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"Convergence Among the CEE Economies and their Catch-up Toward the EU-15"

Verfasst von

Dominika Roza Wcislik Lic.

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Betreuer:	Univ.-Prof. Dipl.-Ing. Dr. Robert Kunst

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Introduction

Along with the development of economic thought numerous approaches towards economic integration and convergence were taken. Within earlier theories and the neoclassical framework, growth and economic integration were meant to increase convergence implying equalisation of growth rates and diminution of the income gap. New Growth models and the New Economic Geography notion (Krugman, 1991) anticipated the opposite. As to empirical studies, the results were likewise ambiguous and did not give an unequivocal answer to that puzzle. With increased economic integration, assessing convergence between countries takes on particular importance. In a world where governments proliferate preferential trade agreements and tighten co-operation in a rapid manner, that it may even seem unthoughtful, it is important to evaluate this process.

As integration is a lengthy process and its results are only visible after a substantial amount of time, it is clear that not every entity is suitable for empirical investigation. Groupings with grounded history, stable co-operation between members and indicating constant unification are of particular interest. Therefore, OECD, WTO, European Union and similar communities have attained a lot of attention.

The case of the EU is an especially interesting example. New joining countries are being constantly compared to the established members of European Community. Parallel with extensions of the European Union, economists can directly monitor how entering economies evolve, adjust their structures and benefit from partnership. Bearing in mind that growth theory has experienced a major revival since the 1950s, applying it to testing convergence was a natural consequence. Scientists also noticed that convergence occurs most often in a group of similar countries, which gave rise to first ideas about club convergence. Although the EU still seems a largely varied formation, it surely aggregates similar countries (countries have to abide by procedures and convergence criteria) or at least quite homogenous building blocks. Apart from that, all new members accessing the community set the aim to catch up with the core of the European Union, to advance towards “western standards”.

Last biggest extension of European Union took place in 2004 and incorporated ten new economies, mainly CEE countries. As these countries are similar in many aspects, this provides an interesting background for research. A substantial part of these countries

belonged to USSR (Estonia, Latvia, Lithuania) or were controlled by it. Since the severance of USSR, their development patterns and GDP levels are comparable. Thus, it is reasonable to infer that they can reveal a convergence pattern within the group. According to growth theory, these economies should also catch up towards developed economies in the EU over time. It has already been clearly visible that these countries seek to fulfil different convergence targets such as law and policy unification, increased market connections and interest rates equalisation.

In light of these changes, confronting the predictions of theory with real performance of economies gives a lot of practical implications. One can forecast how economic development of CEE countries will proceed or answer some vital questions: Is economic integration really beneficial to CEE economies and does it proceed in the right direction? Should CEE then tighten the co-operation and enhance further unification with the EU? Can they really reach the level of development of Western economies like Germany and France and how much time it will take? What policies should be applied to enhance and foster further growth? Etc. It is also possible to generalize results from convergence testing to assess whether integration is generally beneficial for relatively new participating economies and if it really accelerates their development (e.g. if CEE economies indeed catch up towards the EU-15, it may be also true for Bulgaria, Romania etc.)

The main purpose of this study is to assess whether there is convergence of CEE economies towards EU-15 – the most developed economies of the European Union. The research will first inquire about convergence within the groups of the CEE countries and EU-15 separately. A closer focus will also be taken on the transition paths of selected economies to observe how their growth paths evolved over time. There are two novelties that distinguish this study from previous ones. The first one is an innovative framework of convergence testing proposed by Phillips & Sul (2007b). Their approach allows for heterogeneity in technological progress across countries, which enables scientists to build a more realistic model of economic growth. As this method is relatively new, it has not been applied to testing convergence among European Union countries yet. This of course strengthens curiosity for the results. The other issue is the time span of the study. The peak period for testing convergence across EU countries was around 1995 – 2000, so most of the studies relied on historical data and did not exceed the year 2000. This study will, on the other hand, concentrate on the newest data, including the time span of 1995 – 2013. This is especially

important from the point of view of CEE countries, because this is the first study which captures some of the period that these countries actually "spent" within the European Union.

