:

$$KI = \sum_i |s_i - s_i^*|$$

where s_i stands for the share of employment within industry *i* in chosen country, s_i^* denotes the share of employment within industry *i* in the benchmark country, which is in our case the Euro area. KI ranges within the interval <0, 2> where 0 means that

[30] The higher the level of SITC (Standard International Trade Classification) is, the more fragmented the classification becomes and the lower absolute values of HI we will obtain. That implies, once there is a need for comparison of individual HI outcomes the level of SITC cannot be neglected.
For the charts of Eastern, Northern, Western and Southern Europe please see Appendix H.

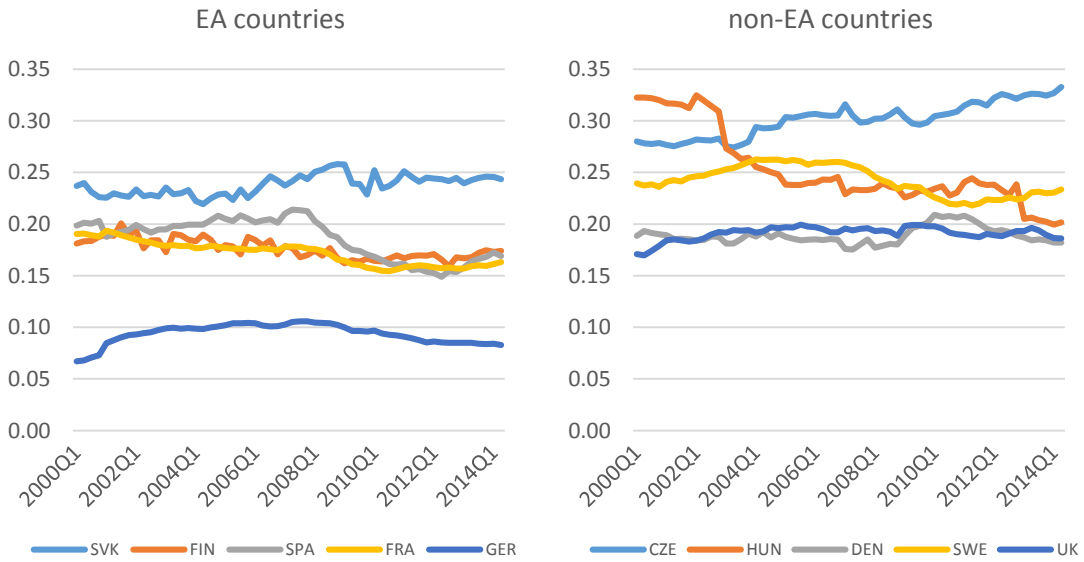
examined regions are perfectly identical in terms of the industry structure and employment. Theoretical value at the level of 2 suggests that countries (regions) in question have perfectly divergent industry structures.

In order to demonstrate the calculation of KI in detail, we transform the index into:

$$KI_t = \sum_{i,t} \left| \frac{L_{i,t,a}}{L_{t,a}} - \frac{L_{i,t,b}}{L_{t,b}} \right|$$

where $L_{i,t,a}$ is the employment L in industry i, time t and country a (EU member state), $L_{i,t,b}$ is the employment L in industry i, time t and country b (in our case benchmark region i.e. EA), $L_{t,a}$ stands for the total employment in time t and country a, $L_{t,b}$ is the abbreviation of total employment in time t and country b. Naturally, the interval remains the same i.e. <0, 2>. Industrial classification goes along with the division of NACE Rev.2[31].

Figure 16 Evolution of Krugman Index in Chosen Countries (quarterly data: 2000Q1 – 2014Q2, NACE Rev.2)[32]



Source: Eurostat, author´s calculations

[31] NACE Rev.2 is the statistical classification of economic activities in the EU revised in the year 2008. Economic activities are divided into 21 sections (section A to U) consisting of 100 divisions in total.

[32] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix I.

Figure 16 depicts the evolution of Krugman index in chosen countries with respect to the benchmark region i.e. the Euro area. The data were obtained with the quarterly frequency. The graph of EA countries shows most of the values to be within the belt of 0.15 to 0.26 which means that from 7.5% to 13%[33] of the labor force should be relocated in some way in order reach the employment/industry structure of the EA. Very exceptional values are reported by Germany which index ranges in the belt of 0.7 and 0.11. This result might be caused due to the strong position of German economy within the Euro area. In case of Germany, in the year 2014 just 4% of the labor force should be relocated in order to meet the industry structure of the EA, furthermore, since 2008 the trend has been negatively sloped, which means that the industry structure of Germany constantly converges towards the structure of Eurozone.

Other countries as France, Finland and Spain report negatively sloped trend line until 2012. Since then these countries show some increase in KI values i.e. the industry structure deviates more from the EA structure. Slovakia is the only country experiencing positively sloped trend throughout the whole period meaning that the industrial structure diverges from the EA, nonetheless, the increase is not of a high degree.

Regarding non-EA countries, these countries deviate in the belt of 0.17 to 0.33 which is significantly higher than EA countries. Just in case of Denmark and the UK we can observe relatively stable performance similar to EA countries which is oscillating around the 0.18 meaning that around 9% of the people employed in these economies should be relocated in order to reach the same level of industry structure as the EA has. The polynomial trend can be observed in case of Sweden. Since 2010 the KI values has been increasing and thus we can say that, lately, Sweden diverges from EA industry structure.

Last but not least, two countries experiencing opposite development of Krugman index are about to be described. Hungary has been increasing the convergence of industry structure considerably. In contrast, Czech Republic reports positively sloped trend which is not desired performance from theoretical point of view. In other words, there are some branches within industry which employ more inhabitants than it is usual in the EA. In 2014 more than 16% of active labor force would need to be relocated in order to meet the industry structure of Eurozone.

[33] KI index ranges in the interval of <0, 2>. If we want to transform the KI value into percentage points, the KI index should be divided by 2 i.e. we will obtain the share of labor which should be relocated in order to reach the employment structure of benchmark country.

5.2.1.4 Landesmann Index

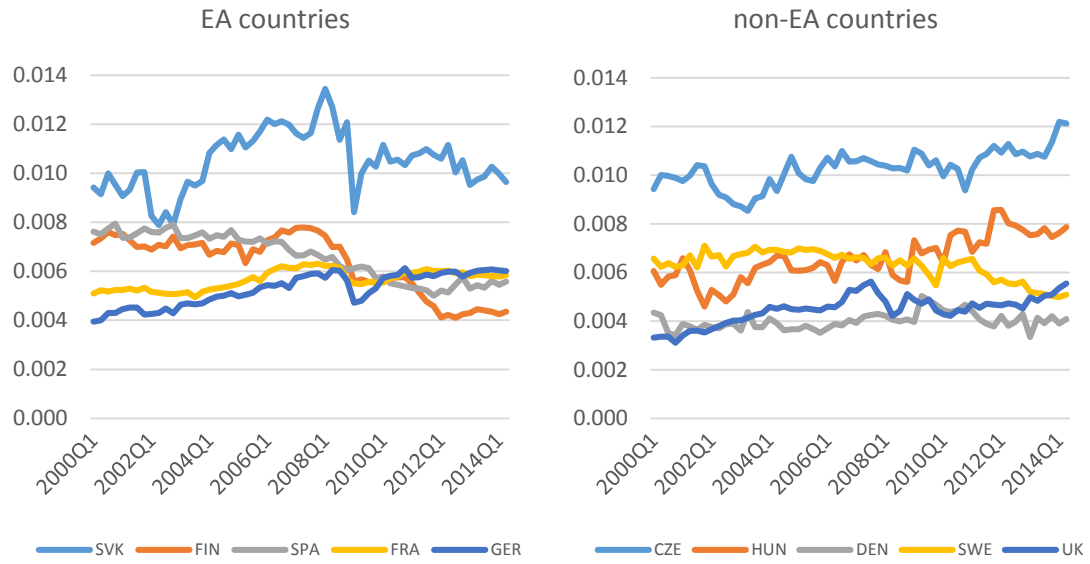
Landesmann index (hereinafter as LI) is implemented in this analysis so we can evaluate the industry structure. On the contrary to the previous chapter, such measurement is based on the share of gross values added generated by industry in question. On the basis of Landesmann and Székely (1995) the formula can take form of:

$$LI_t = \sum_{i=1}^{n} \sqrt{\left[s_{i,t,a} - s_{i,t,b}\right]^2 \times \left[\frac{s_{i,t,a}}{100}\right]}$$

where $s_{i,t,a}$ is the share of industry *i* on total gross values added in time *t* and country *a* (i.e. individual country from the sample), $s_{i,t,b}$ stands for the share of industry *i* on total gross values added in time *t* and country *b* (benchmark country i.e. the EA). The LI ranges within the scope of <0, 1>. Konopczak et al. (2011) states that the lower the Landesmann index is, the higher the similarities in industry structure are. As mentioned above, the benchmark region is the Euro area. The division of industry structure complies with the NACE Rev.2[34].

[34] NACE Rev.2 available at the database of EU statistical office (Eurostat) underwent some aggregation and thus the statistical data are not provided perfectly in accordance with NACE Rev.2 divisions. When calculating LI based on the different statistical reports, some deviations in the absolute values of Landesmann index might occur, therefore when comparing results stemming out from various studies this fact should be taken into consideration. Eurostat aggregates NACE groups as follows: A, B-E, F, G-I, J, K, L, M-N, O-Q, R-U.

Figure 17 Evolution of Landesmann Index in Chosen Countries (quarterly data: 2000Q1 – 2014Q2, NACE Rev.2)[35]



Source: Eurostat, author´s calculations

Figure 17 depicts the evolution of industry structure similarity between chosen EU countries and Eurozone. Regarding EA countries, we can identify that France and Germany have positively sloped trend i.e. the industrial structure diverges from the EA. Spain and Finland report negatively sloped long-run trend and thus these two countries can be considered as converging towards the industrial structure of EA. Slovakia has experienced turbulent times in terms of the LI development increasing the divergence significantly until 2008 and since that time on, in contrast to that, we can see declining tendencies.

Taking into account non-EA countries, Hungary, the UK and the Czech Republic display positively sloped trend which implies that the overall industry structure diverges from EA in time. Sweden slightly decreases its LI performance i.e. the industry structure slightly converges to the EA structure in terms of gross values added. Denmark oscillates around the value of 0.004, which means that industry structure of Denmark is the closest one regarding the industry structure of EA.

Worth mentioning, the impact of crisis can be observed. In 2008 and 2009 all countries experienced either sever or moderate drop in the Landesmann index i.e. the industrial structure of chosen countries temporarily converged to the structure

[35] For the charts of Eastern, Northern, Western and Southern Europe please see Appendix J.

of EA. However, most of the countries restored the prevailing tendencies shortly after that i.e. prevailing trend was restored and such convergence can be seen as a temporary disruption.

Both EA countries and non-EA countries range within a belt of roughly around 0.004 to 0.008, so in terms of absolute values we can state that the level of industrial structure deviates at pretty much the same level. Slovakia and Czech Republic can be denoted as countries experiencing exceptionally high values of LI which implies that these two countries report higher dissimilarities in the industry structure than other countries from our sample.

5.2.2 Panel Regression

Panel regression help us to create models which detect and explain dependencies among chosen variables. To briefly introduce the nature of panel data Gujarati (2004) explains that we can examine three types of data such as time series, cross-sectional and panel data. As he continues, in time series data we collect the development of one or more variables in particular period of time, hence the dimension of time takes place. Cross-sectional data reflect values of one or more variables attributable to various sample units at one point in time and thus the space (unit) dimension takes place. And panel data can be seen as a combination of both time series and cross-sectional data i.e. we collect values of several cross-sectional units over time period, hence the time and unit dimensions take place.

In this chapter, we examine data in various forms of aggregation i.e. we examine the sample of countries in full range (considered as the highest level of aggregation), and then we test two smaller samples comprising of EU core countries and non-EA countries (both as the lower level of aggregation).

5.2.2.1 Panel Regression of 17 EU Countries (full-range sample)

The full range of examined countries consists of 17 countries from the European Union (hereinafter as EU sample) , namely Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Portugal, Slovakia, Slovenia, Spain, Sweden and United Kingdom. The selection of countries is based on criteria like destination (East, North, West or South Europe), membership

in the Eurozone and data availability[36]. The panel data regression has the following structure:

- Dependent variable, which is the business cycle correlation of country in question with the EA (economic activity expressed by GDP, GVA and IPI) measured by the rolling correlation (abbreviated as rw) and Augmented cross-correlation index (referred as aXcorr).
- Independent variables such as Grubel-Lloyd index (GLI), Herfindahl index (HI), Krugman index (KI) and Landesmann index (LI).
- Two dummy variables standing for the membership in the EA11[37] (D_{EA11}; 0 – the country was not the member of EA11, 1 – the country was member of the EA11), and common border with Germany[38] (D_{ComBor}; 0 – country does not have common border with Germany, 1 – country has common border with Germany).

Before we approach towards the analysis of obtained results, one finding should be articulated here a bit in advance. When specifying and estimating models, the dependent variable based on the rolling correlation approach appeared to be inappropriate. All regressions which included $corr(rw_{GDP})_{it}$, $corr(rw_{GVA})_{it}$ and $corr(rw_{IPI})_{it}$ resulted in models not fulfilling classical assumptions of regression model i.e. models reported incorrect specification, heteroskedasticity, serial correlations and not normal distributions within the scope of all panel variations such as pooled regression, FEM with country, time, country and time effects. Neither adjustment of time range nor different sample of countries changed the outcome.

---

[36] In detail, the sample consists of 3 Eastern, 4 Northern, 5 Western and 5 Southern EU countries i.e. geographically speaking, all regions are represented. Moreover, in the sample we can find 5 non-EA countries and 12 EA countries and that is the ration of 1:2.4, in the EU the ratio is 1:2.1 i.e. 9 non-EA countries to 19 EA countries, which implies that from this perspective the sample corresponds with the EU structure. Nonetheless, the sample was also determined by the data availability, in other words, if there were data available for all EU28 countries, the sample would cover all the EU countries.

[37] Dummy variable reflecting EA11 membership was chosen in order to examine whether there is any influence of a fact that the country was a founding member of the Eurozone.

[38] Common border with Germany was chosen in order to examine whether geographical aspects influence the business cycle synchronization within the EU. Germany stands for the strongest economy in the EU and that is why it is present as a benchmark country here.

That is the reason why rolling correlation approach is dropped from the further panel data analysis. The following panel data regression analysis is based on the Augmented cross-correlation index which proved to be more suitable technique.

Let us recall initial theoretical assumptions (hypotheses) which are tested below:

- increase in the intra-industry trade (Grubel-Lloyd index) has positive influence upon the business cycle synchronization i.e. the sign of GLI is positive
- increase in the export specialization (Herfindahl index) has negative impact upon the business cycle synchronization i.e. the sign of HI is assumed to be negative
- increase in the industry specialization (Krugman index) has negative impact upon the business cycle synchronization i.e. the sign of KI is assumed to be negative
- increase in the industry specialization (Landesmann index) has negative impact upon the business cycle synchronization i.e. the sign of LI is assumed to be negative
- being a member of EA has positive impact upon the business cycle synchronization i.e. the sign of D_{EA11} is positive
- having common border with Germany has also positive impact upon the business cycle synchronization i.e. the sign of D_{ComBor} is assumed to be positive

Results for the EU Sample

GLI index is usually insignificant but positive in case of GDP and GVA. Regarding intra-industry trade in connection with the IPI correlations, GLI index is mostly significant and positive. The performance of GLI is stable and consistent.

Herfindahl index does not show such a high level consistency as Grubel-Lloyd index. HI is significant in 6 out of 12 models, mostly in LSDV model with time or country effects. It is negative in case of GDP and GVA and simultaneously positive with IPI correlations all estimated by LSDV model with country or time and country effects, on contrary when there is an estimation by pooled regression or LSDV model with time effects, HI shows positive values.

Krugman index is positive in case of GDP and GVA correlations, and negative in case of IPI correlations with respect to all panel methods. Significance of KI at the level of either 1%, 5% or 10% is perfectly stable throughout the spectrum.

Landesmann index is significant in 8 out of 12 models. Regarding GDP correlations, LI shows positive values when estimated by FEM (country effects) and FEM (time and country effects), and negative values when estimated by pooled regression and FEM (time effects). The case of IPI correlations is the exact opposite of GDP, LI shows negative values with FEM (country effects) and FEM (time and country effects), and positive values with pooled regression and FEM (time effects). Regarding GVA correlations, LI is negative throughout the spectrum of all panel methods except of FEM (country effects).

Dummy variable for membership in the EA11 is significant in 10 out of 12 cases, the sign is positive also in 10 out of 12 cases i.e. all GDP and GVA correlations, and IPI correlations estimated by pooled regression and FEM (time effects). Negative but significant values can be found in case of IPI correlations estimated by FEM (country effects) and FEM (time and country effects).

Dummy variable for common border with Germany is significant in 7 out of 12 cases, nevertheless, it has positive sign when the economic activity is measured by IPI regardless the panel method and, moreover, it is mostly significant. Regarding GDP and GVA correlations, once the pooled regression and FEM (time effects) take place, this dummy variable has positive sign, in case of FEM (country effects) and FEM (time and country effects) it reports negative values.

Considering each and every panel method separately, IPI correlations have higher R^2 adjusted and significantly lower information criteria than GDP which follows, the worst performance is shown by GVA correlations which reports the lowest R^2 adjusted and the highest values of information criteria. Worth mentioning, GDP and GVA do not differ to a great extent.

Regarding the panel method itself, one can find out that as the model specification increases in length the R^2 adjusted increases and information criteria decreases. We can sort the panel methods with the lowest R^2 adjusted and the highest values of information criteria up to the method with the highest R^2 adjusted and the lowest values of information criteria i.e. from the one explaining the least of variability up to the method explaining the most of the variability and that is pooled regression, FEM-LSDV (country effects), FEM-LSDV (time effects) and FEM-LSDV (time and country effects).

Taking into account classical assumptions of regression model, models mostly satisfy assumption I. to VI., which means that we are dealing with BLUE (Best linear unbiased estimator) models.

For the EU sample, we estimated 24 models, 12 models were omitted due to the problem with classical assumptions of regression model (rolling correlation coefficients of GDP, GVA and IPI were excluded from panel regression) and the rest, in general terms, was examined above. Based on the findings above, Table 5 shows the chosen model for the EU sample.

Table 5 Panel Regression: FEM – LSDV (country and time effects) Model of the EU Sample[39]

Panel method	Macro index	Full model							Automatic backward elimination						
		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria	
FEM - LDSV (time and country effects)	IP	const	-2.179	**	1.30E-29	0.218	AIC	459	const	-2.271	***	6.60E-42	0.234	AIC	401
		GLI	0.445	**			HQC	604	GLI	0.475	***			HQC	471
		HI	0.061						HI						
		KI	-0.223	*					KI	-0.233	***				
		LI	-0.107						LI	-0.110	**				
		dComBo	0.096						dComBor	0.103	**				
		dEA11	-0.186	**					dEA11	-0.183	***				

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

Coefficients β are estimated at the significance level of 1% and 5%, model explains 23.4% of all variability and the null hypothesis of F-test about the model insignificance can be rejected due to the p-value (F) being at the level of 6.60E-42, model refers to the BLUE specification. The interpretation follows:

- Regarding GLI, if the growth rate[40] of mutual intra-industry trade intensity between particular country and the Eurozone increases by 1% then the Augmented cross-correlation index of IPI business cycle synchronization increases by 0.475 with respect to the sample and simultaneously keeping the other variables constant, which eventually satisfies previously stated assumption.
- Considering HI, if the export specialization of particular country increases then the business cycle synchronization measured by the industrial production increases, too. Nevertheless, HI was omitted by the backwards elimination method due to its overall insignificance. Despite of this fact, HI report positive value, which goes against the assumptions stated above.

[39] Regarding panel regressions of the EU sample, please see Appendix K which contains the summary table of all models (country and time effects are not included). Estimated models were mostly of BLUE level.

[40] Growth rate i.e. an increase over the previous period.