The structure of the work is as follows. Section 1 presents concepts of convergence with reference to their theoretical background. Then, some flaws in the previous methodology are revealed, and a new measure of convergence involving technological heterogeneity is suggested. Then, the section develops some features and applications of the new measure. Section 2 introduces important phases in convergence research. The evolution of approaches is accompanied by prominent examples of the research on the topic. Greater stress is laid on recent and innovative research methods. Section 3 analyzes the data descriptively. Some justification of the choice of the particular set of countries is provided along with empirical illustrations and statistical analysis. Section 4 concentrates on the data and the research itself. This includes presentation of transition curves and convergence testing. After the explanation of the results some ideas for further research are given. Section 5 concludes.

Section 1 – Theoretical background

1.1 Different measures of convergence

The attitude towards convergence and empirical testing of this notion has been changing in parallel with the evolution of growth theory. The term *convergence* stems from the Solow-Swan model (Solow, 1956; Swan, 1956) and has been further specified by Barro & Sala-i-Martin (1992). In the Solow model, economic growth results from exogenous technological change and capital accumulation. The neoclassical production function ensures decreasing returns to scale and thus entails that the economy converges towards a *steady-state* where income per capita grows at the rate of technological progress. Assuming homogeneous technological change, saving and population growth means that all economies converge towards a single steady-state, even though their initial levels of capital may differ. Mankiw, Romer & Weil (further referred to as MRW), in attempt to make the model more realistic, added human capital to neoclassical production function (1992). They also proved that under such a modification convergence is slower.

For empirical investigation of convergence in neoclassical framework the following concepts were developed. The general concept of *β-convergence* suggests that less developed countries grow faster than those with higher GDP per capita. Argument goes as follows: consider two countries that have a common steady-state and follow a common balanced growth path. The country that starts with a relatively lower level of initial income per capita has a lower ratio of capital to labour and hence has a higher marginal product of capital. Under given investment rate, poorer countries grow relatively faster than richer ones (Durlauf, Johnson & Temple, 2004). *Unconditional β-convergence (absolute convergence)* occurs when no further assumptions are needed. However, most often we deal with *conditional β-convergence*. This means that the poorer country will indeed grow faster than the rich one, but only if they approach the same steady-state and the other conditions in both countries are the same *(ceteris paribus)*. Scientists also distinguish *σ-convergence*, which is commonly called *income convergence*. This type occurs when inequalities in incomes between countries decrease over time. It can be measured by the dispersion measures (variance or standard deviation) of the same variable as *β-convergence* – GDP per capita. *β-convergence* is a necessary but not sufficient condition for the existence of *σ-convergence* (Solow, 1956;

MRW, 1992; Barro & Sala-i-Martin, 1992; Barro & Sala-i-Martin, 2004; Matkowski & Próchniak, 2004).

Alongside with the development of New Growth theory (or endogenous growth theory), attitudes towards convergence and empirical testing have changed. New Growth theorists argued that growth is not a result of an exogenous technological change, but stems from nonconvexities in production function (which may in turn imply that the production function does not have diminishing returns to scale) (Bernard & Durlauf, 1996; Durlauf & Quah, 1999). In endogenous growth theory, factors such as human capital, knowledge and innovation are important determinants of growth. New Growth also investigates positive externalities and spill-over effects of investment in human capital. The family of endogenous growth models is largely varied and has been extended in different directions, e.g. an addition of R&D sector (see Aghion & Howitt 1992; Grossman & Helpman, 1991, cited in Phillips & Sul 2007b), market imperfections etc. For testing endogenous growth models a variety of methods were used e.g. time-series, graphical analysis and various statistical tools (see e.g. Durlauf et al. 2004), but there is no standard approach as endogenous growth models do not always predict convergence.

1.2 Inadequacy of previous measures

As mentioned in the previous section, most of the models assumed homogeneous technology across countries. This is a convenient but rather unrealistic assumption. With the development of growth theory and advancement of econometric tools, scientists have tried to relax this assumption. An important milestone was the application of panel data methods to growth, as it gives an opportunity to model heterogeneity (Phillips & Sul, 2007b). However, these contributions have raised some doubts concerning not only modelling heterogeneity within the previous frameworks, but also these frameworks in general. This and the following subsections provide some theoretical evidence and empirical implications of different ways of testing convergence. Direct examples of research by means of these methods are presented in a literature review in the second chapter.