- If the growth rate of Krugman specialization index decreases by 1% then the business cycle synchronization increases by 0.233 in terms of the Augmented cross-correlation index, such result satisfies previously mentioned assumption.
- Taking into account LI, if the LI index decreases, generally speaking, the business cycle synchronization increases, which again satisfies the theoretical assumption.
- Regarding chosen countries, common border with Germany increases the business cycle synchronization with the EA (intercept moves to -2.271 + 0.103 = 2.168)[41].
- In terms of the business cycle synchronization measured by the IPI, the membership in the EA11 has negative impact upon the synchronization (intercept moves to -2.271 - 0.183 = -2.454).

Table 6 Country and Time Effects of the EU Sample[42]

Country and time effects	Estimated differential coefficient	P-value (t)	Intercept level	Country and time effects	Estimated differential coefficient	P-value (t)	Intercept level
du_1			-2.27	**dt_18**	0.19	***	-2.08
du_4	-0.17	***	-2.45	**dt_19**	-0.17	**	-2.44
du_5	0.29	***	-1.98	**dt_20**	0.20	***	-2.07
du_6	0.21	***	-2.06	**dt_25**	0.12	*	-2.15
du_7	0.21	***	-2.06	**dt_31**	0.28	***	-1.99
du_8	0.43	***	-1.85	**dt_33**	0.12	*	-2.15
du_10	0.12	**	-2.15	**dt_34**	-0.18	**	-2.45
du_11	0.19	***	-2.09	**dt_35**	-0.20	***	-2.47
du_12	0.29	***	-1.98	**dt_36**	-0.43	***	-2.70
du_15	0.24	***	-2.03	**dt_37**	-0.25	***	-2.52
dt_3	0.13	*	-2.14	**dt_38**	-0.20	***	-2.47
dt_6	0.39	***	-1.88	**dt_43**	0.16	**	-2.11
dt_7	-0.15	**	-2.42	**dt_47**	-0.21	***	-2.48
dt_17	0.14	*	-2.13	**dt_52**	0.16	**	-2.11

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

In the Table 6 you can find the results for country and time effects. Due to the dummy-variable trap (perfect multicollinearity), du_1 was omitted from the regression and thus the constant (-2.27) became the constant (intercept) for country effect of region 1, which is Austria. Panel regression estimated the rest of country effects as differential coefficients, for instance du_4 (Denmark) has the intercept at the level

[41] For more information about differential intercepts see table 6 (Country and time effects in detail).

[42] Du_i stands for the country effect of country *i*, and dt_t is the time effect of period *t*. You can find the code table in Appendix N.

of -2.45 (= -2.27 – 0.17), which means that Denmark (i=4) has lower business cycle synchronization due to the virtue of country itself. Among countries having higher business cycle synchronization due to the country effect belong Finland, France, Germany, Greece, Italy, Netherlands, Portugal and Spain. All the other countries not mentioned in the Table 6 above have intercept at the level of -2.27.

Regarding time effects, we can observe that there were some positively influential events in the year 2000Q3 (dt_3) and 2001Q2 (dt_6), we can also see a positive influence of the year 2004 (dt_17-20) and 2007Q3 (dt_31) and 2008Q1 (dt_33), which is substituted by the negative impact of the period 2008Q2-2009Q2. These results support the findings in correlation analysis saying that if there is negative shock influencing all the countries within the EU, then such a shock increases the business cycle synchronization in question, all of this in connection with the Augmented cross-correlation index.

5.2.2.2 Panel Regression of the EU Core

As the panel regression of the EU sample (full sample) uncovered, the model confirmed most of the theoretical assumption which were stated before. In this subchapter we examine what the impact of disaggregation is i.e. what are the results of panel regression for smaller sample sizes. In order to do so, two various samples were created and that is the EU core containing Austria, Belgium, France, Germany, Italy and Netherlands. Second sub-sample refers to non-EA countries consisting of Czech Republic, Denmark, Hungary, Sweden and United Kingdom.

Results for the EU Core

Grubel-Lloyd index is rather insignificant (significant in 5 out of 12 cases), positive in all cases of IPI correlations regardless the panel method, positive in GDP and GVA correlation while measured by pooled regression and FEM (time effects), and negative in GDP and GVA correlations while estimated by FEM (country effects) and FEM (time and country effects).

Herfindahl index is significant in all panel method cases of GVA and IPI correlations implying insignificant performance in all cases of GDP business cycle synchronization. In 11 out of 12 models, HI reports positive values, which can be seen as a stable performance.

Regarding Krugman index, it is significant in 10 out of 12 models. The sign is positive in all cases of GDP and GVA correlations, its values are negative in 3 out of

4 cases of IPI correlations (the exception is positive value in panel method of FEM-LSDV model reflecting country and time effects).

Landesmann index is significant in 6 out of 12 cases. Regardless the panel method, values are positive in all cases where economic activity correlation is measured by GDP and GVA. Most of the IPI correlations between the sample countries and the EA report negative values.

Dummy variable for common border is significant just in 5 out of 12 models. Its sign is negative in 11 out of 12 cases which seems as robust performance.

The overall tendencies of panel methods are the same as in case of EU sample i.e. IPI correlations resulted in higher R^2 adjusted in comparison with GDP or GVA correlations, put differently, in terms of R^2 adjusted the following relationships hold: $adjR^2_{corr(aXcorr_{IPI})} > adjR^2_{corr(aXcorr_{GDP})} > adjR^2_{corr(aXcorr_{GVA})}$ with respect to each panel method separately.

When sorting out panel methods with respect to R^2 adjusted (or information criteria), findings of the EU sample are true also in case of the EU core.

The Table 7 shows two models which are based on above mentioned findings. Although the highest R^2 adjusted (or the lowest information criteria) can be found in case of IPI correlation estimated by FEM (country and time effects), such model does not reflect prevailing tendencies of regressors, and thus different models were chosen.

Table 7 Panel Regression: FEM – LSDV (time effects; time and country effects) Model of the EU Core[43]

Panel method	Macro index	Full model							Automatic backward elimination						
		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria	
FEM - LSDV model (**time effects**)	IPI	const	0.747		3.97E-09	0.24	AIC	223	const	1.958	***	1.86E-20	0.3	AIC	159
		GLI	0.436				HQC	319	GLI					HQC	186
		HI	0.651	***					HI	0.630	***				
		KI	-0.195	***					KI	-0.252	***				
		LI	0.068						LI						
		dComBor	-0.101						dComBor						
		dEA11	Omitted						dEA11	Omitted					
FEM - LDSV model (**time and country effects**)	GVA	const	7.515		0.01052	0.09	AIC	587	const	3.271	***	4.89E-10	0.16	AIC	514
		GLI	-0.766				HQC	689	GLI					HQC	534
		HI	0.483						HI	0.642	***				
		KI	0.409						KI	0.269	***				
		LI	0.197						LI						
		dComBor	-0.200						dComBor						
		dEA11	Omitted						dEA11	Omitted					

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

Coefficients β are estimated at the significance level of 1%, time effects model explains 29.64% and time and country effects model explains 15.5% of all variability, the null hypothesis of F-test about the model insignificance can be rejected due to the p-value (F) being at very low level (lower than 0,05). Both models are BLUE models satisfying all classical assumptions of regression model except of normality in residuals. Both models can be interpreted as follows:

- Regarding time effect model (hereinafter as model 1) Grubel-Lloyd index had positive but insignificant sign in 8 out of 12 cases, which is reflected in the model, meaning that the level of intra-industry trade has positive impact upon the business cycle synchronization of industrial production (theoretical assumption is fulfilled). This finding goes along with the assumption made by European Commission. Regarding time and country effect model (hereinafter as model 2), GLI reports negative values meaning that increase in intra-industry trade decreases the business cycle synchronization expressed in GVA. Such statement complies with the Krugman´s view.
- In model 1 and 2 HI reports positive and significant values regardless the panel method i.e. overall export specialization is supposed to have positive influence

[43] Regarding panel regressions of the EU core, please see Appendix L which contains the summary table of all models (country and time effects are not included). Estimated models were mostly of BLUE level.

upon the correlation of IP indices between core country and EA. This outcome goes against the hypothesis assumed above.

- Increase in KI index has significant and negative impact in case of IPI correlations, which means that if Krugman index decreases over the previous period by 1%, Augmented cross-correlation index increases by 0.252, and such relationship is satisfies the theoretical assumption. On the other hand regarding model 2, if the economic activity is measured by GVA then increase in KI increases business cycle synchronization, which is not supported by the theoretical assumption stated above.
- Considering model 1, Landesmann index has insignificant and positive value in our model, other IPI correlation models reported negative and significant constants of much greater value, which implies that the positive value of LI does not have to be taken seriously here. Regarding model 2, all GVA and GDP correlations report positive but sometimes insignificant values implying that deviation from industry structure of EA does not have negative impact upon the overall business cycle synchronization. This particular model shows positive but insignificant relation between economic cycle synchronization and the LI.
- Taking into account both models, dummy variable for common border says that being a neighboring country to Germany decreases the intercept value i.e. the business cycle synchronization decreases, which goes against the initial assumption.

Below in the Table 8, you can find the outcomes of time and country effects model (model 2). Results of country effects model (model 1) are neglected here due to the general similarity with one another.

Table 8 Country and Time Effects of the EU Core

Country and time effects	Differential coefficient	P-value (t)	Fitted coefficients
du_1		***	3.27
dt_1	-0.41	**	2.86
dt_5	-1.06	***	2.21
dt_29	-0.42	**	2.86
dt_47	0.64	***	3.91
dt_53	0.47	**	3.74
dt_56	0.48	**	3.75

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

This particular model does not report any influential country effect, nevertheless, based on the findings in other country or time-and-country effects models, Germany prevailed to have positive and significant differential intercept meaning that Germany itself has higher business cycle synchronization with the Eurozone from the virtue of the country itself. Analyzing results from other models, Belgium and Netherlands also have different intercepts in comparison with the rest of countries, nevertheless, these are of negative and significant value i.e. Belgium and Netherlands have lower intercepts in comparison with other countries such as Austria, France and Italy.

Considering time effects, business cycle synchronization measured by GVA was negatively influenced by the significant period of 2000Q1 and 2001Q1. On contrary, the period of 2013Q1 and Q4 had positive impact upon the business cycle synchronization between the EU core and Eurozone.

5.2.2.3 Panel Regression of Non-EA Countries

Regarding the sample of non-EA countries, the estimation of models revealed following results.

Results for Non-EA Countries

At the first sight results of the panel regression have considerably different outcomes in terms of the F-test which measures the overall significance of the model. Neither pooling regression nor FEM (country effects) provided us with significant models i.e. the p-value (F) was too high implying that the null hypothesis about the model insignificance could not be rejected. Hence we are about to describe just the outcomes of FEM (time effects) and FEM (country and time effects).

Worth highlighting, all indices are reporting mostly insignificant values, as the exception can be seen Krugman index which is significant in 4 out of 6 models.

Grubel-Lloyd index has positive sign in 5 out of 6 models. Herfindahl index reports positive signs in case of GVA and IPI correlations, but negative sign in case of GVA correlations. Krugman index refers to positive values in case of GDP and GVA correlations, and negative values are obtained when the correlation is measured by IP index. Landesmann index shows negative values in all regressions regardless macro index and panel method. Dummy variable for common border with Germany shows positive results in 4 out of 6 cases. Below you can see Table 9 which illustrates estimated model reflecting fore mentioned results.

Table 9 Panel Regression: FEM – LSDV (time and country effects) Model of Non-EA Countries[44]

Panel method	Macro index	Full model							Automatic backward elimination						
		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria	
FEM - LDSV (time and country effects)	IP	const	-3.743		0.021	0.1	AIC	178	const	-3.575	*	4.21E-08	0.17	AIC	115
		GLI	0.538				HQC	276	GLI	0.725	*			HQC	144
		HI	0.149						HI						
		KI	-0.428						KI	-0.413	*				
		LI	-0.314	*					LI	-0.191	*				
		dComBor	0.337						dComBor	0.165	**				
		dEA11	Omitted						dEA11	Omitted					

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

Coefficients β are estimated at the significance level of 10% or 5%, model explains 17% of variability, p-values of F-test allows us to reject null hypothesis about the insignificance of model. Above specified model satisfies BLUE conditions. Model takes the following interpretation:

- Grubel-Lloyd index shows positive and significant estimation meaning that if the value of intra-industry trade increases by 1% over the previous period, the business cycle synchronization (based on IP index and measured by Augmented cross-correlation index) between non-EA countries and Eurozone increases by 0.725. This finding satisfies the theoretical assumption stated at the very beginning of regression analysis;
- Herfindahl index reports positive but insignificant value of 0.149 which is not expected result regarding tested assumptions;
- Considering Krugman index, we can observe negative and significant fit which means that if we decrease KI by 1% over the previous period, business cycle correlation increases by 0.413 i.e. if the industry structure gets closer to the structure of EA then the correlation of cycles increases. This outcome was assumed to occur;
- Landesmann index goes along with the theory, too. Model estimated the LI fits to be negative and significant meaning that the lower the LI, the higher the business cycle synchronization.
- D_{EA11} was omitted due to the fact that the sample does not comprise of countries which were members of EA11 and thus any testing of such factor makes no

[44] Regarding panel regressions of the non-EA countries, please see Appendix M which contains the summary table of all models (country and time effects are not included). Estimated models were mostly of BLUE level.

sense. However, common border with Germany is supposed to have positive and significant influence upon the business cycle performance i.e. for instance the intercept of Czech Republic is higher by 0.165 (intercept equals to -3.575 + 0.165 = -3.41) in comparison with, let´s say, Hungary.

Table 10 Country and Time Effects of Non-EA Countries[45]

Country and time effects	Differential coefficient	P-value (t)	Fitted coefficients
du_1		*	-3.57
du_2	-0.19	**	-3.76
dt_6	0.34	***	-3.23
dt_17	0.25	*	-3.32
dt_19	-0.31	**	-3.88
dt_20	0.22	*	-3.35
dt_31	0.34	***	-3.23

Country and time effects	Differential coefficient	P-value (t)	Fitted coefficients
dt_33	0.26	**	-3.31
dt_34	-0.25	*	-3.82
dt_36	-0.32	**	-3.89
dt_37	-0.28	**	-3.85
dt_46	0.29	**	-3.28
dt_54	0.30	**	-3.27

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

From Table 10 we can observe country and time effects. Country 2 (du_2) has lower business cycle correlation by 0.19 with respect to all other countries. On average, as positively influential time period can be seen the year 2004 (dt_17, 19, 20), also periods of 2007Q3 and 2008Q1 have some positive and significant impact upon the growth cycle correlation. The quarters 2008Q2, 2008Q3 and 2009Q1 negatively affect business cycle correlation, on contrary to this, positive impact of 2011Q2 and 2013Q1 is observed.

5.2.2.4 Comparison of Various Aggregation Levels

Various aggregation levels were introduced in the panel regression analysis, namely sample of 17 EU countries, the EU core and non-EA countries. Comparison of models can be found in Table 11 below.

[45] Du_i stands for the country effect of country *i*, and dt_t is the time effect of period *t*. You can find the code table in Appendix N.

Table 11 Panel Regression: Comparison of Various Aggregation Levels

Level of aggregation	Panel method	Macro index	Full model							Automatic backward elimination						
			Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria		Index	OLS/ LSDV fits	P-value (t)	P-value (F)	R^2 adj	Information criteria	
EU sample	FEM - LSDV (time and country effects)	**IPI**	const	-2.179	**	1.30E-29	0.218	AIC	459	const	-2.271	***	6.60E-42	0.234	AIC	401
			GLI	0.445	**			HQC	604	GLI	0.475	***			HQC	471
			HI	0.061						HI						
			KI	-0.223	*					KI	-0.233	***				
			LI	-0.107						LI	-0.110	**				
			dComBo	0.096						dComBor	0.103	**				
			dEA11	-0.186	**					dEA11	-0.183	***				
EU core	FEM - LSDV model (**time effects**)	**IPI**	const	0.747		3.97E-09	0.243	AIC	223	const	1.958	***	1.86E-20	0.296	AIC	159
			GLI	0.436				HQC	319	GLI					HQC	186
			HI	0.651	***					HI	0.630	***				
			KI	-0.195	***					KI	-0.252	***				
			LI	0.068						LI						
			dComBo	-0.101						dComBor						
			dEA11	Omitted						dEA11	Omitted					
	FEM - LSDV model (**time and country effects**)	**GVA**	const	7.515		0.010521	0.091	AIC	587	const	3.271	***	4.89E-10	0.155	AIC	514
			GLI	-0.766				HQC	689	GLI					HQC	534
			HI	0.483						HI	0.642	***				
			KI	0.409						KI	0.269	***				
			LI	0.197						LI						
			dComBo	-0.200						dComBor						
			dEA11	Omitted						dEA11	Omitted					
non-EA countries	FEM - LSDV (time and country effects)	**IPI**	const	-3.743		0.021	0.1	AIC	178	const	-3.575	*	4.21E-08	0.17	AIC	115
			GLI	0.538				HQC	276	GLI	0.725	*			HQC	144
			HI	0.149						HI						
			KI	-0.428						KI	-0.413	*				
			LI	-0.314	*					LI	-0.191	*				
			dComBo	0.337						dComBor	0.165	**				
			dEA11	Omitted						dEA11	Omitted					

Source: author´s calculations
Note: ***, ** and * denote the significance level of 1%, 5% and 10% respectively

Regarding the models in question, Grubel-Lloyd index reports significant and positive values in case of EU sample and non-EA countries whilst in case of EU core GLI shows insignificant results and, moreover, unstable i.e. positive sign is seen when the economic performance is measured by the IPI, negative sign is observed in case of GVA. Based on the result, we can say that increase in intra-industry trade intensity positively increases business cycle synchronization of industrial production regarding the all examined samples. From this point of view EU countries experience similar effect which was described by Fidrmuc (2001) complying with the European Commission point of view of One Market, One Money (1990).

While testing GVA correlation of EU core, results show Krugman´s point of view, nevertheless insignificant, which could be interpreted that GVA business cycle convergence between EU core and the Eurozone is negatively affected with increasing intra-industry trade intensity, however, such impact is of insignificant dimension.

Herfindahl index is positive and significant in case of EU core, positive and insignificant in remaining samples i.e. EU sample and non-EA countries. This particular finding goes against the theoretical presumption made before. Here, increase in

export specialization also increases business cycle convergence in all cases of economic measures. Such relationship suggest that in past in times of business synchronization the export specialization increased and vice versa.

Krugman index is significant in all cases, whilst the economic activity is measured by the industrial production then Krugman index reports negative values. In case of GVA correlations of EU core the KI gains positive effect upon the business cycle synchronization. Based on the result, industrial diversification increases business cycle correlation of industrial production index in chosen EU countries regardless the level of aggregation. Nevertheless in case of EU core, increase of specialization might improve business cycle convergence of GVA.

Landesmann index is significant and negative considering samples of 17 EU countries and non-EA countries, in case of EU core Landesmann index reports insignificant and positive values. This situation shows similar outcomes as Krugman index. While the industry specialization decreases, the business cycle correlation of EU countries and non-EA countries increases. As the theory suggests, such performance of industrial diversification was anticipated. In case of EU core countries, increase of industry specialization increases also business cycle co-movements, which goes against the assumption.

The common border with Germany has significant and positive impact upon the business cycle convergence in case of EU sample and non-EA countries. Regarding EU core, the common border does not have significant influence, however, the relation is estimated as negative. This might be caused due to the fact that in the EU core sample we can find just one country (Italy) which does not share a common border with Germany. No-border status of Italy might results in negative sing (bias) of common border dummy variable.

The membership in EA11 took place just in case of EU sample regression. The influence seems to be significant and negative i.e. being a founding country of the Eurozone does not imply higher business cycle synchronization.

6 Discussion

The thesis is based on the methodology which focuses on the correlation analysis and panel data regression. As mentioned in the literature review, implementation of different methods, datasets and ranges might report various results. Each method has its own advantages and disadvantages and common methodological concept is missing.

Considering the business cycles, the way of extracting cyclical component is not definite. We can use Hodrick-Prescott filter or Baxter-King filter for investigation of growth cycles, or first differences for the examination of classical cycles. Each method provides us with various results which can differ substantially and that is why we need to distinguish among the de-trending techniques.