Bernard & Durlauf (1996) showed that different approaches in empirical testing of convergence make different assumptions about data and thus may produce diverse results. Authors distinguished two main notions in convergence testing. The first one involves cross-country growth regressions, the other is based on time-series approach. These frameworks

rely on different definitions of convergence, which make such studies hardly comparable. Cross-section studies follow the definition of *β-convergence* and examine the relationship between initial income levels and growth rates. A negative relationship between these variables implies that there is convergence between countries and that economies with lower per capita income will grow faster.

On the other hand, the time-series approach concentrates on income differences across countries in the long run. In this approach, if a forecast on difference in incomes between a pair of any two countries converges asymptotically to zero, this means that these differences are transitory and this is interpreted as a proof of convergence. To test whether convergence exists one has to apply time-series methods. Bernard & Durlauf assert that *"convergence, according to this approach, has the strong implication that output differences between two economies cannot contain unit roots or time trends and the weak implication that output levels in two economies must be cointegrated"*[1] (1996).

As mentioned before, both methods have often given contradictory results. Cross-section tests usually reject the null hypothesis of no convergence (e.g. Baumol, 1986; Barro & Sala-i-Martin 1992), whereas time-series methods tend to support the null hypothesis (e.g. Bernard & Durlauf, 1995). These disparities stem from different features of tests and data. For example, for the cross-section test to perform well, it is expected that countries in the sample are far from steady-state (in transition). On the other hand, the time-series approach presumes that countries are close to steady-state and their initial conditions do not have any statistically significant effect on output differences. Moreover, cross-country tests can reject the no-convergence null even if countries are converging to different steady states or if some of them converge to a common steady state and others do not. Therefore, this method cannot identify convergence clubs or even distinguish which countries are not converging at all. Finally, it has been shown that if these two approaches were applied to the same dataset, outcomes would be inconsistent. This is because of the fact that cross-section testing requires that first difference of cross-country income differences have a nonzero mean, whereas time-series must possess a zero mean (for the complete proof see Bernard & Durlauf, 1996).

[1] It is worth to point out that this is not always the case. Phillips & Sul (2007b) remind that *"the two hypotheses of cointegration and convergence are related but have distinct features (...). Even though there may be no empirical support for cointegration between two series X_{it} and X_{jt}, it does not mean there is an absence of comovement or convergence between X_{it} and X_{jt}. (...) and standard cointegration tests [may] have low power to detect the asymptotic comovement."*

Phillips & Sul (2007a) further show how these and other methods are not suitable for modelling heterogeneity in technological progress. One of the popular methods in investigating convergence and also growth determinants are so-called augmented Solow regressions (abbr. *ASR* or *augmented cross-section regressions*). These regressions are the extensions of normal cross-section regression: they include variables of augmented Solow model (initial income, physical capital investment rate, human capital investment rate and population growth rate) and other control variables. The set of control variables differs from study to study and there are around hundred variables that are frequently used. Phillips & Sul (2007a) provide a comparison between common formulations of ASR under different assumptions (i.e. introducing heterogeneity in some determinants of growth). They prove that the ASR regressions are not suitable for testing convergence when technology is heterogeneous across countries and over time as in this case the regressions are misspecified. This is because of an omission of some control variables which are proxies of technological progress, which in turn results in endogeneity of error term.

1.3. Turn towards modelling heterogeneity

To overcome the technical difficulties in modelling convergence, Phillips & Sul (2007b) proposed a new framework based on a time varying factor model. The idea behind this is to introduce a time varying idiosyncratic element. Namely, authors start with the modification of the general form of single factor model given as:

$$Y_{it} = b_i \mu_t + \varepsilon_{it}$$

where b_i is the measure of idiosyncratic distance between a common factor μ_t and a systematic part of Y_{it}. μ_t may be for example a common technology available for countries. However, countries' shares in it will be different depending on economies' features, e.g. developed countries who create the technology may utilize most of it whereas developing countries who catch up may utilize previous technology first or may try to develop infrastructure to fully participate in pooled technology (Phillips & Sul, 2009). This model includes two components to account for idiosyncratic differences: b_i and ε_{it}. The first one reveals country characteristic features and the second one is an error.