Regarding methods evaluating business cycle synchronization, one finding took place in favor of Augmented-cross correlation index. Rolling window and fore mentioned index provide researcher with considerably different outcomes i.e. as an example can serve the case of Germany or Slovakia. Rolling window reports significantly high correlations of Germany with the EA throughout of time, whereas Augmented cross-correlation index shows decreasing trend of GDP business cycle synchronization in the post-crisis period resulting in the Germany being the country with the lowest correlation values in the group of examined EA countries. Similarly the case of Slovakia, rolling correlation ranked Slovakian co-movements with the EA as reaching below-average values, which was concluded by significant drop in 2013. On contrary, Augmented cross-correlation index reports some considerable drops in 2007 and 2009, nevertheless, the trend of business cycle synchronization is positively sloped. Heterogeneous outcomes might be seen as a consequence of time windows being biased by the presence of extremes and/or by the nature of time window itself. Such bias is not present in the calculation of cross-correlation index due to the fact that the Augmented cross-correlation index is based on the year-by-year basis, solely. Furthermore, Augmented cross-correlation index seems to be more appropriate for the implementation into the panel regression.

Furthermore, correlation can be measured by other indices which were not implemented into the thesis. Such index might be for instance the Cross-correlation index of Cerquiera (2010) which further adjusts the Cross-correlation index of Cerquiera-Martins (2009). The Fisher´s transformation goes beyond the transfor-

mation of Artis-Okubo (2011) and introduces the "Augmented" cross-correlation index in the domain of <-1, 1>. This interval might be seen as suitable when the comparison with Pearson´s correlation coefficient is needed.

In order to improve model estimations, further implementation of independent variables could be useful. The thesis does not reflect the impact of fiscal policy, the role of foreign direct investments, finance and many others. There is a room for other studies to examine the impact of various indices separately or altogether.

The thesis implemented panel regression based on the mutual relations between particular country and the Eurozone. Nevertheless, the relations could be investigated from country-to-country point of view. In other words, we would get much higher number of pair-wise indices as an input data implying that such panel regression would examine the relations in much broader context. Moreover, implementation of lagged values could reveal further time relations within the scope of examined dataset. For such purpose, dynamic panel models could take place.

When speaking about the data, some countries did not provide some of the statistical data in late 1990s and early 2000s. That is why those countries were excluded from our analysis, which introduces certain level of bias regarding the EU level perspective.

7 Conclusion

The thesis introduced the OCA theory in connection with the recent literature about the business cycle synchronization. We empirically examined the level of business cycle synchronization and convergence in the European Union. Subsequently, we assessed the overall impact of chosen indices. Based on the results, the hypothesis about positive influence of structural convergence upon the business cycle convergence is rejected due to the heterogeneous outcomes of structural indices. Export convergence reports negative influence, whereas industry structure convergence indicates unstable and rather positive impact upon the correlations of examined economic activities.

We also tested the hypothesis which refers to the positive influence of higher intra-industry trade intensity. The results show that the hypothesis cannot be rejected. In accordance with the outcomes, increase in the intra-industry trade intensity increases the business cycle synchronization. The performance of Grubel-Lloyd index is stable and positive throughout the spectrum of various aggregation levels and panel methods.

The hypothesis reflecting the closeness to the EU core assumed that countries sharing common border with Germany have higher business cycle synchronization with the Eurozone. This hypothesis cannot be rejected due to the robust outcomes. Sharing a common border with Germany implies business cycle convergence.

Considering the EA11 membership, the hypothesis states that being a member of EA11 results in the higher business cycle co-movements. This hypothesis in question is rejected. The thesis provided us with significant results showing us that being a founding country of the Eurozone does not necessarily imply higher business cycle synchronization.

Taking into account the correlation analysis, we took a closer look at the business cycles in the EU. We could observe that business cycles are more stable, consistent and moderate in EA countries, and more heterogeneous and volatile in terms of non-EA countries.

Mutual correlations between EU countries revealed that Luxembourg can be considered as a forecasting country. In other words, what happens in Luxemburg will happen within the EU with respect to the level of correlation and lag. Higher mutual correlations were identified among the countries of particular geographical region such as EU core, Baltic states, Benelux countries, Northern Europe countries

(Denmark, Finland, Ireland, Sweden and UK) and Visegrad Four countries. On contrary, southern countries on the periphery of the EU account for the low level of synchronization between one another. Considerably low performance is seen in case of Greece which cross-correlations are the lowest in the EU. Such poor performance should not be neglected due to the fact that these countries form monetary union, which further implies that monetary policy cannot be effectively applied.

Based on the results of this thesis, we cannot clearly state when the non-EA countries should join monetary union and thus relinquish national currencies. Before the crisis came, we could observe positively sloped trends of business cycle synchronization with respect to both non-EA countries and EA countries. Such situation corresponds with the phenomenon of endogeneity i.e. the convergence process continued even after the country had joined the monetary union. From the business cycle convergence point of view, the events were in favor of joining monetary union.

When the crisis hit the European Union, we could observe rapid increase in the convergence of economic activities. Lately, as the crisis fades away some business cycles become less synchronized and start to deviate from the Eurozone. That is due to the fact that each economy recovers from the shock differently. Moreover, when considering current instability of the EU and Eurozone (caused by the recent political and economic situation in Greece, and political situation in Great Britain), non-EA countries should postpone the relinquishment of national currency until the effect of recent crisis and political instability develops further, so one can get the overall picture of the Eurozone in the time of both stability and uncertainty.

Nevertheless, let us go beyond the panel regression and business cycle synchronization. When taking into account just the development of intra-industry trade, export specialization and industry specialization for the majority of the EU countries, we can observe both increasing or neutral development of intra-industry trade intensity, as well as export convergence (HI) and industry structure convergence (KI). In accordance with this finding, we might question the hypothesis of Krugman who states that the increase in intra-industry trade implies also increase in specialization due to the lack of trade barriers and presence of economies of scale.

8 List of Sources

AGUIAR-CONRARIA, L. and M. J. SOARES. Business cycle synchronization across the euro area: A wavelet analysis. *NIPE, Universidado De Minho*, 2009.

ARTIS, M. and T. OKUBO. DOES INTERNATIONAL TRADE REALLY LEAD TO BUSINESS CYCLE SYNCHRONIZATION?—A PANEL DATA APPROACH*. *The Manchester School*, 2011, 318-332.

ASTERIOU, D. and A. MOUDATSOU. Business Cycle Synchronization in the Enlarged EU: The Role of Bilateral Trade and FDI. *Review of Development Economics*, 2015, 196-207.

BAGLIANO, F. C. and C. MORANA. Business cycle comovement in the G-7: common shocks or common transmission mechanisms?. *Applied Economics*, 2010, 2327-2345.

BALDWIN, R. E. and C. WYPLOSZ. *Ekonomie evropské integrace*. 4. vyd. Překlad Stanislav Šaroch. Praha: Grada, 2013, 580. ISBN 978-80-247-4568-8.

BAXTER, M. and R. G. KING. Measuring business cycles: approximate band-pass filters for economic time series. *Review of economics and statistics*, 1999, 575-593.

BECK, K. Determinants of Business Cycles Synchronization in the European Union and the Euro Area. *Equilibrium*, 2014, 25-48.

BECK, K. Structural Similarity as a Determinant of Business Cycle Synchronization in the European Union: A Robust Analysis. *Research in Economics and Business: Central and Eastern Europe*, 2014, 5.2.

BONENKAMP, J. et al. *Measuring business cycles in The Netherlands, 1815-1913: a comparison of business cycle dating methods*. University of Groningen, 2001.

BURNS, A. F. and W.C. MITCHELL. Measuring Business Cycles: Vol. 2 of Studies in Business Cycles. New York: NBER, 1946.

CERQUEIRA, P. E. The Worldwide Business Cycle Synchronization Evolution. *Faculty of Economics and GEMF, University of Coimbra*, 2010.

CERQUEIRA, P. A. and R. MARTINS. Measuring the determinants of business cycle synchronization using a panel approach. *Economics Letters*, 2009, 106-108.

ČESKÁ NÁRODNÍ BANKA. Analýzy stupně ekonomické sladěnosti České republiky s eurozónou. *Praha: ČNB*, 2013.

DE GRAUWE, P. *Economics of monetary union*. 8th ed. New York: Oxford University Press, 2009, 290. ISBN 0199563233.

DE GRAUWE, P. *Economics of monetary union*. 10th ed. Oxford: Oxford University Press, 2014, x, 267. ISBN 9780199684441.

EC COMMISSION et al. One market, one money. *European Economy,* 1990.

Eurostat: *Your key to European Statistics* [online]. 2015. [cit. 2015-01-15]. Available at http://ec.europa.eu/eurostat/data/database

FIDRMUC, J. The Endogeneity of the Optimum Currency Area Kriteria, Trada, and Labour Market Rigidities: Implications for EMU Enlargement, *EUI Working Paper RSCAS No. 2004/16*, 2004.

FIDRMUC, J. The Endogenity of the Optimum Currency Area Criteria, Intra-Industry, and EMU Enlargement. *LICOS Discussion Paper*. June 2001, 106, 1-22.

FLEMING, J. M. On exchange rate unification. *The economic Journal*, 1971, 467-488.

FRANKEL, J. A. and A. K. ROSE. The Endogeneity of the Optimum Currency Area Criteria. *The Economic Journal*, 1998, vol. 108, no.449, 1009–1025.

FRIEDMAN, M. *Essays in positive economics*. Chicago: University of Chicago Press, 1953, 328. ISBN 0-226-26403-3.

GÄCHTER, M. and A. RIEDL. One money, one cycle? The EMU experience. *Journal of Macroeconomics*, 2014, 141-155.

Glossary of statistical terms: BUSINESS CYCLES - OECD. 2013. *OECD* [online]. [cit. 2015-01-15]. Available at http://stats.oecd.org/glossary/detail.asp?ID=244

GREENAWAY, D. and C. MILNER. On the measurement of intra-industry trade. *The Economic Journal*, 1983, 900-908.

GREENE, W. H. Econometric Analysis. *New Jersey, Prentice Hall*, 2003, 135-145.

GRUBEL, H. G. and P. J. LLOYD. Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products. *The Economic Journal*, 1975.

GUJARATI, D. N. *Basic econometrics*. 4th ed., Tata McGraw-Hill ed. New Delhi: Tata McGraw-Hill, 2004. ISBN 9780070597938.

HIRSCHMAN, A. O. *National power and the structure of foreign trade*. Expanded ed. Berkeley: University of California Press, c1980, xxii, 172. ISBN 0-520-04082-1.

HODRICK, R. J. and E. C. PRESCOTT. Postwar US business cycles: an empirical investigation. *Journal of Money, credit, and Banking*, 1997, 1-16.

INGRAM, J. C. *Regional payments mechanisms: The case of Puerto Rico*. University of North Carolina Press, 1962.

IOSSIFOV, P. K. *Cross-border production chains and business cycle co-movement between Central and Eastern European countries and euro area member states*. ECB Working Paper No. 1628, 2014.

KALLER, S. and U. STRÖMBERG. *Towards Optimum: Can Europe become an optimum currency area.* University of Gothenburg, 2013.

KAWAI, M. Optimum Currency Areas. *In The New Palgrave: A Dictionary of Economics*. New York: Stockton Press, 1987.

KENNEN, D. The theory of optimal currency areas: an eclectic view. In MUNDEL R: and A. SWOBODA (eds.), *Monetary Problems of the International Economy*, Chicago: University of Chicago Press, 1969.

KRUGMAN, P. and M. OBSTFELD. *International Economics: Theory and Policy*. New York: Harper Collins, 1994, 795. ISBN 0-673-52300-4.

KRUGMAN, P. Lessons of Massachusetts for EMU. In TORRES, F. and F. GIAVAZZI (eds.): *Adjustment and Growth in the European Monetary Union.* Cambridge: Cambridge University Press and CEPR, 1993, 241–261.

LA, J. J. Correlations-adjusted export market diversification. *Journal of East Asian Economic Integration*, 2011, 15.1.

LACINA, L. and P. ROZMAHEL. *Euro: ano-ne?*. Praha: Alfa Nakladatelství, 2010, 319. Ekonomie studium. ISBN 978-80-87197-26-4.

LACINA, L. et al. *Měnová integrace: náklady a přínosy členství v měnové unii.* Praha: C.H. Beck, 2007, 538. Beckova edice ekonomie. ISBN 978-80-7179-560-5.

LACINA, L., A. RUSEK et al. *Evropská unie: trendy, příležitosti, rizika.* Plzeň: Aleš Čeněk, 2007. 260. ISBN 978-80-7380-077-2.

LEHWALD, S. *Has the Euro changed business cycle synchronization? Evidence from the core and the periphery*. *Empirica*, 2013, 655-684.

LOW, P., M. OLARREAGA and J. SUAREZ. *Does globalization cause a higher concentration of international trade and investment flows?.* WTO Staff Working Paper, 1998.

LUCAS, R. E. Understanding business cycles. In: *Carnegie-Rochester conference series on public policy*. North-Holland, 1977, 7-29.

MALE, R.. *Developing country business cycles: Revisiting the stylised facts*. Working Paper//School of Economics and Finance, Queen Mary, University of London, 2010.

MARCZEWSKI, K. and K. KONOPCZAK. Why so different from other CEECs-Poland's cyclical divergence from the euro area during the recent financial crisis. *Bank i Kredyt*, 2011, 7-30.

MCKINNON, R. I. Optimum currency areas. *The American Economic Review*, 1963, 717-725.

MISE, E., T. KIM and P. NEWBOLD. On suboptimality of the Hodrick–Prescott filter at time series endpoints. *Journal of Macroeconomics*, 2005, 53-67.

MONGELLI, F. P. *'New' views on the optimum currency area theory: What is EMU telling us?*. ECB Working Paper No. 138, 2002.

MUNDELL, R. A. A theory of optimum currency areas. *The American Economic Review*, 1961, 657-665.

MUNDELL, R. A. Currency areas, common currencies, and EMU. *The American Economic Review*, 1997, 214-216.

MUNDELL, R. A. Uncommon arguments for common currencies. *The economics of common currencies*, 1973, 114-132.

NAJMAN, N. and P. ROZMAHEL. Business Cycle Similarity Measuring in the Eurozone Member and Candidate Countries: An Alternative Approach. *Ekonomický časopis*, 2011, 445-458.

NALDI, M. and M. FLAMINI. *The CR4 index and the interval estimation of the Herfindahl-Hirschman Index: an empirical comparison*. HAL Working Paper, 2014.

OECD.StatExtracts [online]. 2015. [cit. 2015-01-15]. Available at http://stats.oecd.org/

PALAN, N. *Measurement of Specialization–The Choice of Indices*. FIW, 2010.

PUIU, C. Optimum currency area: an epistemological view. *MPRA Paper No. 35055*, 2011.

REICHLIN, L. *The Euro area business cycle: stylized facts and measurement issues*. Centre for Economic Policy Research, 2004.

REV, N.A.C.E. 2. Statistical classification of economic activities in the European Community. *Luxembourg: Office for Official Publications of. the European Communities*, 2008.

ROZMAHEL, P. Význam endogenity teorie optimálních měnových oblastí v procesu evropské měnové integrace. *Národohospodářský obzor*, 2008, 50-63.

ROZMAHEL, P., L. GROCHOVÁ and M. LITZMAN. *The effect of asymmetries in fiscal policy conducts on business cycle correlation in the EU.* WWWforEurope, 2014.

SCHLEICHER, C. *An introduction to wavelets for economists*. Bank of Canada, 2002.

SHARMA, J.K. *Business statistics*. 2nd ed. New Delhi: Dorling Kindersley, 2012. ISBN 9788177586541.

TAVLAS, G. S. The 'new' theory of optimum currency areas. *The world economy*, 1993, 663-685.

TOWER, E. and T. D. WILLETT. *The theory of optimum currency areas and exchange-rate flexibility*. International Finance Section, Dept. of Economics, Princeton University, 1976.

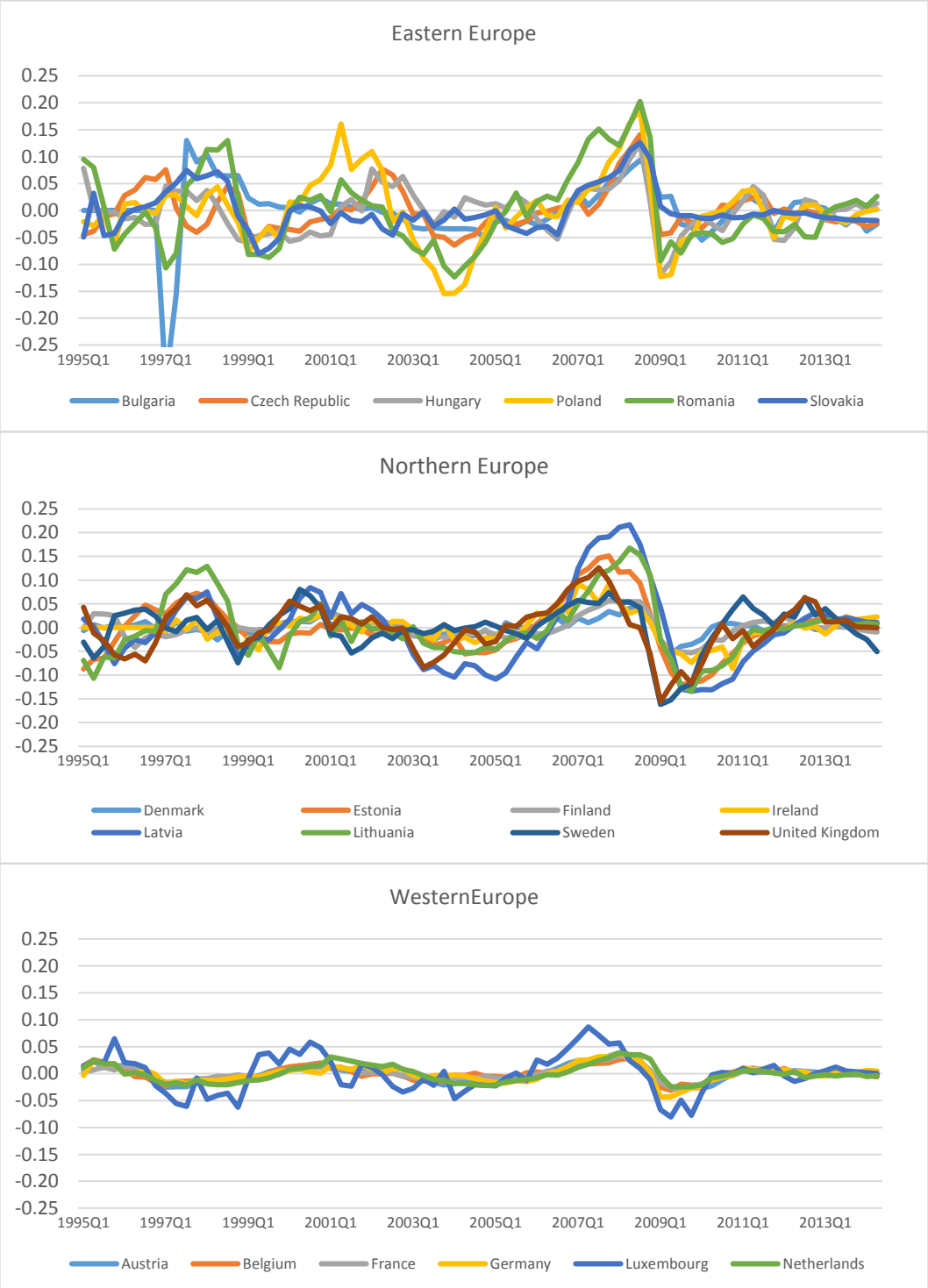
Treaty Series*: treaties and international agreements registered or filed and recorded with the Secretariat of the United Nations*. New York: United Nations, 1960, viii, 463.