Authors modify this model into a time varying factor model. They allow for a systematic idiosyncratic component to change over time i.e. b_i is substituted with b_{it}. This

enables them to include heterogeneous technology across countries and permit for its changes over time. They also include a random element in b_{it} which already contains ε_{it} and thus permits for a convergence behaviour in b_{it} over time with regard to the common factor μ_t. The new model looks as follows:

$$Y_{it} = b_{it}\mu_t$$

Furthermore, this setup is applied to represent convergence.[2] Income per capita in logarithmic form is denoted as

$$logy_{it} = b_{it}\mu_t$$

In this specification b_{it} is a measure of economy's i share in the common trend μ_t. Technology accumulation A_{it} for country i is decomposed as

$$logA_{it} = logA_{i0} + x_{it}t$$

where A_{i0} is an initial state of technology and x_{it} is a rate of technological progress that can vary over time. Following standard neoclassical specification of growth model and including heterogeneous technology, income per capita can be expressed as

$$logy_{it} = a_{it} + x_{it}t$$

where

$$a_{it} = log\widetilde{y^*}_i + [log\tilde{y}_{i0} - log\widetilde{y^*}_i]e^{-\beta_{it}t} + logA_{i0}{}^3$$

and β_{it} is a parameter measuring the speed of convergence.

Considering the above and assuming a trend of common technology in the form of $\mu_t = \xi t$, log income per capita can be rewritten as

$$y_{it} = \left(\frac{a_{it}}{\xi t} + \gamma_{it}\right)\xi t = b_{it}\mu_t$$

where

$$\gamma_{it} = \frac{x_{it}}{\xi}$$

[2] The model was fully specified for the first time in Phillips & Sul (2007b). In this study the model will be presented consistently with the notation in Phillips & Sul (2007a) as it seems more intuitive and clear, although the model still remains the same.

[3] A_{i0} was included in specification of a_{it} according to Phillips & Sul (2009).

From this expression it can be inferred that parameter b_{it} depends on parameter β_{it}, which measures the speed of convergence; rate of technological change, initial level of technology and income, and a steady-state setup.

Further, it can be noticed that when $t \rightarrow \infty$, then

$$b_{it} = \frac{a_{it}}{\xi t} + \gamma_{it} = \gamma_{it} + O(t^{-1}) \simeq \gamma_{it}{}^{4}$$

where γ_{it} is a time varying factor and measures the relation between A_{it} – technology of country i and $\mu_t = \xi t$ – common technology.

Considering relative differences in income between countries specified as

$$logy_{it} - logy_{jt} = \left(b_{it} - b_{jt}\right)\mu_t$$

it can be inferred that, in the long run, these disparities can be explained only by technological differences between economy i and j. On the basis of this expression, it is natural to formulate convergence condition as

$$\lim_{t\to\infty} b_{it} = b$$

or

$$\lim_{t\to\infty} \frac{\log y_{it}}{\log y_{jt}} = 1$$

Phillips & Sul call these conditions relative convergence conditions, as upon some specifications of b_{it}, log income differentials can diverge.

1.4 New measure of convergence

Based on their general model, Phillips & Sul (2007a, 2007b, 2009) propose broad applications of their methodology. Their model forms a strong theoretical background for investigating growth issues, convergence, transition process of different economies and even determinants of growth. These methods are presented here, with a focus on those which are used later in this work.

[4] Big O notation or Landau notation – describes behaviour of a function along when arguments are increasing to a certain threshold or infinity (limiting behaviour).

Relative transition

To verify whether there is convergence between countries b_{it} has to be found. One has to know how countries' share in common technology evolve over time to check for convergence condition. However, it is not possible to estimate it because there are more unknown variables than observations in the panel. Therefore, Phillips & Sul suggest another relative measure that allows to approximate this parameter. In the h_{it} measure

$$h_{it} = \frac{\log y_{it}}{\frac{1}{N}\sum_{i=1}^{N} \log y_{it}} = \frac{\log b_{it}}{\frac{1}{N}\sum_{i=1}^{N} \log b_{it}},$$

the common trend μ_t has been removed by scaling. h_{it} was named by authors *relative transition parameter* or *transition path*. This index shows transition process for economy *i* in relation to the cross-section average in period *t* (which is assumed to be different from zero). Graphical representation of these transition paths can reveal convergent, as well as divergent, behaviour over time between countries. It is worth to notice that if $b_{it} \to b$ then $h_{it} \to 1$ for all economies as $t \to \infty$. If relative transition parameter converges towards unity, it means that there is an ultimate growth convergence across countries.

The transition path measure can be further modified to show transition patterns in a particular group with reference to other groups or even single countries. For example, consider a panel, which consists of two sets of countries: OECD (G_1) and MERCOSUR (G_2). For every MERCOSUR country *j,* the relative transition parameter can be calculated, where OECD countries serve as a benchmark.

$$\eta_{jt} = \left[\frac{\log y_{jt}}{\frac{1}{|G_1| + |G_2|}\sum_{i \in G_1 \cup G_2} \log y_{it}} \right]$$

and $j \in G_2$.

Estimating η_{it} for every *t* and plotting it on the graph, will yield relative transition curves for all countries within the group. After taking the cross-sectional average of this indicator, an overall performance of MERCOSUR countries against OECD countries can be observed, i.e.

$$\eta_{G_2,t} = \frac{1}{|G_2|}\sum_{j\in G_2}\left[\frac{\log y_{jt}}{\frac{1}{|G_1|+|G_2|}\sum_{i\in G_1\cup G_2}\log y_{it}}\right]$$

This expression can be modified freely. It depends which countries are of one's interest. Single countries can be compared to groups (then G_2 contains only on component) and groups can be compared to single countries (then is G_1 a singleton).

Convergence testing

The next application of the framework is a regression convergence test called *regression t test* or *log t regression test*.

The general model assumes the following specifications:

$$b_{it} = b_i + \sigma_{it}\zeta_{it}$$

where

$$\sigma_{it} = \frac{\sigma_i}{L(t)t^{\alpha}}$$

with

$$\zeta_{it} \text{ is iid.}$$

Within this maintained model the null and the alternative hypothesis are formulated. The null hypothesis has a semiparametric form, which guarantees that b_{it} converges towards b_i.

H_0: Convergence across all *i* countries $b_i = b$ and $\alpha \geq 0$.[5]

H_1: No convergence for some *i* countries $b_i \neq b$.[6]

To test the null one has to run the following regression

$$\log\left(\frac{H_1}{H_t}\right) - 2logL(t) = a + blogt + u_t$$

where

[5] Where α is a parameter for speed of convergence.
[6] This formulation of an alternative hypothesis includes two cases: either $b_i \neq b$ for some *i* and $\alpha \geq 0$ – which allows for multiple equilibria i.e. club convergence or $\alpha < 0$ – divergence.

$$H_t = \frac{1}{N}\sum_{i=1}^{N}(h_{it} - 1)^2$$

This specification requires that $\hat{b} = 2\hat{\alpha}$ and $L(t)$ is a slowly varying function. Here, following Phillips & Sul (2007b), the setting $L(t) = \log(t + 1)$ will be used, where data for the estimations start at $t = [rT]$ (integer part of rT), and $r = 0.3$ is recommended.

In the context of this estimation, hypotheses are equivalent to

$$H_0: b \geq 0$$

and

$$H_1: b < 0$$

To test the null with weak inequality, a one-sided *t test* can be used. The test is obtained with heteroskedasticity and autocorrelation consistent (HAC) residuals $\hat{u}_t$ from this regression. As it was mentioned before, the null hypothesis indicates only relative convergence. To test for unconditional convergence, the null should be modified into

$$H_0: b \geq 2^7$$

This is only a brief specification of a formal regression test including main steps. Phillips & Sul (2007b) provide the deeper rationale behind the testing procedure and develop asymptotic properties of the test.