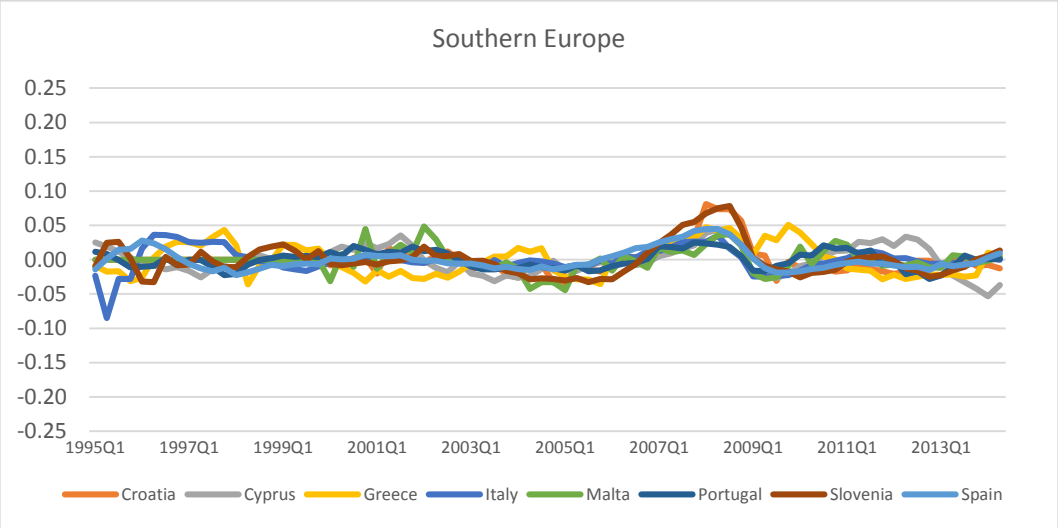
United Nations Statistics Division. 2013. *Composition of macro geographical (continental) regions, geographical sub-regions, and selected economic and other groupings* [online]. [cit. 2015-01-15]. Available at http://unstats.un.org/unsd/methods/m49/m49regin.htm

Appendix

A Growth Cycles of GDP

Charts of GDP growth cycles




Southern Europe
0.25
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
-0.25
1995Q1
1997Q1
1999Q1
2001Q1
2003Q1
2005Q1
2007Q1
2009Q1
2011Q1
2013Q1
Croatia
Cyprus
Greece
Italy
Malta
Portugal
Slovenia
Spain

B GDP Cross-Correlation Indices of Selected EU Countries (full-length table)

Benchmark country

Lagged country	EA		AUS		BEL		BUL		CRO		CYP		CZE		DEN		EST		FIN		FRA		GER		GRE		HUN	
	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag
EA	x		0.86***	-1	0.79***	-1	0.28**	0	0.77***	1	0.54***	1	0.67***	1	0.73***	0	0.68***	0	0.81***	0	0.91***	0	0.91***	0	0.27**	4	0.5***	1
AUS	0.86***	1	x		0.90***	0	0.36***	0	0.74***	2	0.61***	1	0.56***	2	0.76***	0	0.57***	1	0.81***	0	0.95***	0	0.88***	0	-0.21*	-3	0.31***	1
BEL	0.79***	1	0.90***	0	x		0.33***	0	0.63***	1	0.67***	1	0.43***	4	0.75***	0	0.44***	1	0.82***	0	0.89***	1	0.84***	0	-0.21*	2	0.33***	0
BUL	0.28**	0	0.36***	0	0.33***	0	x		0.78***	0	0.41***	0	0.27**	-2	0.33***	-1	0.45***	-2	0.42***	0	0.36***	0	0.27**	0	0.26**	-2	-0.34***	4
CRO	0.77***	-1	0.74***	-2	0.63***	-1	0.78***	0	x		0.50***	0	0.72***	0	0.62***	-1	0.80***	-2	0.71***	-1	0.75***	-2	0.67***	-2	0.55***	4	0.48***	0
CYP	0.54***	-1	0.61***	-1	0.67***	-1	0.41***	0	0.50***	0	x		0.38***	1	0.52***	0	0.26**	-1	0.66***	0	0.62***	0	0.52***	-1	0.24**	-4	-0.19*	-4
CZE	0.67***	-1	0.56***	-2	0.43***	-4	0.27**	2	0.72***	0	0.38***	-1	x		0.50***	0	0.49***	0	0.44***	-1	0.57***	-1	0.51***	-1	0.40***	4	0.51***	0
DEN	0.73***	0	0.76***	0	0.75***	0	0.33***	1	0.62***	1	0.52***	0	0.50***	0	x		0.63***	1	0.72***	0	0.80***	0	0.75***	0	-0.13	-4	0.35***	0
EST	0.68***	0	0.57***	-1	0.44***	-1	0.45***	2	0.80***	2	0.26**	1	0.49***	0	0.63***	-1	x		0.62***	0	0.64***	0	0.60***	-1	0.48***	4	0.41***	0
FIN	0.81***	0	0.81***	0	0.82***	0	0.42***	0	0.71***	1	0.66***	0	0.44***	1	0.72***	0	0.62***	0	x		0.85***	0	0.85***	0	-0.12	1	0.42***	0
FRA	0.91***	0	0.95***	0	0.89***	-1	0.36***	0	0.75***	2	0.62***	0	0.57***	1	0.80***	0	0.64***	0	0.85***	0	x		0.90***	0	0.23**	4	0.34***	0
GER	0.91***	0	0.88***	0	0.84***	0	0.27**	0	0.67***	2	0.52***	1	0.51***	1	0.75***	0	0.60***	1	0.85***	0	0.90***	0	x		-0.28**	-4	0.44***	1
GRE	0.27**	-4	-0.21*	3	-0.21*	-2	0.26**	2	0.55***	-4	0.24**	4	0.40***	-4	-0.13	4	0.48***	-4	-0.12	-1	0.23**	-4	-0.28**	4	x		0.08	-4
HUN	0.5***	-1	0.31***	-1	0.33***	0	-0.34***	-4	0.48***	0	-0.19*	4	0.51***	0	0.35***	0	0.41***	0	0.42***	0	0.34***	0	0.44***	-1	0.08	4	x	
IRE	0.73***	0	0.72***	0	0.66***	0	0.26**	3	0.70***	4	0.28**	1	0.41***	4	0.66***	0	0.80***	1	0.70***	0	0.73***	0	0.70***	0	-0.39***	-4	0.38***	0
ITA	0.47***	0	0.31***	-2	0.22*	-2	0.51***	2	0.71***	1	0.23**	2	0.53***	0	0.42***	0	0.71***	0	0.30***	3	0.36***	-1	0.36***	-1	0.32***	1	0.36***	1
LAT	0.74***	-1	0.72***	-1	0.60***	-1	0.44***	1	0.80***	1	0.48***	0	0.46***	1	0.72***	-2	0.87***	-1	0.77***	0	0.74***	-1	0.68***	-1	0.36***	4	0.40***	0
LIT	0.59***	-1	0.45***	-2	0.37***	-2	0.50***	2	0.80***	0	0.28**	0	0.50***	0	0.60***	-1	0.90***	-1	0.59***	0	0.53***	-1	0.50***	-2	0.36***	4	0.48***	0
LUX	0.78***	2	0.86***	1	0.79***	1	0.20*	4	0.71***	3	0.46***	3	0.46***	3	0.72***	1	0.56***	2	0.67***	2	0.84***	1	0.75***	1	-0.25	-4	-0.33***	-4
MAL	0.55***	1	0.53***	-1	0.47***	0	0.52***	2	0.45***	2	0.41***	0	0.62***	0	0.60***	0	0.41***	0	0.51***	1	0.52***	0	0.52***	-1	0.16	4	0.46***	0
NET	0.87***	0	0.87***	-1	0.85***	-1	0.32***	0	0.73***	1	0.64***	0	0.50***	1	0.72***	-1	0.42***	0	0.82***	0	0.85***	-1	0.82***	0	0.16	4	0.36***	0
POL	0.67***	0	0.61***	-1	0.54***	-1	0.34***	2	0.64***	1	0.54***	0	0.68***	0	0.66***	0	0.52***	0	0.63***	0	0.62***	0	0.54***	0	0.11	4	0.51***	0
POR	0.62***	1	0.57***	0	0.59***	0	0.24**	-3	0.52***	1	0.57***	2	0.43***	0	0.56***	0	0.23**	0	0.64***	1	0.56***	0	0.60***	0	0.20*	-3	-0.35***	-4
ROM	0.58***	0	0.56***	0	0.52***	0	0.58***	0	0.78***	0	0.44***	0	0.47***	1	0.54***	0	0.68***	-1	0.65***	0	0.62***	0	0.52***	0	0.43***	4	0.46***	0
SLO	0.7***	-1	0.62***	-1	0.51***	-1	0.40***	1	0.85***	0	0.46***	1	0.56***	0	0.51***	-1	0.71***	-2	0.73***	0	0.65***	-1	0.65***	-1	0.41***	4	0.42***	-1
SPA	0.84***	0	0.84***	-1	0.76***	-1	0.26**	2	0.87***	1	0.43***	1	0.61***	1	0.69***	0	0.66***	1	0.65***	-1	0.84***	-1	0.76***	-1	0.55***	4	0.29***	-1
SVK	0.50***	-2	0.33***	-3	-0.37***	4	0.44***	1	0.80***	0	0.31***	0	0.50***	0	0.39***	-2	0.69***	-2	0.42***	0	0.37***	-1	0.36***	-3	0.48***	-1	0.48***	-1
SWE	0.55***	1	0.59***	1	0.58***	0	-0.34***	-4	-0.65***	-4	0.36***	1	0.40***	-4	0.67***	1	0.67***	1	0.60***	2	0.66***	1	0.61***	0	-0.28**	-4	0.34***	2
UK	0.6***	2	0.66***	2	0.60***	1	0.40***	3	0.67***	4	0.41***	2	0.37***	4	0.66***	1	0.73***	1	0.78***	2	0.70***	2	0.62***	1	-0.23**	-4	0.38**	2

Benchmark country

Lagged country	IRE		ITA		LAT		LIT		LUX		MAL		NET		POL		POR		ROM		SLO		SPA		SVK		SWE		UK	
	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag	correlation and signif.	lag
EA	0.73***	0	0.47***	0	0.74***	1	0.59***	1	0.78***	-2	0.55***	-1	0.87***	0	0.67***	0	0.62***	-1	0.58***	0	0.7***	1	0.84***	0	0.5***	2	0.55***	-1	0.6***	-2
AUS	0.72***	0	0.31***	2	0.72***	1	0.45***	2	0.86***	-1	0.53***	1	0.87***	1	0.61***	1	0.57***	0	0.56***	0	0.62***	1	0.84***	1	0.33***	3	0.59***	-1	0.66***	-2
BEL	0.66***	0	0.22*	2	0.60***	1	0.37***	2	0.79***	-1	0.47***	0	0.85***	1	0.54***	1	0.59***	0	0.52***	0	0.51***	1	0.76***	1	-0.37***	-4	0.58***	0	0.60***	-1
BUL	0.26**	-3	0.51***	-2	0.44***	-1	0.50***	-2	0.20*	-4	0.52***	-2	0.32***	0	0.34***	-2	0.24**	3	0.58***	0	0.40***	-1	0.26**	-2	0.44***	-1	-0.34***	4	0.40***	-3
CRO	0.70***	-4	0.71***	-1	0.80***	-1	0.80***	0	0.71***	-3	0.45***	-2	0.73***	-1	0.64***	-1	0.52***	-1	0.78***	0	0.85***	0	0.87***	-1	0.80***	0	-0.65***	4	0.67***	-4
CYP	0.28**	-1	0.23**	-2	0.48***	0	0.28**	0	0.46***	-3	0.41***	0	0.64***	0	0.54***	0	0.57***	-2	0.44***	0	0.46***	-1	0.43***	-1	0.31***	0	0.36***	-1	0.41***	-2
CZE	0.41***	-4	0.53***	0	0.46***	-1	0.50***	0	0.46***	-3	0.62***	0	0.50***	-1	0.68***	0	0.43***	0	0.47***	-1	0.56***	0	0.61***	-1	0.50***	0	0.40***	4	0.37***	-4
DEN	0.66***	0	0.42***	0	0.72***	2	0.60***	1	0.72***	-1	0.60***	0	0.72***	1	0.66***	0	0.56***	0	0.54***	0	0.51***	1	0.69***	0	0.39***	2	0.67***	-1	0.66***	-1
EST	0.80***	-1	0.71***	0	0.87***	1	0.90***	1	0.56***	-2	0.41***	0	0.42***	0	0.52***	0	0.23**	0	0.68***	1	0.71***	2	0.66***	-1	0.69***	2	0.67***	-1	0.73***	-1
FIN	0.70***	0	0.30***	-3	0.77***	0	0.59***	0	0.67***	-2	0.51***	-1	0.82***	0	0.63***	0	0.64***	-1	0.65***	0	0.73***	0	0.65***	1	0.42***	0	0.60***	-2	0.78***	-2
FRA	0.73***	0	0.36***	1	0.74***	1	0.53***	1	0.84***	-1	0.52***	0	0.85***	1	0.62***	0	0.56***	0	0.62***	0	0.65***	1	0.84***	1	0.37***	1	0.66***	-1	0.70***	-2
GER	0.70***	0	0.36***	1	0.68***	1	0.50***	2	0.75***	-1	0.52***	1	0.82***	0	0.54***	0	0.60***	0	0.52***	0	0.65***	1	0.76***	1	0.36***	3	0.61***	0	0.62***	-1
GRE	-0.39***	4	0.32***	-1	0.36***	-4	0.36***	-4	-0.25	4	0.16	-4	0.16	-4	0.11	-4	0.20*	3	0.43***	-4	0.41***	-4	0.55***	-4	0.48***	1	-0.28**	4	-0.23**	4
HUN	0.38***	0	0.36***	-1	0.40***	0	0.48***	0	-0.33***	4	0.46***	0	0.36***	0	0.51***	0	-0.35***	4	0.46***	0	0.42***	1	0.29***	1	0.48***	1	0.34***	-2	0.38**	-2
IRE	x		0.60***	1	0.82***	1	0.58***	1	0.69***	-1	0.33***	0	0.63***	1	0.46***	0	0.34***	0	0.64***	1	0.64***	3	0.75***	1	0.56***	3	0.60***	-1	0.72***	-1
ITA	0.60***	-1	x		0.56***	2	0.71***	1	0.41***	-3	0.45***	0	0.15	1	0.45***	0	0.17	0	0.42***	2	0.45***	3	0.48***	-1	0.65***	2	0.57***	-1	0.37***	1
LAT	0.82***	-1	0.56***	-2	x		0.83***	0	0.68***	-3	0.49***	0	0.66***	0	0.65***	0	0.45***	-1	0.76***	0	0.77***	1	0.68***	0	0.65***	1	0.63***	-2	0.81***	-2
LIT	0.58***	-1	0.71***	-1	0.83***	0	x		0.47***	-3	0.51***	0	0.36***	-1	0.60***	0	0.25**	-2	0.68***	0	0.59***	1	0.52***	-1	0.76***	0	0.64***	-2	0.71***	-2
LUX	0.69***	1	0.41***	3	0.68***	3	0.47***	3	x		0.49***	1	0.75***	2	0.49***	1	0.50***	0	0.42***	2	0.52***	3	0.78***	2	0.43***	4	0.64***	0	0.53***	-1
MAL	0.33***	0	0.45***	0	0.49***	0	0.51***	0	0.49***	-1	x		0.67***	1	0.69***	-1	0.65***	0	0.56***	0	0.57***	0	0.50***	0	0.38***	0	0.26**	-1	0.40***	-2
NET	0.63***	-1	0.15	-1	0.66***	0	0.36***	1	0.75***	-2	0.67***	-1	x		0.68***	-1	0.74***	-1	0.57***	-1	0.65***	0	0.73***	0	0.27**	1	0.42***	-2	0.60***	-3
POL	0.46***	0	0.45***	0	0.65***	0	0.60***	0	0.49***	-1	0.69***	1	0.68***	1	x		0.58***	0	0.69***	0	0.56***	1	0.54***	0	0.47***	0	0.41***	-1	0.57***	-2
POR	0.34***	0	0.17	0	0.45***	1	0.25**	2	0.50***	0	0.65***	0	0.74***	1	0.58***	0	x		0.42***	0	0.67***	1	0.51***	1	0.23**	4	0.24**	0	0.31***	-1
ROM	0.64***	-1	0.42***	-2	0.76***	0	0.68***	0	0.42***	-2	0.56***	0	0.57***	1	0.69***	0	0.42***	0	x		0.70***	1	0.59***	1	0.65***	0	0.43***	-2	0.71***	-2
SLO	0.64***	-3	0.45***	-3	0.77***	-1	0.59***	-1	0.52***	-3	0.57***	0	0.65***	0	0.56***	-1	0.67***	-1	0.70***	-1	x		0.66***	0	0.57***	0	0.40***	-3	0.63***	-4
SPA	0.75***	-1	0.48***	1	0.68***	0	0.52***	1	0.78***	-2	0.50***	0	0.73***	0	0.54***	0	0.51***	-1	0.59***	-1	0.66***	0	x		0.55***	3	0.41***	-2	0.57***	-3
SVK	0.56***	-3	0.65***	-2	0.65***	-1	0.76***	0	0.43***	-4	0.38***	0	0.27**	-1	0.47***	0	0.23**	-4	0.65***	0	0.57***	0	0.55***	-3	x		-0.62***	4	0.41***	-1
SWE	0.60***	1	0.57***	1	0.63***	2	0.64***	2	0.64***	0	0.26**	1	0.42***	2	0.41***	1	0.24**	0	0.43***	2	0.40***	3	0.41***	2	-0.62***	-4	x		0.64***	0
UK	0.72***	1	0.37***	-1	0.81***	2	0.71***	2	0.53***	1	0.40***	2	0.60***	3	0.57***	2	0.31***	1	0.71***	2	0.63***	4	0.57***	3	0.41***	1	0.64***	0	x	

C General Statistics of the Cross-Correlations

average	0.69	0.64	0.57	0.34	0.67	0.45	0.52	0.61	0.62	0.65	0.68	0.62	0.13	0.30
count of average+	22	21	15	2	21	6	7	18	16	19	20	16	2	0
count of 0.7+	12	12	9	1	16	0	1	9	7	11	12	9	0	0
count of 0.8+	6	8	5	0	2	0	0	0	2	6	8	6	0	0
count of 0.9+	2	1	0	0	0	0	0	0	0	0	2	1	0	0
max	0.91	0.95	0.9	0.78	0.87	0.67	0.72	0.8	0.9	0.85	0.95	0.9	0.55	0.51
min	0.27	-0.2	-0.37	-0.34	-0.65	-0.19	0.27	-0.13	0.23	-0.12	0.23	-0.28	-0.3	-0.35
st.deviation	0.17	0.25	0.30	0.23	0.28	0.18	0.10	0.19	0.17	0.21	0.20	0.24	0.30	0.27

	IRE	ITA	LAT	LIT	LUX	MAL	NET	POL	POR	ROM	SLO	SPA	SVK	SWE	UK
average	0.58	0.44	0.67	0.58	0.56	0.50	0.61	0.57	0.44	0.60	0.61	0.64	0.43	0.39	0.57
count of average+	18	8	19	14	13	7	17	17	10	16	17	18	9	12	17
count of 0.7+	7	3	12	6	9	0	11	0	1	3	4	9	2	0	6
count of 0.8+	1	0	4	2	2	0	6	0	0	0	1	4	0	0	1
count of 0.9+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
max	0.82	0.71	0.87	0.9	0.86	0.69	0.87	0.69	0.74	0.78	0.85	0.87	0.8	0.67	0.81
min	-0.39	0.22	0.36	0.25	-0.33	0.26	0.27	0.34	-0.3	0.42	0.4	0.26	-0.62	-0.65	-0.2
st.deviation	0.25	0.14	0.14	0.16	0.28	0.10	0.18	0.09	0.22	0.11	0.12	0.16	0.30	0.38	0.20