Club convergence

Even if the null in the *log t test* is rejected, this does not mean that there is no convergence between economies or, at least, between some of them. Authors remind that there may still be club convergence and propose an algorithm to test for it. Club convergence occurs when there are several groupings within a larger community and they converge to their own steady-states. Procedure consists of several steps and is fully developed in Phillips & Sul (2007b). The main idea is to order the countries according to their income in the last period. Then form a core subgroup – the one that is potentially most cohesive and with a strong convergence between members. Then, countries are added one by one to the group and tested

[7] This corresponds to $\alpha \geq 1$.

whether they also converge towards the group. If not, other subgroups are formed and procedure is repeated.

Determinants of growth

Phillips & Sul (2007a) also provide an alternative to ASR models for investigating growth determinants. One possible application is to examine the relation between speed of learning and technological progress and thus economic growth. To test whether speed of learning is a significant determinant of growth one has to modify relative transition parameter in such a way that it resembles speed of learning indices' evolution. Phillips & Sul discover that indeed speed of learning is a good proxy for technological change and traces growth path in case of many economies.

Section 2 – Literature review

The field of empirical testing of growth models and convergence consists of a variety of studies. Numerous methods have already been applied to test different approaches towards growth issues. In this section some examples on these testing methods will be provided.

The first popular tool for testing *β-convergence* included cross-section regression. One of the first studies in this field were the one carried out by Baumol (1986) and De Long (1988). Baumol examined Maddison's historical data on productivity (1982), investment and income levels over a period of 1870 – 1979. He found a strong convergence pattern among industrialized economies as he observed a strong negative correlation between countries' productivity levels in 1870 and their average productivity growth rate in the following period. Medium income and centrally-planned economies seemed to participate in convergence, but only to a certain extent, whereas no convergence trends existed within remarkably poorer countries. De Long pointed out several flaws in Baumol's study, namely, Maddison's sample suffers from selection bias – 16 countries included are already rich and well developed and there is a measurement error in initial income variable. After accounting for these issues, De Long did not find support for convergence and claimed that if there are any convergent forces they are in fact not much stronger than divergent ones. De Long's study was the first one that seriously undermined the belief in convergence existence and thus directed empirical testing onto endogenous growth models.

The family of augmented Solow regression is an extension of usual cross-country regression. In the basic setup, human capital is added like in the famous Mankiw, Romer & Weil study (MRW, 1992). In this study, authors also used a much bigger sample than in previous studies – 98 countries in total. MRW found strong and significant evidence on convergence, especially among 22 OECD states and found some evidence that the augmented Solow model matches reality more closely and explains convergence patterns better than the original Solow model. Other studies based on ASR include a variety of control variables. These models have the objective to investigate not only convergence, but also other determinants of growth. For example, Barro (1996) investigated the influence of socio-economic and political set of variables on growth. Not only did he confirm the convergence hypothesis, but he also found democracy, rule of law and other policy-related issues as significant determinants of growth. The related studies of Sala-i-Martin (1997), Bleaney &

Nishiyama (2002), Levine & Renelt (1992) use a variety of control variables. They include most often indices on: education attainment, inequality, health, government spending, politics, trade & country openness, exchange rates, inflation, prices etc. (for a complete review of variables and examples of studies see: Durlauf & Quah, 1999; Sala-i-Martin, 1997). Several reviews like Durlauf, Johnson & Temple (2004), find that around 100 – 150 are frequently used (not to mention interactions between them and non-linear forms) and give significant results. One reason for such a big diversity is the question of how to proxy a particular variable from a theoretical model e.g. schooling/human capital can be measured by total years of schooling, average years of schooling, separately between males and females, primary/secondary education attainment etc. Sala-i-Martin, Doppelhofer & Miller (2003) have tried to restrict the set of variables by an Bayesian Averaging of Classical Estimates (BACE). Within an investigated set of 67 explanatory variables they found 18 to be robust and significant in explaining long-term growth. They found the strongest evidence for the relative price of investment, primary school enrolment and the initial level of real GDP per capita as major growth determinants.

It is also worth to point out that some studies based on cross-country regression focused on investigating convergence and growth in light of economic integration. Such studies tried to assess whether economic integration enhances growth and is convergence stimulating. Matkowski & Próchniak (2000, 2004), Crespo et al. (2008) test for convergence among EU countries and use different measures for EU participation e.g. dummy variable (1 – when economy is a member of the EU, 0 – otherwise) or years in the EU. Jones tests for convergence in ECOWAS (2002); Griffith et al. (2000) test for convergence in OECD countries. In majority of studies there is a positive impact of economic integration on growth and convergence.