D Lagged Pairwise Correlations with the EA

GDP correlations

GDP																					
1995Q1 - 2014Q2																					
LAG	EA countries										Non-EA countries										
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK		
-4	0.14		0.04		-0.02		0.40	***	0.26	**	0.40	***	-0.09		0.22	*	-0.32	***	-0.25	**	
-3	0.37	***	0.30	***	0.24	**	0.47	***	0.47	***	0.54	***	0.17		0.28	**	-0.11		-0.08		
-2	0.59	***	0.58	***	0.50	***	**0.50**	***	0.67	***	0.64	***	0.41	***	0.40	***	0.13		0.10		
-1	0.75	***	0.79	***	0.75	***	0.47	***	0.80	***	**0.67**	***	0.63	***	**0.50**	***	0.35	***	0.30	***	
0	**0.81**	***	**0.91**	***	**0.91**	***	0.37	***	**0.84**	***	0.60	***	**0.73**	***	0.48	***	0.50	***	0.45	***	
1	0.73	***	0.86	***	0.85	***	0.21	*	0.76	***	0.41	***	0.70	***	0.37	***	**0.55**	***	0.56	***	
2	0.57	***	0.72	***	0.71	***	0.00		0.60	***	0.14		0.59	***	0.18		0.50	***	**0.60**	***	
3	0.39	***	0.52	***	0.52	***	-0.16		0.40	***	-0.08		0.45	***	0.00		0.42	***	0.58	***	
4	0.18		0.30	***	0.30	***	-0.28	**	0.21	*	-0.24	**	0.31	***	-0.16		0.28	**	0.51	***	

GDP																					
1995Q1 - 2008Q2																					
LAG	EA countries										Non-EA countries										
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK		
-4	0.21		0.13		0.25	*	0.27	**	0.20		0.46	***	0.10		**0.50**	***	0.01		-0.09		
-3	0.32	**	0.31	**	0.42	***	0.31	**	0.38	***	0.57	***	0.27	*	0.49	***	0.09		0.01		
-2	0.46	***	0.52	***	0.58	***	0.34	**	0.57	***	0.61	***	0.40	***	0.47	***	0.18		0.11		
-1	0.62	***	0.72	***	0.75	***	**0.36**	***	0.74	***	**0.62**	***	0.54	***	0.46	***	0.31	**	0.23	*	
0	**0.76**	***	**0.89**	***	**0.90**	***	0.34	**	**0.86**	***	0.56	***	**0.67**	***	0.35	**	0.37	***	0.33	**	
1	0.72	***	0.86	***	0.83	***	0.21		0.81	***	0.35	**	0.65	***	0.18		0.38	***	0.49	***	
2	0.64	***	0.76	***	0.70	***	0.08		0.70	***	0.14		0.63	***	0.07		**0.40**	***	0.56	***	
3	0.54	***	0.65	***	0.60	***	-0.01		0.58	***	0.01		0.56	***	-0.06		0.38	***	**0.57**	***	
4	0.41	***	0.52	***	0.45	***	-0.09		0.47	***	-0.07		0.54	***	-0.19		0.31	**	0.54	***	

GDP																					
2008Q3 - 2014Q2																					
LAG	EA countries										Non-EA countries										
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK		
-4	0.01		-0.10		-0.14		0.05		-0.07		-0.08		-0.29		-0.11		-0.23		0.01		
-3	0.17		0.07		-0.05		0.07		0.07		-0.07		-0.25		-0.23		-0.13		0.08		
-2	0.42	**	0.32		0.08		0.11		0.29		-0.03		0.02		-0.22		0.02		0.07		
-1	0.75	***	0.68	***	0.54	***	0.38	*	0.56	***	0.33		0.52	**	0.22		0.33		0.33		
0	**0.94**	***	**0.96**	***	**0.94**	***	**0.51**	**	**0.71**	***	**0.75**	***	**0.87**	***	**0.75**	***	0.73	***	**0.62**	***	
1	0.56	***	0.63	***	0.73	***	-0.05		0.18		0.34	*	0.61	***	0.52	**	**0.75**	***	0.61	***	
2	0.15		0.25		0.43	**	-0.47	**	-0.29		-0.09		0.31		0.19		0.59	***	0.50	**	
3	-0.06		0.03		0.24		-0.56	***	-0.44	**	-0.23		0.16		0.06		0.44	**	0.37	*	
4	-0.21		-0.12		0.05		-0.53	***	-0.48	**	-0.30		-0.01		-0.04		0.28		0.23		

IPI correlations

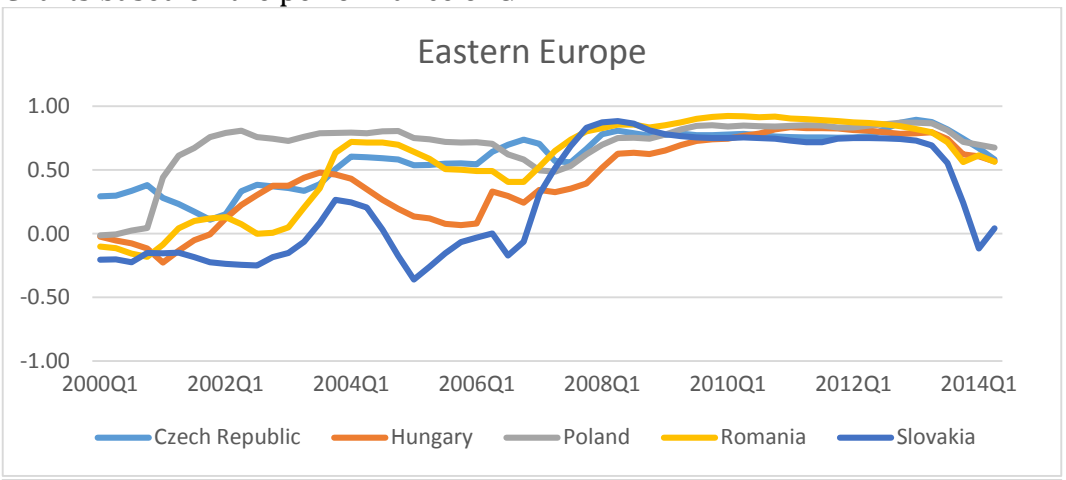
IP																					
1995Q1 - 2014Q2																					
LAG	EA countries										Non-EA countries										
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK		
-4	-0.09		-0.22	**	-0.15		-0.25	**	-0.32	***	-0.15		-0.03		-0.20	*	-0.18		-0.36	***	
-3	0.21	*	0.08		0.17		-0.03		-0.07		0.13		0.24	**	0.10		0.15		-0.04		
-2	0.54	***	0.44	***	0.52	***	0.29	**	0.27	**	0.44	***	0.50	***	0.46	***	0.51	***	0.35	***	
-1	0.83	***	0.79	***	0.85	***	0.62	***	0.64	***	0.74	***	**0.64**	***	0.79	***	0.81	***	0.69	***	
0	**0.91**	***	**0.98**	***	**0.99**	***	**0.82**	***	0.91	***	**0.89**	***	0.61	***	**0.95**	***	**0.94**	***	**0.91**	***	
1	0.68	***	0.82	***	0.78	***	0.73	***	**0.92**	***	0.80	***	0.39	***	0.83	***	0.78	***	0.82	***	
2	0.31	***	0.47	***	0.42	***	0.42	***	0.67	***	0.47	***	0.15		0.51	***	0.44	***	0.53	***	
3	-0.04		0.10		0.06		0.06		0.32	***	0.08		-0.08		0.13		0.08		0.19	*	
4	-0.32	***	-0.23	**	-0.24	**	-0.23	**	-0.03		-0.21	*	-0.26	**	-0.21	*	-0.23	**	-0.11		

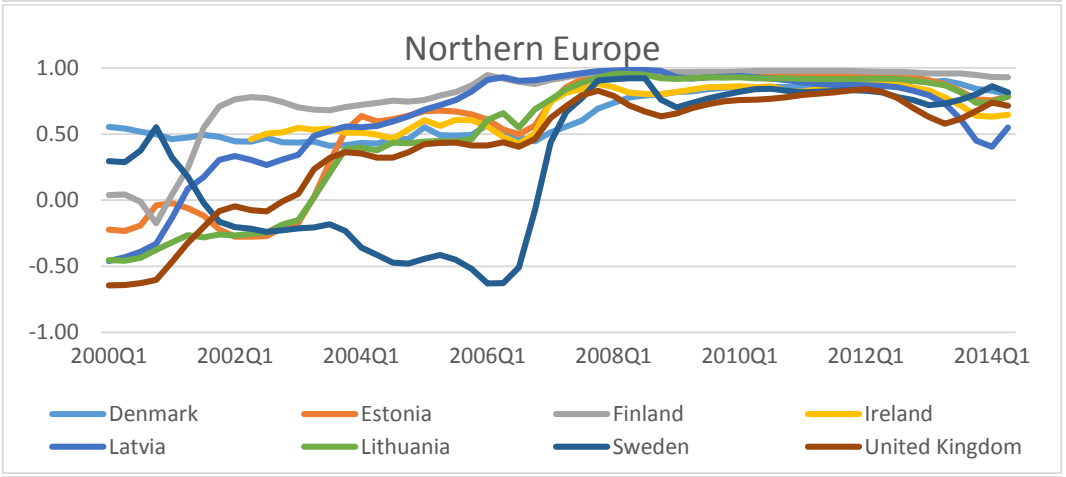
IP																					
1995Q1 - 2008Q2																					
LAG	EA countries										Non-EA countries										
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK		
-4	0.02		0.11		0.11		0.15		-0.01		0.11		-0.03		0.12		0.13		0.02		
-3	0.22		0.32	**	0.33	**	0.35	**	0.20		0.32	**	0.09		0.30	**	0.32	**	0.16		
-2	0.45	***	0.55	***	0.56	***	0.52	***	0.45	***	0.53	***	0.24	*	0.53	***	0.54	***	0.40	***	
-1	0.70	***	0.79	***	0.81	***	0.68	***	0.71	***	0.72	***	0.35	***	0.76	***	0.73	***	0.63	***	
0	**0.86**	***	**0.96**	***	**0.98**	***	**0.76**	***	**0.91**	***	**0.83**	***	**0.45**	***	**0.94**	***	**0.88**	***	**0.83**	***	
1	0.71	***	0.76	***	0.80	***	0.54	***	0.86	***	0.66	***	0.34	**	0.82	***	0.74	***	0.74	***	
2	0.48	***	0.50	***	0.55	***	0.31	**	0.67	***	0.45	***	0.25	*	0.59	***	0.51	***	0.56	***	
3	0.24	*	0.24	*	0.30	**	0.12		0.49	***	0.20		0.10		0.33	**	0.29	**	0.34	**	
4	0.06		0.01		0.10		-0.01		0.30	**	0.05		0.04		0.12		0.14		0.19		

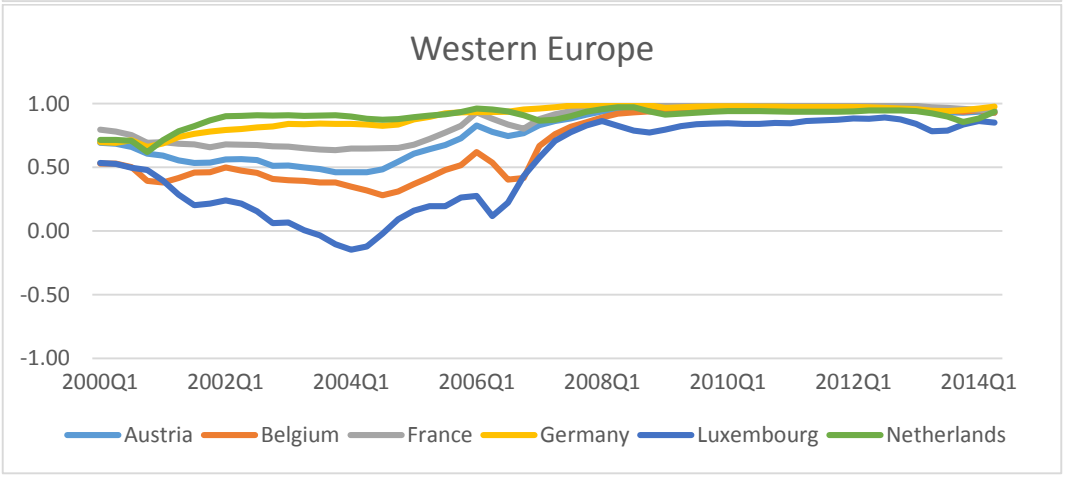
IP																					
2008Q3 - 2014Q2																					
LAG	EA countries										Non-EA countries										
	FIN		FRA		GER		SVK		SPA		CZE		DEN		HUN		SWE		UK		
-4	-0.14		-0.25		-0.17		-0.32		-0.29		-0.16		-0.11		-0.25		-0.23		-0.40	**	
-3	0.04		-0.12		-0.02		-0.26		-0.19		-0.02		0.18		-0.08		-0.01		-0.19		
-2	0.39	*	0.22		0.33	*	0.00		0.05		0.23		0.60	***	0.26		0.33	*	0.19		
-1	0.80	***	0.70	***	0.77	***	0.50	**	0.52	***	0.64	***	**0.85**	***	0.71	***	0.76	***	0.64	***	
0	**0.95**	***	**0.99**	***	**0.99**	***	**0.87**	***	**0.93**	***	**0.94**	***	0.82	***	**0.97**	***	**0.97**	***	**0.96**	***	
1	0.58	***	0.75	***	0.68	***	0.75	***	0.86	***	0.77	***	0.40	**	0.73	***	0.70	***	0.77	***	
2	0.08		0.30		0.22		0.32		0.46	**	0.32		-0.03		0.28		0.25		0.36	*	
3	-0.27		-0.06		-0.13		-0.05		0.08		-0.09		-0.31		-0.09		-0.10		0.01		
4	-0.38	*	-0.22		-0.28		-0.19		-0.10		-0.25		-0.41	**	-0.25		-0.24		-0.15		

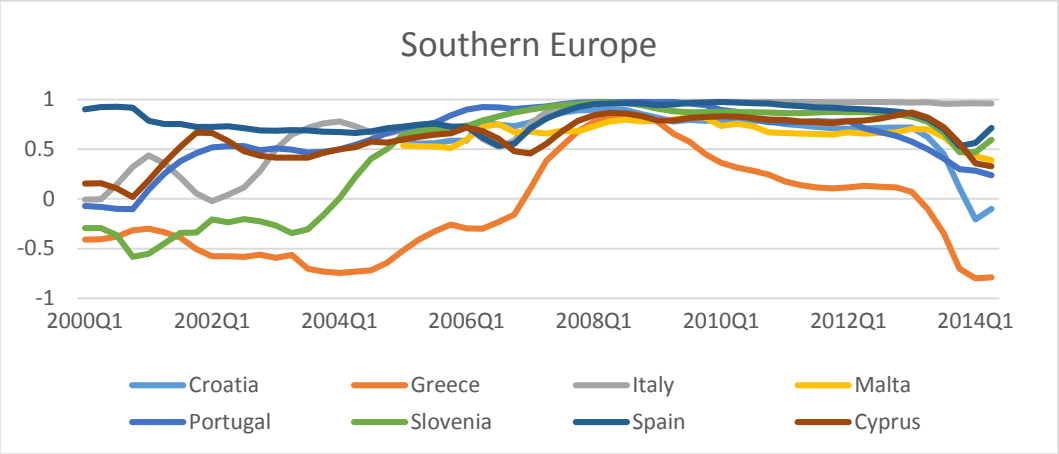
E Business Cycle Synchronization with the EA (rolling correlation)