Most of the studies mentioned above study also patterns of *σ-convergence*. This is usually done by an observation of real GDP per capita dispersion or formal tests. For example, Crespo et al. (2008) use a test proposed by Carree and Klomp (1997). This is a T_2 test statistic with $\chi^2(1)$ distribution if null hypothesis of no convergence is true. Matkowski & Próchniak (2004) test also for cyclical convergence to check for the synchronisation of business cycles within CEE economies. This is done through an analysis of industrial production growth rates. Where there is correlation of these rates between pairs of countries, they conclude that cyclical convergence exists. Majority of studies investigating *σ-convergence* confirm the presence of convergent forces.

Although economic environment was aware that technological progress rates or even production functions between countries may differ, little effort was actually done in order to model these differences more closely. Including heterogeneity in technological levels was possible for the first time thanks to panel data methods, and they are considered a "milestone" in the evolution of econometric tools. Islam (1995) used dynamic panel data model and various estimators to study convergence. On three large samples (NONOIL, INTER, OECD), similar to the ones that were used by MRW (1992), Islam conducted pooled OLS estimation, Minimum Distance estimation with correlated effects and LSDV estimation with fixed effects. He found that rates of convergence from panel estimations are much higher than in cross-section results. He also noticed that rates of technological change and initial levels of technology differ substantially across countries and account for the fact that panel data methods give outcomes different from cross-section regressions. Lee et al. (1997) proposed a stochastic version of Solow growth model. They performed fixed effects estimation on a panel of 102 non-oil countries derived from PWT with a time span of 1960-1989. Their results are consistent with Islam (1995) – rates of technological progress largely differ across countries, and when these disparities are introduced into the model, this gives much higher estimates of *β-convergence* (30% per year instead of 2% per year). However, authors argued that these estimates cannot be interpreted directly as in previous studies because of the fact that relaxing assumption of homogeneity poses a large bias on β parameter. On the contrary, they showed that *"In the context of a stochastic model (...) this growth heterogeneity will be the major determinant of the cross-country output dispersion. Our estimates indicate that growth of technology has been higher in OECD countries with a smaller dispersion as compared to the world as a whole. In consequence, global dispersion is increasing: countries are diverging, not converging."* Barossi-Filho et al. (2005) also employed dynamic panel data approach and analysed data gathered by Heston & Summers (1991, cited in Barossi-Filho et al.). Firstly, they conducted preparatory times-series analysis (unit root tests for time-series of each country) and panel analysis (panel unit root tests, panel cointegration tests). As time series turned out to be *I(1)* (integrated of order one) for most countries and panel data turned out to be non-stationary as well, Solow growth model was estimated under error-correction model (ECM). They computed that economies, on the average, converge at the rate of 7.42%. Moral-Benito (2008) applied Bayesian Averaging of Maximum Likelihood Estimates (BAMLE) (which is similar to BACE approach) to a panel data to identify determinants of growth and test for convergence. He obtained 0.6% conditional convergence rate and discovered that there are many economic, institutional, geographic and demographic factors

that influence growth (of which the price of investment, distance to big cities and political rights are most significant). Author also claimed, consistently with previous studies, that country-specific effects are essential to study growth determinants, because they reveal some growth factors that cannot be identified in cross-section regressions.