Charts based on the performance of GDP

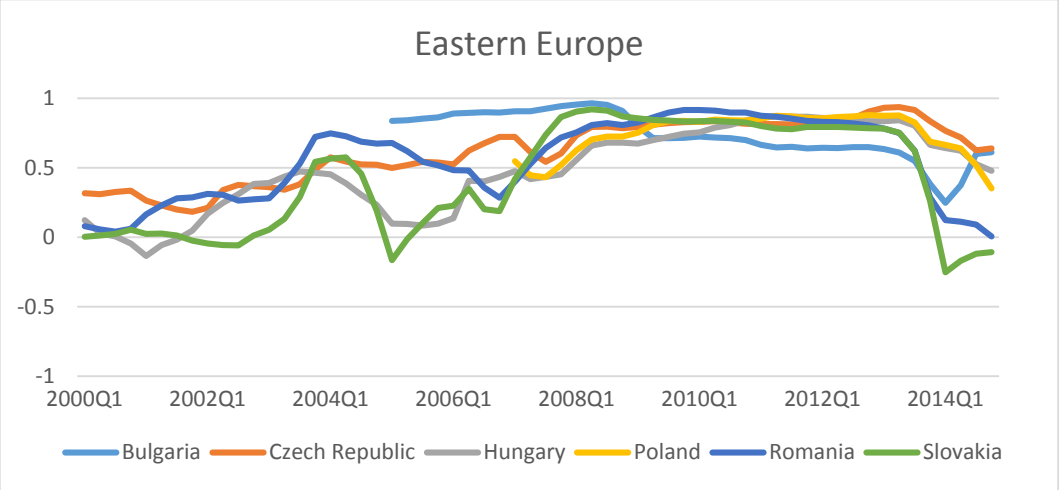


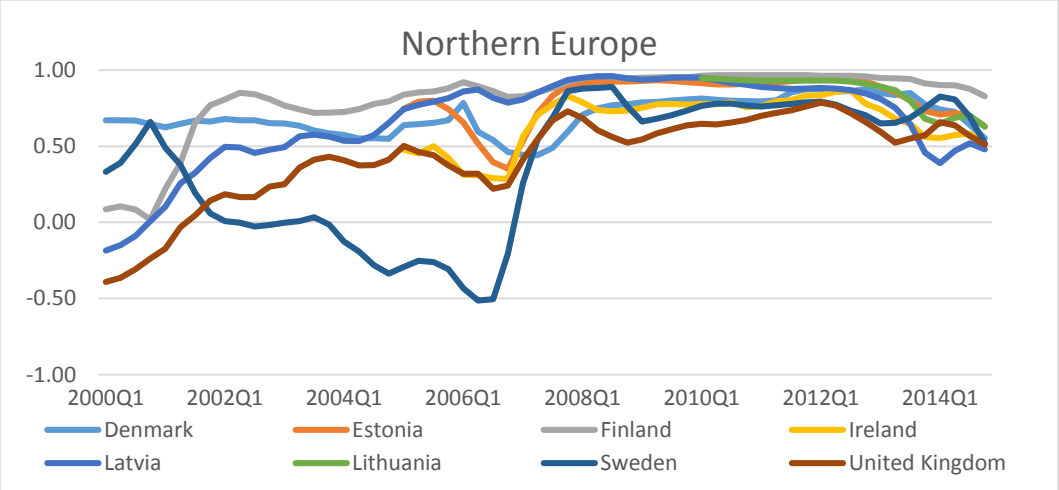


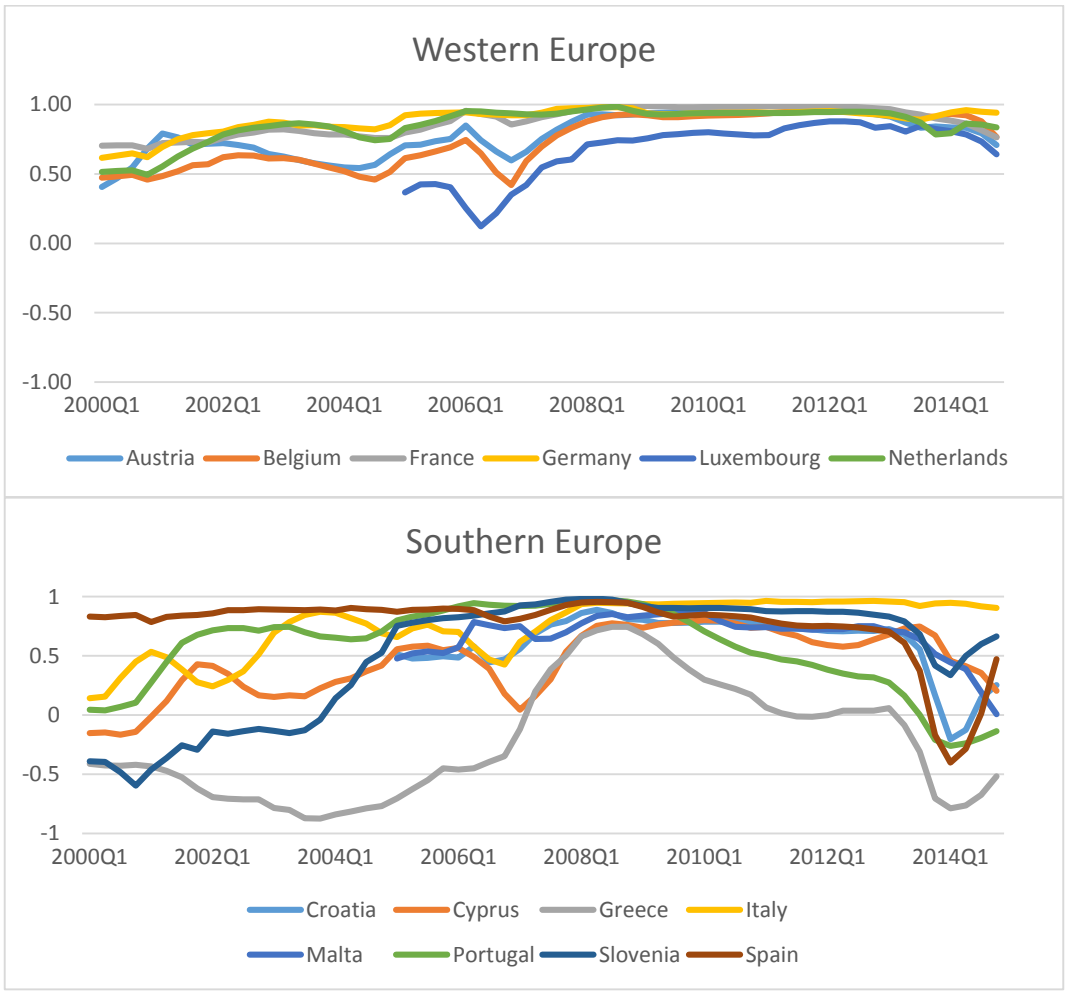




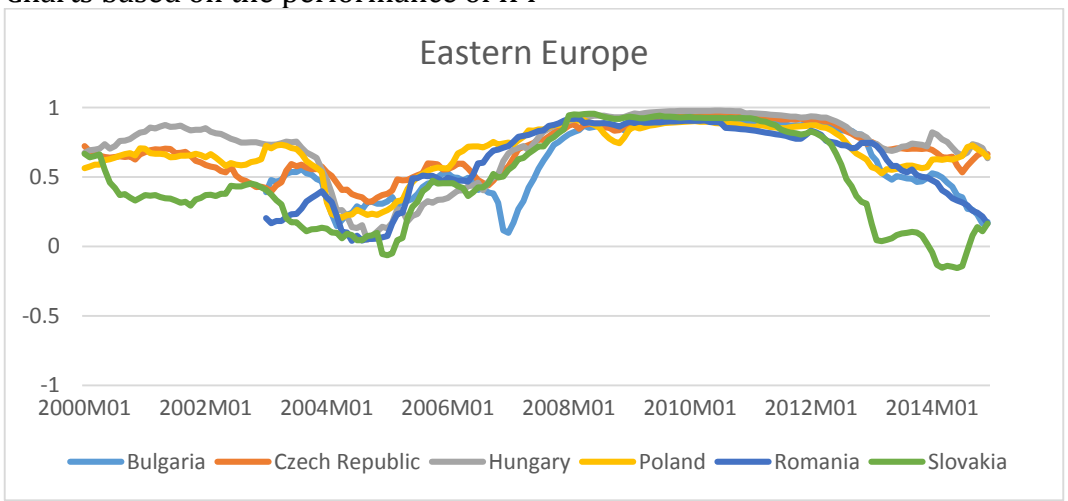
Charts based on the performance of GVA

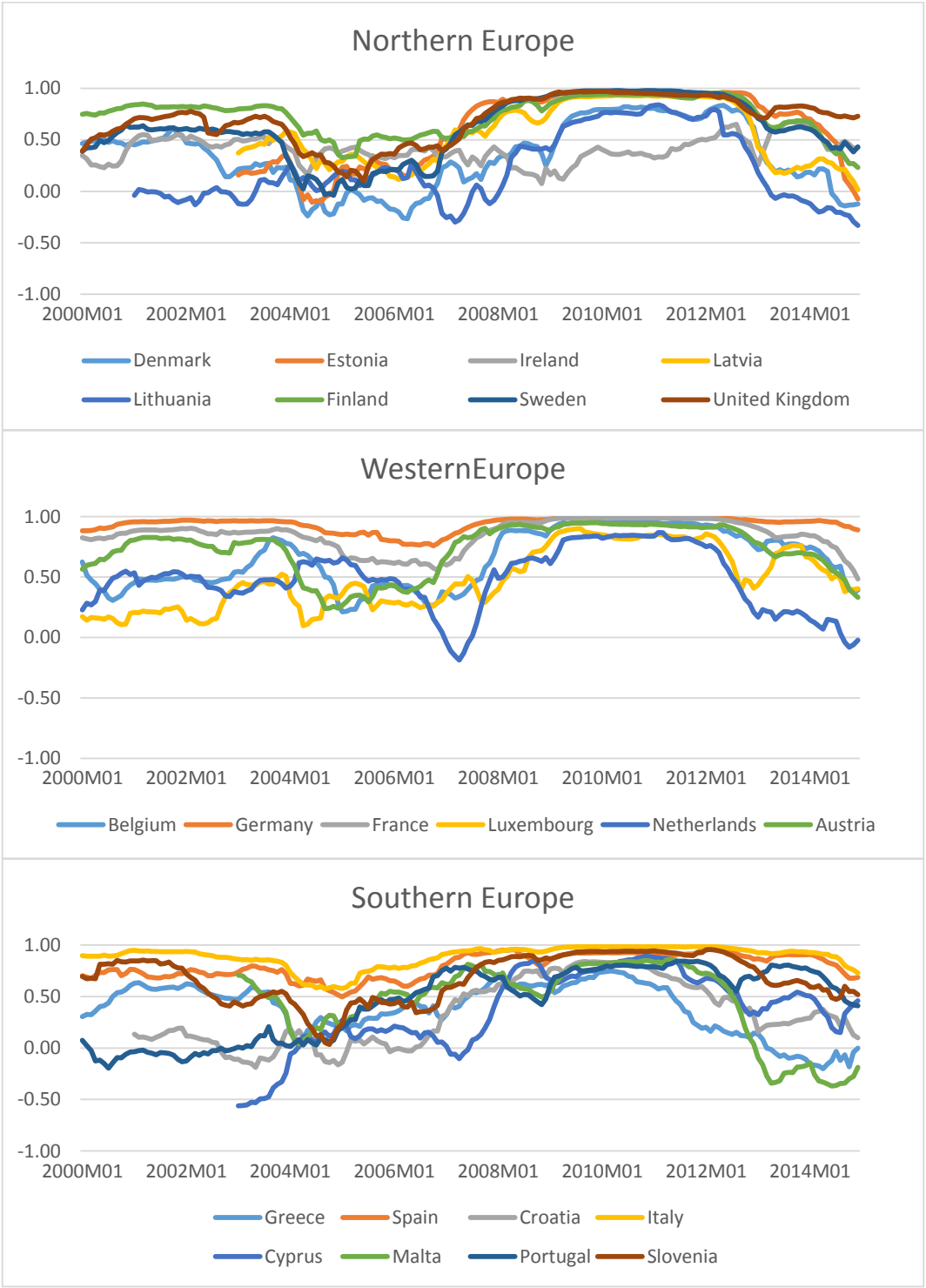






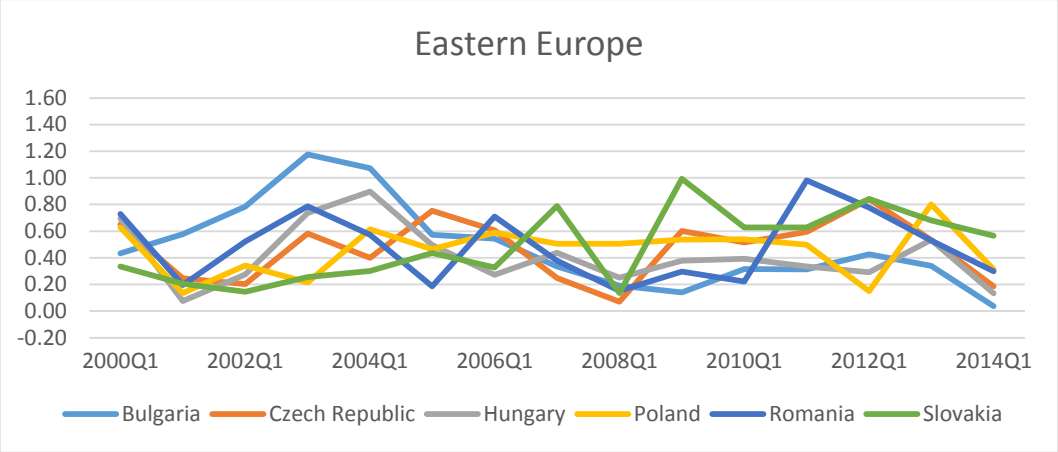
Charts based on the performance of IPI

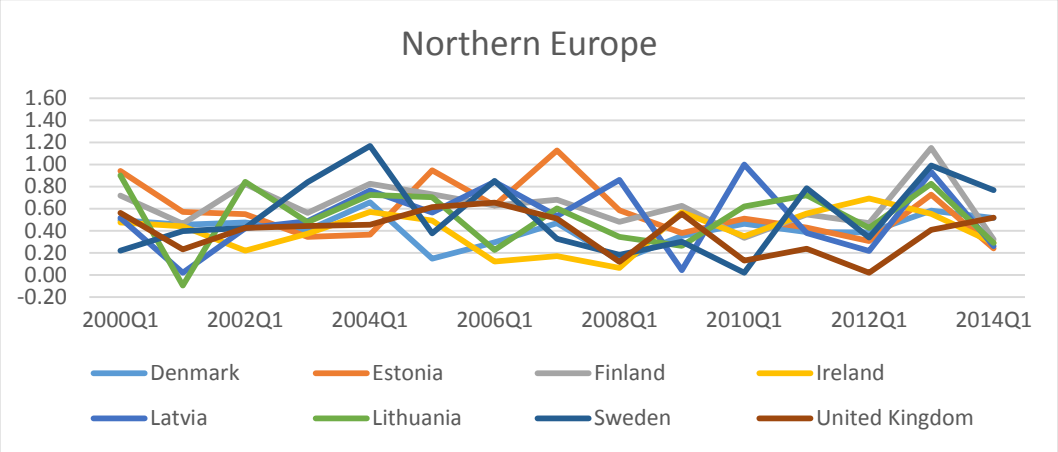


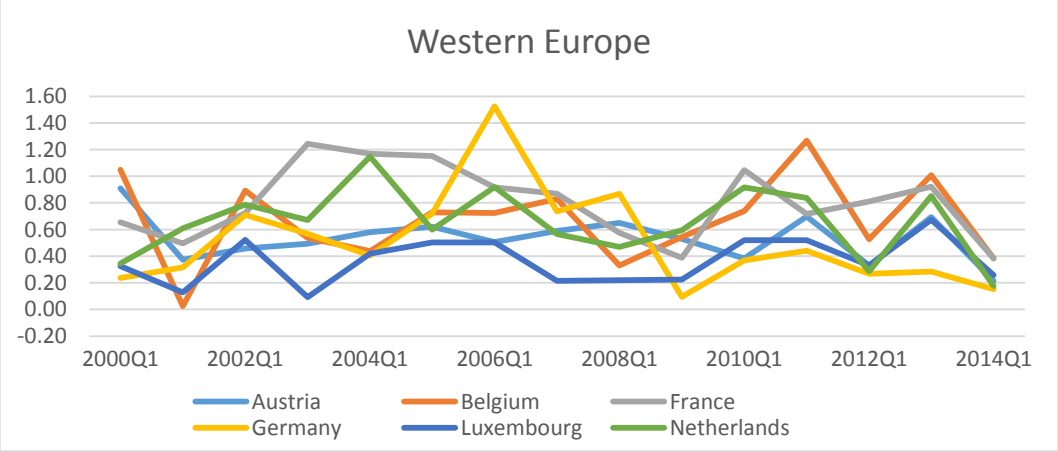

Northern Europe
1.00
0.50
0.00
-0.50
-1.00
2000M01
2002M01
2004M01
2006M01
2008M01
2010M01
2012M01
2014M01
Denmark
Estonia
Ireland
Latvia
Lithuania
Finland
Sweden
United Kingdom
WesternEurope
1.00
0.50
0.00
-0.50
-1.00
2000M01
2002M01
2004M01
2006M01
2008M01
2010M01
2012M01
2014M01
Belgium
Germany
France
Luxembourg
Netherlands
Austria
Southern Europe
1.00
0.50
0.00
-0.50
-1.00
2000M01
2002M01
2004M01
2006M01
2008M01
2010M01
2012M01
2014M01
Greece
Spain
Croatia
Italy
Cyprus
Malta
Portugal
Slovenia

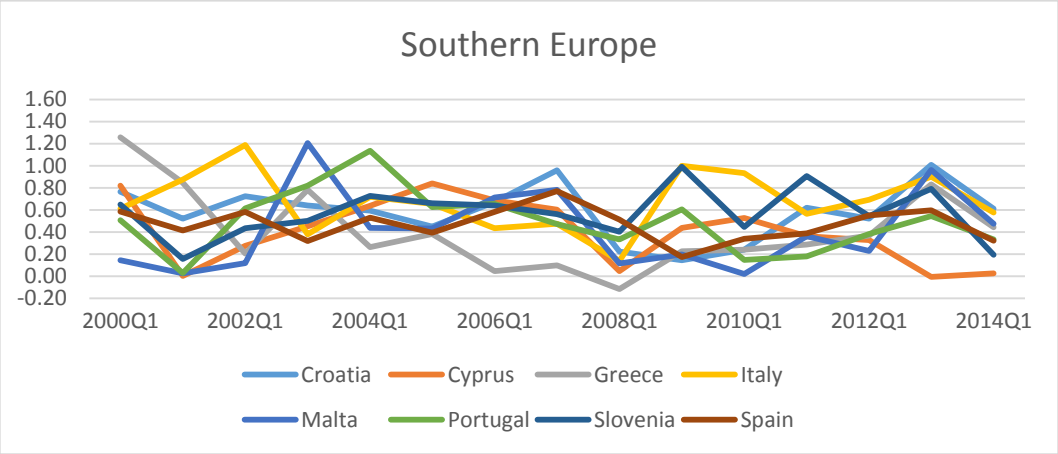
F Business Cycle Synchronization with the EA (Augmented cross-correlation index)

Charts based on the performance of GDP

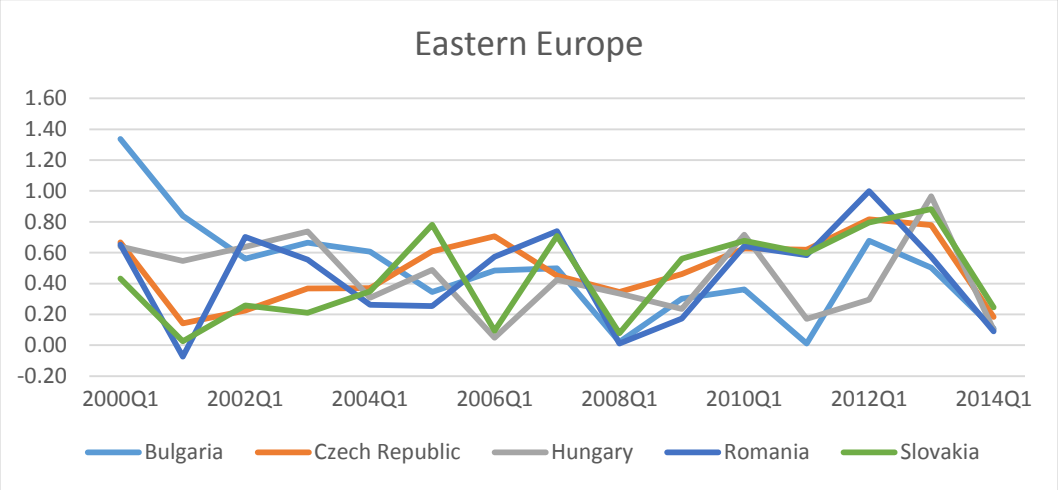


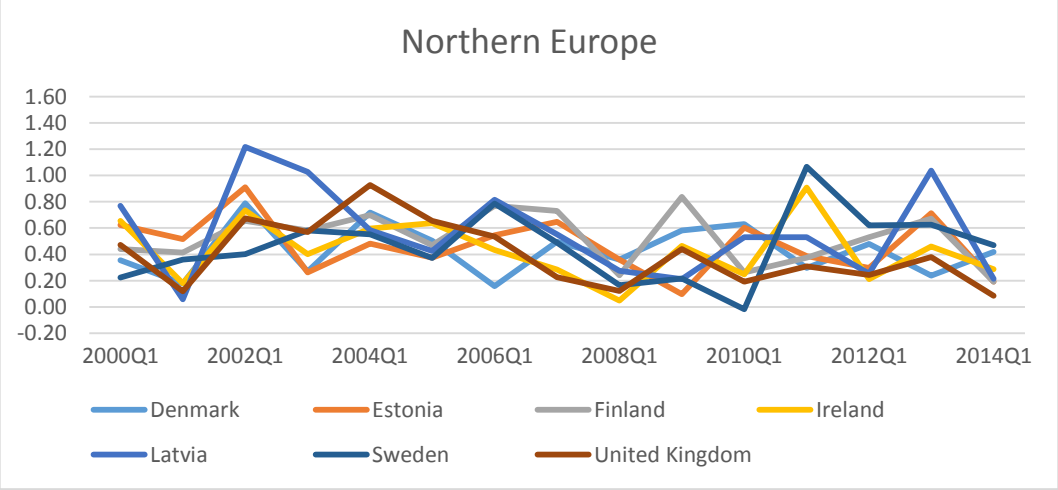


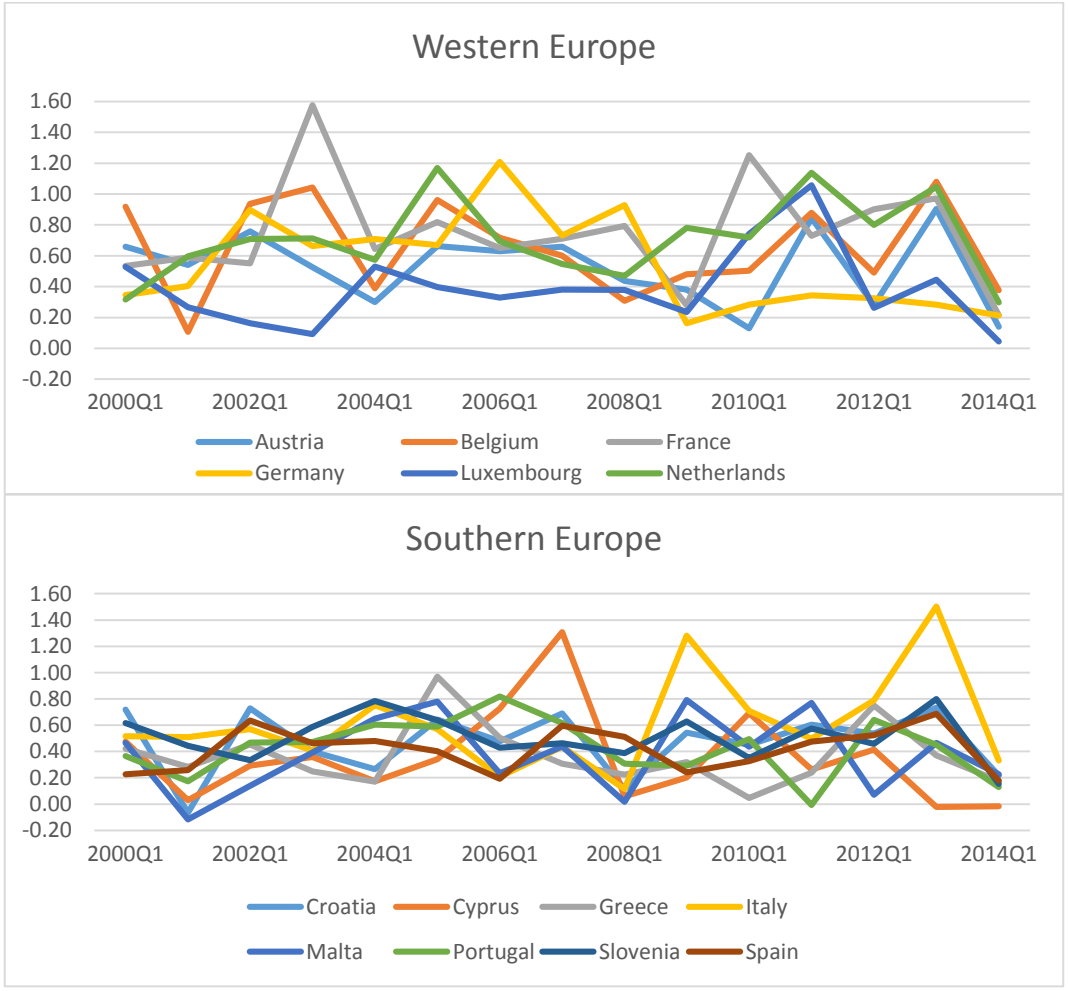




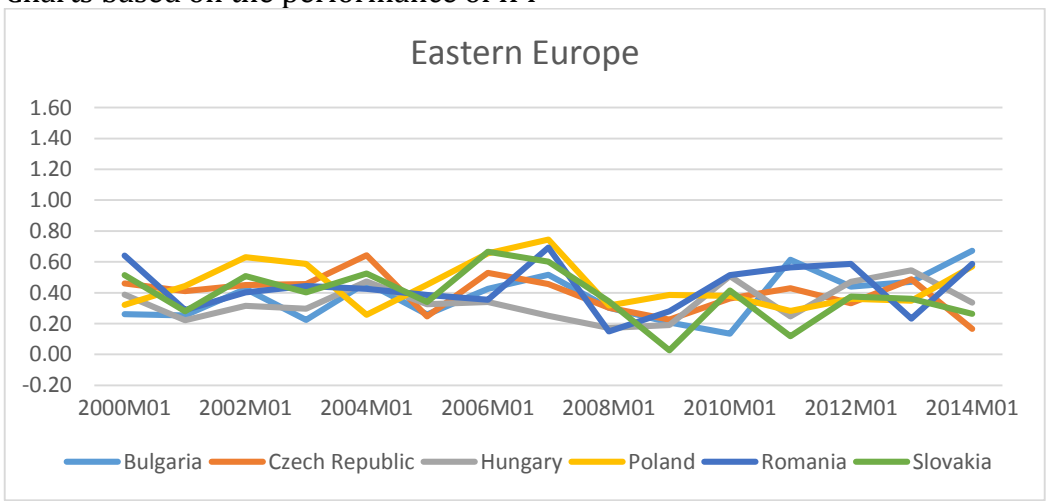
fs based on the performance of GVA

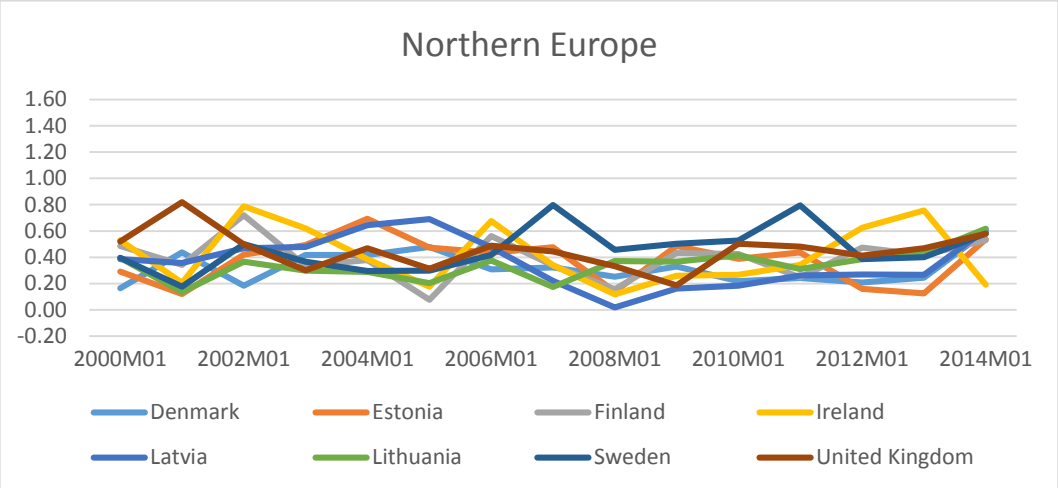


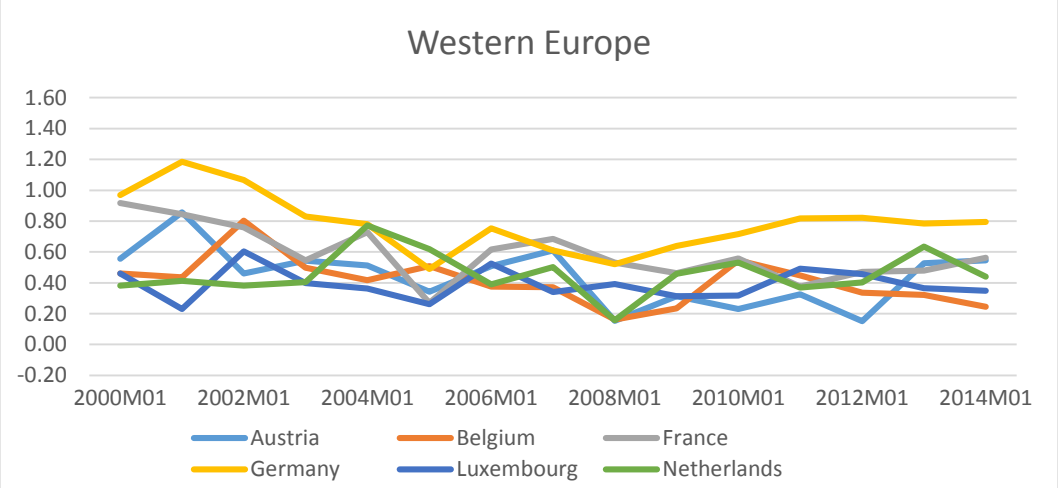


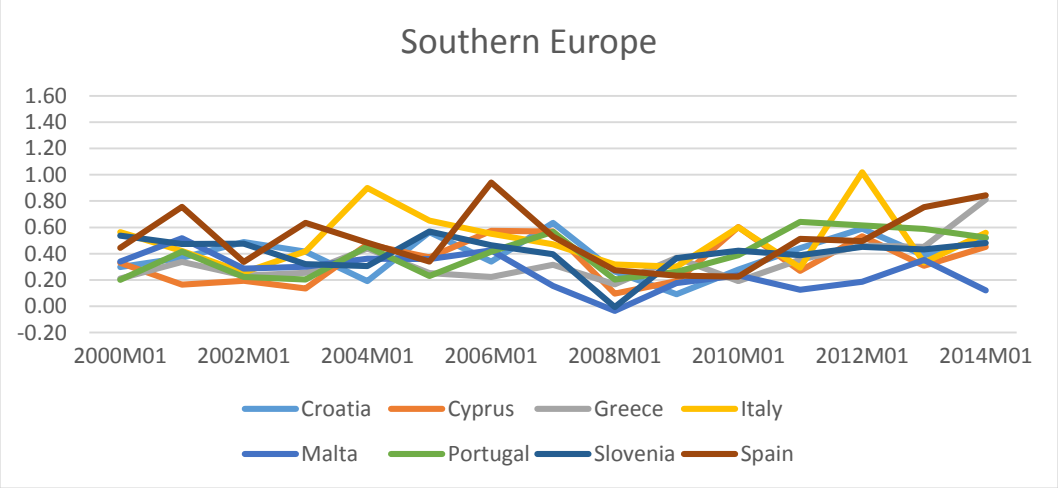


Charts based on the performance of IPI

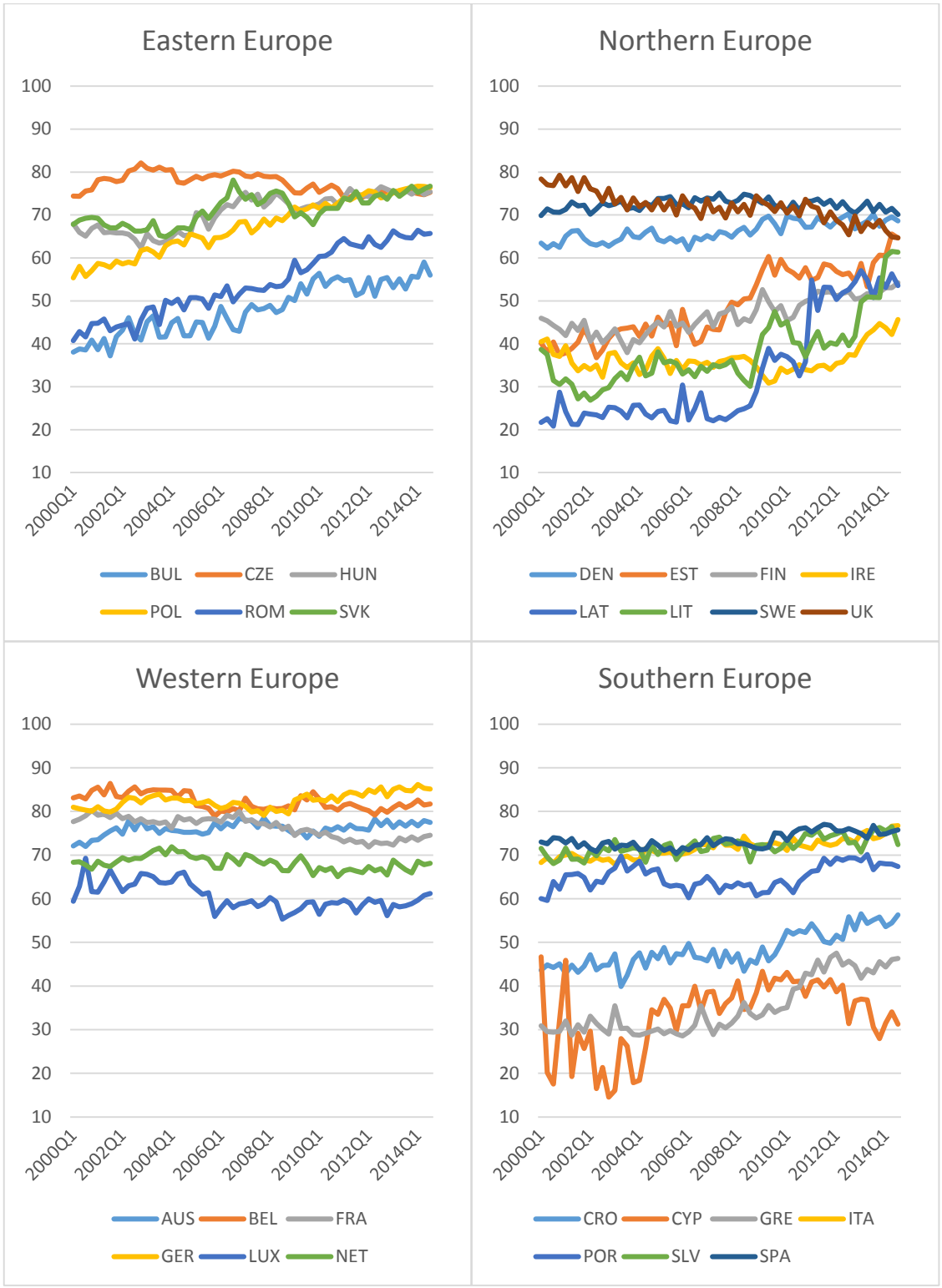



Northern Europe
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2000M01
2002M01
2004M01
2006M01
2008M01
2010M01
2012M01
2014M01
Denmark
Estonia
Finland
Ireland
Latvia
Lithuania
Sweden
United Kingdom

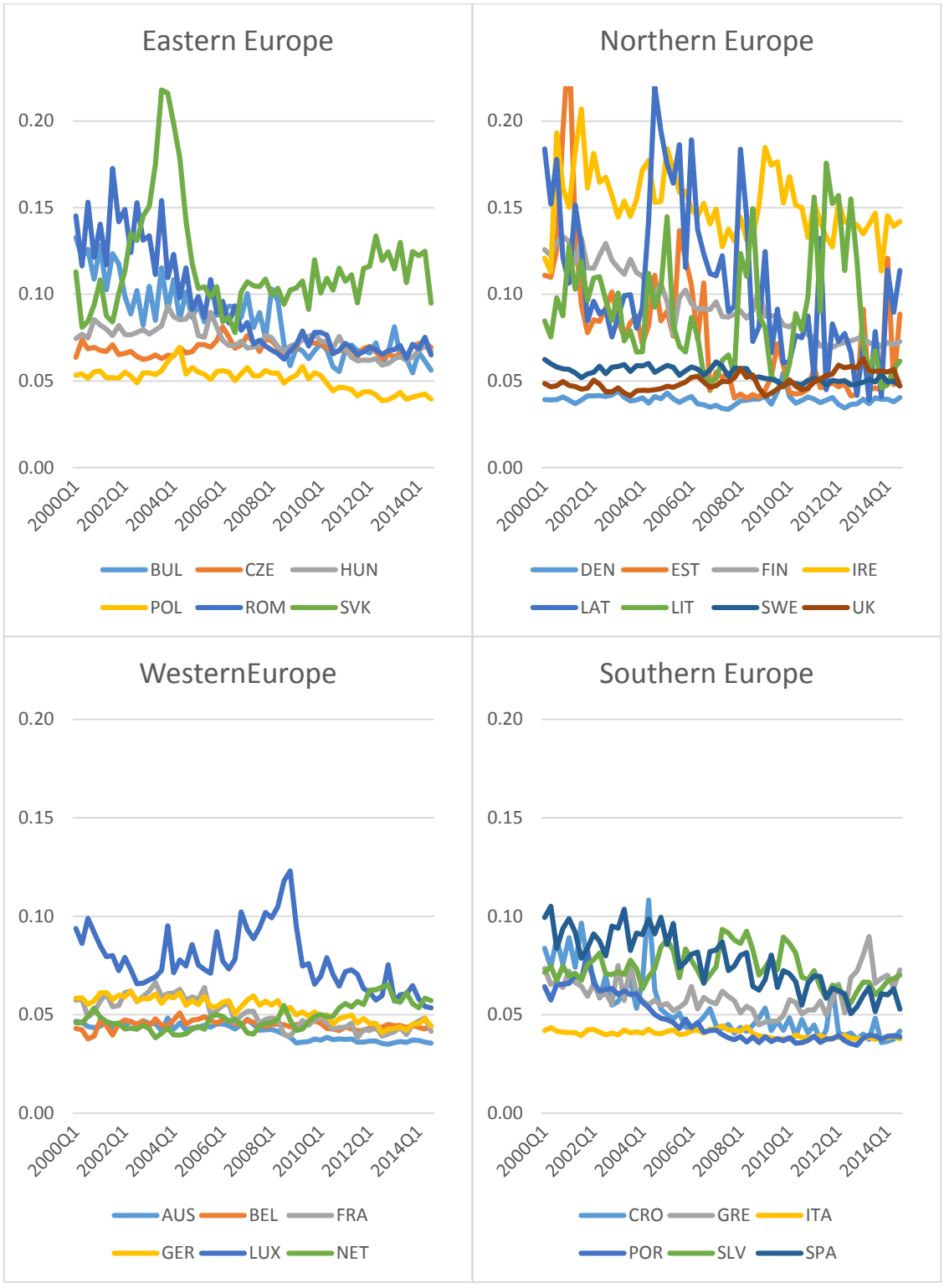

Western Europe
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2000M01
2002M01
2004M01
2006M01
2008M01
2010M01
2012M01
2014M01
Austria
Belgium
France
Germany
Luxembourg
Netherlands


Southern Europe
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
2000M01
2002M01
2004M01
2006M01
2008M01
2010M01
2012M01
2014M01
Croatia
Cyprus
Greece
Italy
Malta
Portugal
Slovenia
Spain

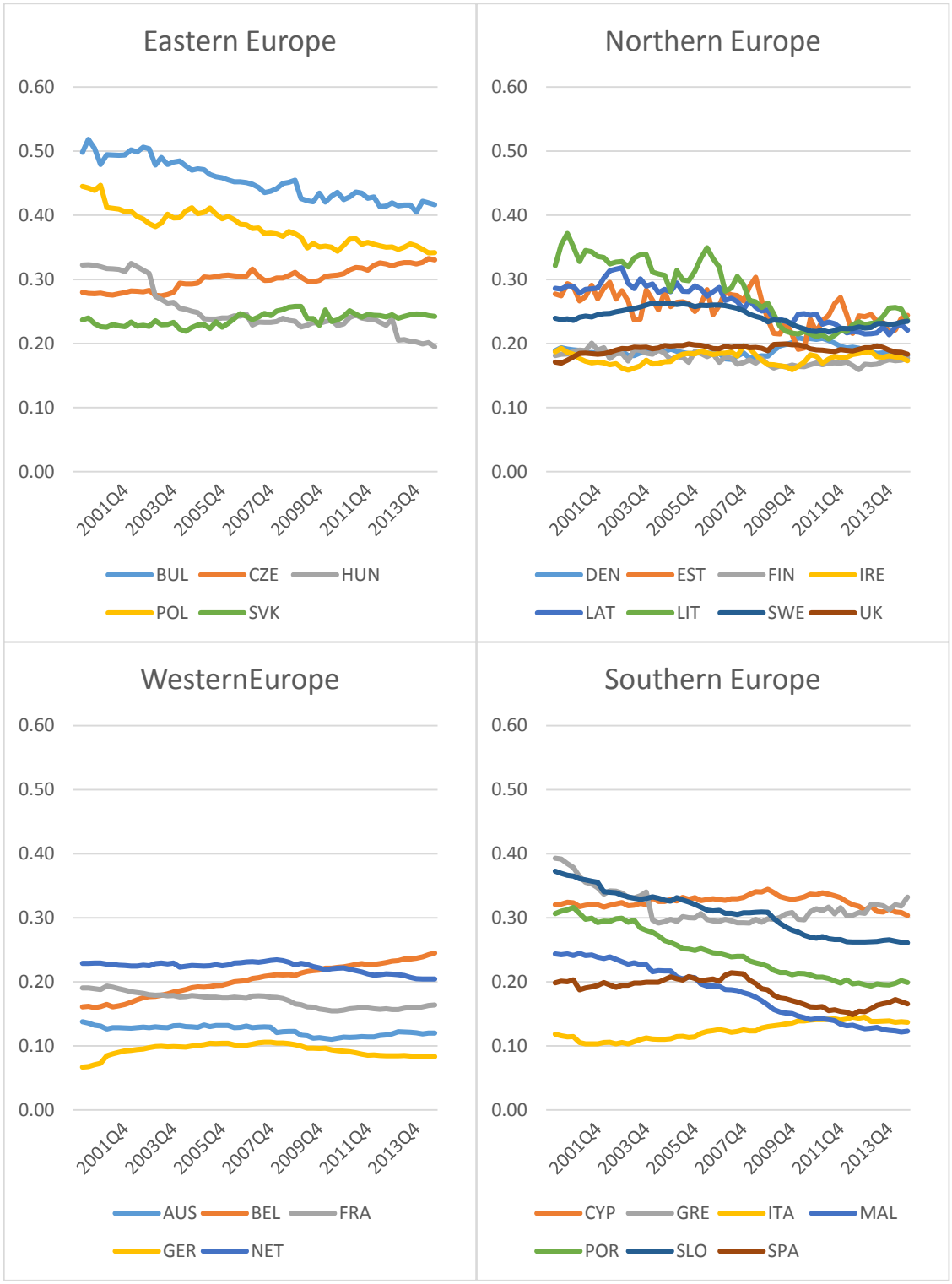
G Grubel-Lloyd Index for EU Countries



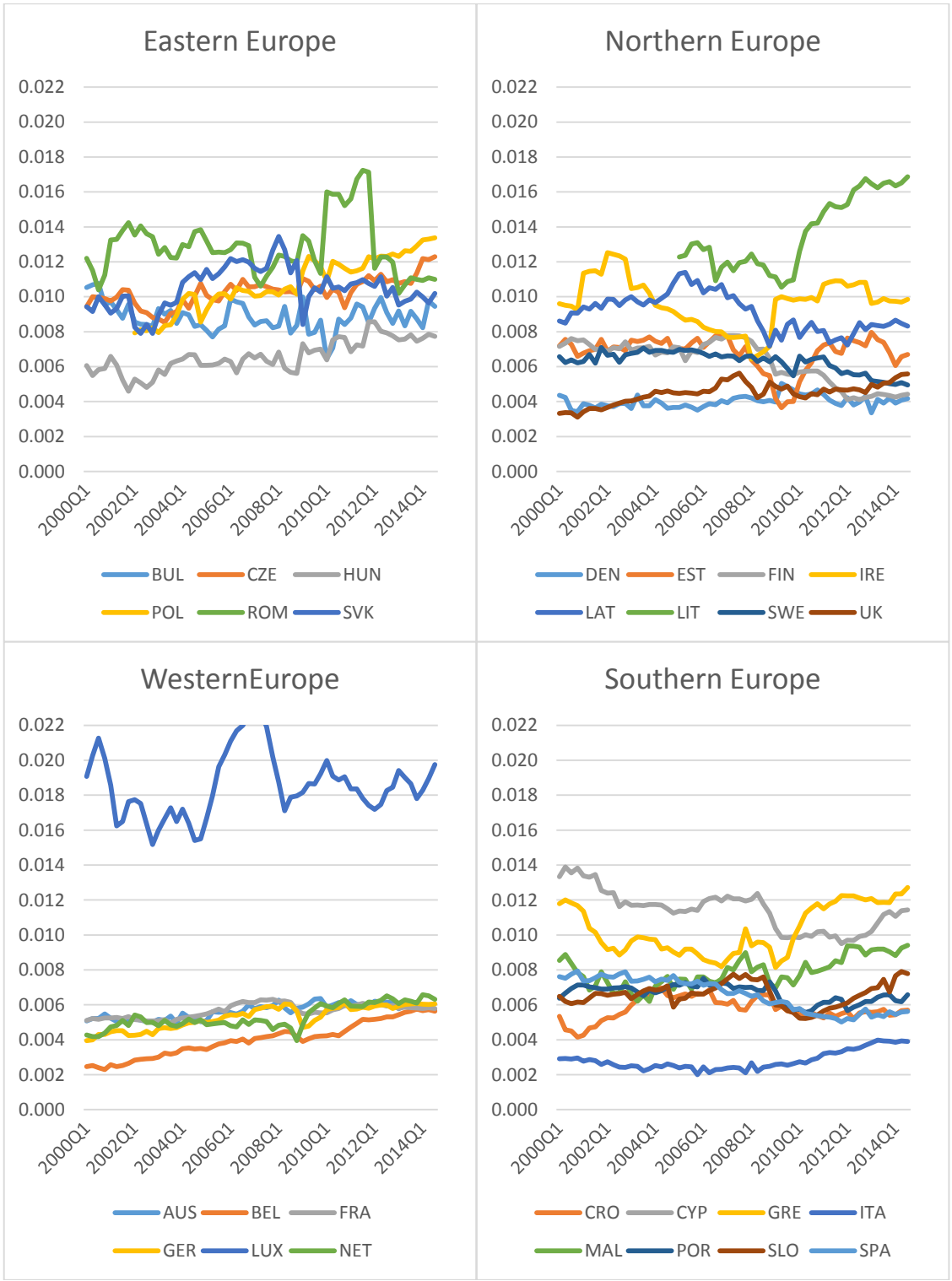
H Herfindahl Index for EU Countries



I Krugman Index for EU Countries



J Landesmann Index for EU Countries



K Panel Models (17 EU countries)

Sample of 17 EU countires	Correlation via AUGMENTED CROSS-CORRELATION INDEX	Panel method	Macro index	Full model						Automatic backward elimination					
				Index	OLS/LSDV fits	P-value (t)	R^2 adj	Information criteria		Index	OLS/LSDV fits	P-value (t)	R^2 adj	Information criteria	
		Fixed effects - pooled regression (naive regression) Intercepts, slope constants and error term are all constant across the time and space	GDP	const	0.657		0.03	AIC	1387	const	0.657	***	0.03	AIC	1384
				GLI	0.049			HQC	1400	GLI				HQC	1391
				HI	0.079					HI					
				KI	0.188	***				KI	0.147	**			
				LI	-0.089					LI					
				dComBor	0.199	*				dComBor	0.062	*			
				dEA11	0.072	***				dEA11	0.198	***			
			GVA	const	0.083		0.03	AIC	1349	const	0.260		0.03	AIC	1387
				GLI	0.055			HQC	1362	GLI				HQC	1400
				HI	0.056					HI					
				KI	0.144	**				KI	0.135	**			
				LI	-0.092					LI	-0.070	*			
				dComBor	0.105	***				dComBor	0.101	***			
				dEA11	0.154	***				dEA11	0.151	***			
			IP	const	-0.147		0.069	AIC	564	const			0.069	AIC	562
				GLI	0.142	**		HQC	577	GLI	0.128	**		HQC	571
				HI	0.078	*				HI	0.093	**			
				KI	-0.210	***				KI	-0.227	***			
				LI	0.030					LI					
				dComBor	0.033					dComBor	0.039	*			
				dEA11	0.033					dEA11					
		Fixed effects model (FEM) - LSDV (Least-squares dummy variable) model (individual effects i,e country effects) Slope coefficients are constant, intercepts vary across individuals	GDP	const	1.143		0.049	AIC	1379	const	1.500	***	0.054	AIC	1367
				GLI	0.149			HQC	1418	GLI				HQC	1393
				HI	-0.088					HI	-0.110	´			
				KI	0.595	***				KI	0.460	***			
				LI	0.121					LI	0.124	´			
				dComBor	-0.029					dComBor					
				dEA11	0.382	**				dEA11	0.298	***			
			GVA	const	1.567		0.038	AIC	1352	const	1.500	***	0.047	AIC	1332
				GLI	-0.137			HQC	1391	GLI				HQC	1350
				HI	-0.135					HI	-0.110	´			
				KI	0.383	**				KI	0.460	***			
				LI	0.063					LI	0.124	´			
				dComBor	-0.033					dComBor					
				dEA11	0.297	**				dEA11	0.298	***			
			IP	const	-1.932	**	0.105	AIC	539	const	-2.055	***	0.107	AIC	532
				GLI	0.446	**		HQC	578	GLI	0.438	**		HQC	562
				HI	0.199	**				HI	0.155	**			
				KI	-0.250	*				KI	-0.199	***			
				LI	-0.120					LI	-0.139	**			
				dComBor	0.094					dComBor	0.099	**			
				dEA11	-0.169	*				dEA11	-0.159	***			
		Fixed effects (FEM) - LSDV model (time effects) Slope coefficients are constant, intercepts vary across time	GDP	const	0.056		0.161	AIC	1297	const	0.375		0.169	AIC	1247
				GLI	0.032			HQC	1416	GLI				HQC	1288
				HI	0.115	*				HI	0.121	*			
				KI	0.206	***				KI	0.200	***			
				LI	-0.125	**				LI	-0.130	**			
				dComBor	0.083	**				dComBor	0.090	***			
				dEA11	0.201	***				dEA11	0.200	***			
			GVA	const	-0.152		0.152	AIC	1269	const	0.111		0.16	AIC	1226
				GLI	0.025			HQC	1388	GLI				HQC	1280
				HI	0.116	*				HI	0.131	**			
				KI	0.172	***				KI	0.172	***			
				LI	-0.150	**				LI	-0.163	***			
				dComBor	0.126	***				dComBor	0.133	***			
				dEA11	0.158	***				dEA11	0.158	***			
			IP	const	-0.131		0.18	AIC	492	const	-0.303	´	0.195	AIC	438
				GLI	0.157	***		HQC	611	GLI	0.169	***		HQC	486
				HI	0.027					HI					
				KI	-0.220	***				KI	-0.246	***			
				LI	0.061					LI	0.071	**			
				dComBor	0.018					dComBor					
				dEA11	0.030					dEA11					
		Fixed effects (FEM) - LSDV model (time effects and country effects) Slope coefficients are constant, intercepts vary across time and individuals	GDP	const	1.343		0.185	AIC	1282	const	0.097		0.187	AIC	1243
				GLI	0.147			HQC	1427	GLI	0.301	***		HQC	1317
				HI	-0.066					HI					
				KI	0.663	***				KI	0.500	***			
				LI	0.068					LI					
				dComBor	-0.028					dComBor					
				dEA11	0.427	***				dEA11	0.415	***			
			GVA	const	1.882		0.164	AIC	1267	const	0.818	***	0.185	AIC	1200
				GLI	-0.256			HQC	1413	GLI				HQC	1259
				HI	-0.044					HI					
				KI	0.503	***				KI	0.226	***			
				LI	-0.065					LI					
				dComBor	-0.024					dComBor					
				dEA11	0.393	***				dEA11	0.274	***			
			IP	const	-2.179	**	0.218	AIC	459	const	-2.271	***	0.234	AIC	401
				GLI	0.445	**		HQC	604	GLI	0.475	***		HQC	471
				HI	0.061					HI	0.102	*			
				KI	-0.223	*				KI	-0.233	***			
				LI	-0.107					LI	-0.110	**			
				dComBor	0.096					dComBor	0.103	**			
				dEA11	-0.186	**				dEA11	-0.183	***			

L Panel Models (EU core countries)

Sample of the EU core	Correlation via AUGMENTED CROSS-CORRELATION INDEX	Panel method	Macro index	Full model							Automatic backward elimination						
				Index	OLS/LSDV fits	P-value (t)	R^2 adj	Information criteria			Index	OLS/LSDV fits	P-value (t)	R^2 adj	Information criteria		
		Fixed effects - pooled regression (naive regression) Intercepts, slope constants and error term are all constant across the time and space	GDP	const	1.355		0.036	AIC	466		const	2.684	***	0.033	AIC	466	
				GLI	0.642			HQC	475		GLI				HQC	472	
				HI	0.224						HI						
				KI	0.372	***					KI	0.292	***				
				LI	0.322	**					LI	0.233	*				
				dComBor	-0.407	***					dComBor	-0.252	**				
				dEA11	Omitted						dEA11	Omitted					
			GVA	const	2.754		0.032	AIC	555		const	4.346	***	0.033	AIC	553	
				GLI	0.490			HQC	564		GLI				HQC	561	
				HI	0.465	**					HI	0.459	**				
				KI	0.353	***					KI	0.298	***				
				LI	0.335	**					LI	0.273	*				
				dComBor	-0.373	**					dComBor	-0.286	**				
				dEA11	Omitted						dEA11	Omitted					
			IP	const	1.023		0.13	AIC	220		const	2.218	***	0.133	AIC	216	
				GLI	0.303			HQC	230		GLI				HQC	221	
				HI	0.739	***					HI	0.712	***				
				KI	-0.229	***					KI	-0.266	***				
				LI	-0.014						LI						
				dComBor	-0.047						dComBor						
				dEA11	Omitted						dEA11	Omitted					
		Fixed effects model (FEM) - LSDV (Least-squares dummy variable) model (individual effects i,e country effects) Slope coefficients are constant, intercepts vary across individuals	GDP	const	7.663	*	0.043	AIC	468		const	11.440	***	0.049	AIC	461	
				GLI	-1.075			HQC	484		GLI	-2.172	***		HQC	469	
				HI	0.043						HI						
				KI	0.616	*					KI	0.704	***				
				LI	0.160						LI						
				dComBor	-0.200						dComBor						
				dEA11	Omitted						dEA11	Omitted					
			GVA	const	5.239		0.022	AIC	562		const	4.346	***	0.033	AIC	553	
				GLI	-0.077			HQC	577		GLI				HQC	561	
				HI	0.482	*					HI	0.459	**				
				KI	0.278						KI	0.298	***				
				LI	0.364						LI	0.273	*				
				dComBor	-0.361	*					dComBor	-0.286	**				
				dEA11	Omitted						dEA11	Omitted					
			IP	const	-4.234		0.143	AIC	219		const	-4.334	***	0.149	AIC	212	
				GLI	1.200			HQC	235		GLI	1.345	***		HQC	220	
				HI	0.485	***					HI	0.614	***				
				KI	-0.083						KI						
				LI	-0.169						LI	-0.182	***				
				dComBor	-0.032						dComBor						
				dEA11	Omitted						dEA11	Omitted					
		Fixed effects (FEM) - LSDV model (time effects) Slope coefficients are constant, intercepts vary across time	GDP	const	0.970		0.148	AIC	474		const	1.003		0.208	AIC	414	
				GLI	0.860	*		HQC	571		GLI	0.756	*		HQC	448	
				HI	0.068						HI						
				KI	0.408	***					KI	0.385	***				
				LI	0.511	***					LI	0.456	***				
				dComBor	-0.522	***					dComBor	-0.465	***				
				dEA11	Omitted						dEA11	Omitted					
			GVA	const	2.786		0.1	AIC	580		const	3.208	***	0.147	AIC	516	
				GLI	0.302			HQC	677		GLI				HQC	535	
				HI	0.507	**					HI	0.629	***				
				KI	0.327	***					KI	0.273	***				
				LI	0.249						LI						
				dComBor	-0.307	*					dComBor	-0.140	*				
				dEA11	Omitted						dEA11	Omitted					
			IP	const	0.747		0.243	AIC	223		const	1.958	***	0.296	AIC	159	
				GLI	0.436			HQC	319		GLI				HQC	186	
				HI	0.651	***					HI	0.630	***				
				KI	-0.195	***					KI	-0.252	***				
				LI	0.068						LI						
				dComBor	-0.101						dComBor						
				dEA11	Omitted						dEA11	Omitted					
		Fixed effects (FEM) - LSDV model (time effects and country effects) Slope coefficients are constant, intercepts vary across time and individuals	GDP	const	10.470	**	0.163	AIC	471		const	12.056	***	0.218	AIC	407	
				GLI	-1.527			HQC	574		GLI	-2.313	***		HQC		
				HI	-0.227						HI						
				KI	0.488						KI	0.708	***				
				LI	0.499	*					LI						
				dComBor	-0.408	*					dComBor						
				dEA11	Omitted						dEA11	Omitted					
			GVA	const	7.515		0.091	AIC	587		const	3.271	***	0.155	AIC	514	
				GLI	-0.766			HQC	689		GLI				HQC	534	
				HI	0.483						HI	0.642	***				
				KI	0.409						KI	0.269	***				
				LI	0.197						LI						
				dComBor	-0.200						dComBor						
				dEA11	Omitted						dEA11	Omitted					
			IP	const	-3.034		0.271	AIC	213		const	-4.690	**	0.328	AIC	149	
				GLI	0.805			HQC	316		GLI	1.273	***		HQC	187	
				HI	0.302						HI	0.330	**				
				KI	0.218						KI	0.152					
				LI	-0.267						LI	-0.189	***				
				dComBor	0.063						dComBor						
				dEA11	Omitted						dEA11	Omitted					

M Panel Models (non-EA countries)

Sample of non-EA countries	Correlation via AUGMENTED CROSS-CORRELATION INDEX	Panel method	Macro index	Full model						Automatic backward elimination					
				Index	OLS/LSDV fits	P-value (t)	R^2 adj	Information criteria		Index	OLS/LSDV fits	P-value (t)	R^2 adj	Information criteria	
		Fixed effects (FEM) - LSDV model (time effects) Slope coefficients are constant, intercepts vary across time	GDP	const	-1.741		0.2	AIC	398	const	0.772	***	0.26	AIC	338
				GLI	0.351			HQC	491	GLI				HQC	365
				HI	0.058					HI					
				KI	0.483					KI	0.209	*			
				LI	-0.271					LI					
				dComBor	0.079					dComBor					
				dEA11	Omitted					dEA11	Omitted				
			GVA	const	-1.443		0.14	AIC	419	const	-4.918	***	0.16	AIC	116
				GLI	0.244			HQC	511	GLI	1.103	***		HQC	141
				HI	-0.385					HI					
				KI	0.996	***				KI					
				LI	-0.236					LI	-0.114	*			
				dComBor	-0.061					dComBor					
				dEA11	Omitted					dEA11	Omitted				
			IP	const	-5.923	***	0.09	AIC	179	const	0.112		0.21	AIC	354
				GLI	1.348	***		HQC	272	GLI				HQC	381
				HI	0.318					HI					
				KI	-0.246					KI	0.618				
				LI	-0.226					LI	-0.245				
				dComBor	0.094					dComBor					
				dEA11	Omitted					dEA11	Omitted				
		Fixed effects (FEM) - LSDV model (time effects and country effects) Slope coefficients are constant, intercepts vary across time and individuals	GDP	const	-0.071		0.2	AIC	403	const	1.323	***	0.22	AIC	387
				GLI	0.274			HQC	500	GLI				HQC	470
				HI	0.058					HI					
				KI	0.524					KI					
				LI	-0.174					LI					
				dComBor	-0.050					dComBor					
				dEA11	Omitted					dEA11	Omitted				
			GVA	const	-1.602		0.13	AIC	423	const	0.112		0.21	AIC	355
				GLI	-0.027			HQC	521	GLI				HQC	381
				HI	-0.578					HI					
				KI	0.870	**				KI	0.618	**			
				LI	-0.336					LI	-0.245	*			
				dComBor	0.180					dComBor					
				dEA11	Omitted					dEA11	Omitted				
			IP	const	-3.743		0.1	AIC	178	const	-3.575	*	0.17	AIC	115
				GLI	0.538			HQC	276	GLI	0.725	*		HQC	144
				HI	0.149					HI					
				KI	-0.428					KI	-0.413	*			
				LI	-0.314	*				LI	-0.191	*			
				dComBor	0.337					dComBor	0.165	**			
				dEA11	Omitted					dEA11	Omitted				

N Code Tables for Panel Regression

COMMON CODE TABLE
for all regressions

Time *t*	Code	Time *t*	Code
2000Q1	1	2007Q2	30
2000Q2	2	2007Q3	31
2000Q3	3	2007Q4	32
2000Q4	4	2008Q1	33
2001Q1	5	2008Q2	34
2001Q2	6	2008Q3	35
2001Q3	7	2008Q4	36
2001Q4	8	2009Q1	37
2002Q1	9	2009Q2	38
2002Q2	10	2009Q3	39
2002Q3	11	2009Q4	40
2002Q4	12	2010Q1	41
2003Q1	13	2010Q2	42
2003Q2	14	2010Q3	43
2003Q3	15	2010Q4	44
2003Q4	16	2011Q1	45
2004Q1	17	2011Q2	46
2004Q2	18	2011Q3	47
2004Q3	19	2011Q4	48
2004Q4	20	2012Q1	49
2005Q1	21	2012Q2	50
2005Q2	22	2012Q3	51
2005Q3	23	2012Q4	52
2005Q4	24	2013Q1	53
2006Q1	25	2013Q2	54
2006Q2	26	2013Q3	55
2006Q3	27	2013Q4	56
2006Q4	28	2014Q1	57
2007Q1	29	2014Q2	58

CODE TABLE
for the regression of EU sample

Country *i*	Code	Country *i*	Code
Austria	1	Italy	10
Belgium	2	Netherlands	11
Czech Republic	3	Portugal	12
Denmark	4	Slovakia	13
Finland	5	Slovenia	14
France	6	Spain	15
Germany	7	Sweden	16
Greece	8	United Kingdom	17
Hungary	9		

CODE TABLE
for the regression of EU core

Country *i*	Code	Country *i*	Code
Austria	1	Germany	4
Belgium	2	Italy	5
France	3	Netherlands	6

CODE TABLE
for the regression of non-EA countries

Country *i*	Code	Country *i*	Code
Czech Republic	1	Sweden	4
Denmark	2	United Kingdom	5
Hungary	3		