Another alternative for cross-country regressions are time-series methods. Bernard & Durlauf (1995) argued that cross-section regressions may give ambiguous and misleading results. They contributed largely to developing time-series methods for the investigation of convergence. They proposed new definitions for convergence (pairwise convergence and overall convergence) – convergence exists if the long run forecast on output differences tends to zero at a fixed time horizon. In empirical testing, this implies that outputs of two countries are cointegrated (presence of unit root in cross-pair differences is rejection of convergence). In a first step, authors tested for convergence within pairs of countries, and then overall convergence (this is equivalent to the situation when convergence exists in all possible combinations of two countries). Authors did not identify substantial evidence on convergence across countries, so they tested on the existence of common trends affecting output. They discovered that *"there is a set of common long-run factor which jointly determines international output growth among (...) OECD economies."* Greasley & Oxley (1997) applied a similar procedure to test for pairwise convergence in particular OECD countries. They performed pairwise unit root tests and identified *"bivariate convergence between: France and Italy; Belgium and The Netherlands; Australia and the United Kingdom; and Sweden and Denmark."* Pesaran (2004) proposed a new procedure for pairwise convergence testing. For the income gap between each pair of countries he performed pairwise unit root tests by means of three econometric tools: augmented Dickey-Fuller test (ADF) and its modifications ADF-GLS by Eliot et al. (1996, cited in Pesaran, 2004) and ADF-WS by Park & Fuller (1995, cited in Pesaran, 2004). The time series in their study consist of PPP adjusted real GDP per capita from PWT including different set of countries over different time spans. Pesaran found very little evidence on overall convergence and some ambiguous indications on club convergence. Results were robust with respect to different choices of countries groups and time spans. Erlat (2007) took similar approach to test for convergence among MENA countries using ADF and KPSS tests. Tests identified several converging pairs, but the results were not robust with respect to different periods and base years.

The latest trends in convergence testing concentrate on applying heterogeneity to data and clustering analysis. The following studies apply innovative methods to study convergence

and growth determinants proposed by Phillips & Sul. Here, some examples using this methodology will be presented. The examples are derived mainly from studies by the authors as the method is not yet widely known. One of the first studies where heterogeneity was applied was a study investigating the convergence in costs of living in 19 US metropolitan cities (2007b). Authors proxied the cost of living by a modified CPI index and plotted relative transition parameters for largest metropolitan cities over the period of 1960 – 2000. Observation of transition curves and results from *log t test* indicated that there is no overall convergence across US metropolitan cities. Therefore, clustering analysis was employed. It revealed that there exist three convergence clubs (high cost, medium cost and low cost of living) and there was some convergence between them until 1982, but since then they exhibit divergent behaviour. In the other study (Phillips & Sul, 2009) a variety of examples was provided. Authors applied the testing procedures towards 18 OECD countries, 48 US states and 88 countries for which data were taken from Penn World Tables (PWT). For US states they investigated separately state transition patterns as well as regional transition patterns and observed an overall convergence. OECD countries exhibited some divergent behaviour in the past but since 1950 a majority of them seem to be converging. As to 88 PWT countries, the results were not so clear. Authors observed that these economies are largely varied and if they present some convergent behaviour, they are in different phases of convergence. According to the expectations, *log t test* confirmed convergence for OECD economies and US states, however rejected it for PWT 88. Therefore, clustering analysis was applied to the latter. They found that there is convergent behaviour in separate subgroups and that subgroups tend to catch up to the upper one (respectively). Finally, in a third study, Phillips & Sul (2007a) study determinants of growth, namely whether the speed of learning reflects growth patterns by influencing technological progress of countries. It turned out that for India, the Asian Dragons and the NIEs speed of learning traces technological change, and thus, transition paths, well. In some cases, this implies that poor countries grow faster than rich ones, because their learning capacity and speed is higher. For these countries convergent behaviour was observed. On the other hand, authors found an evidence that for regions such as Sub-Saharan Africa and Latin America and Caribbean the opposite is true. Speed of learning is decreasing and technological process is slowing down. Borsi & Metiu (2013) employed partially the Phillips & Sul framework to investigate the evolution of convergence in the EU. They looked at real income per capita for 27 EU economies between 1970 and 2010. They did not identify any overall real income per capita convergence, however, they discovered some clubs that converge to separate steady-states. These clubs were identified by means of clustering analysis proposed

by Phillips & Sul (2007b). One of their less comforting findings is the fact that *"empirical evidence suggests a clear separation between the new and old EU member states in the long run."*

Least, but not last one should be aware that modelling heterogeneity has been popular also in different economic and financial aspects. For example Fama & French (1996, cited in Phillips & Sul, 2007b), Glabadanidis (2008) used time varying factor to model return on stocks. They noticed that there are some common factors that influence asset prices and included time varying factors parameters that reflected the strength of factor's influence on return on stock.

This concise literature review revealed that a large variety of empirical methods has been employed to test for various growth issues, inter alia convergence and growth determinants. Various methods tended to give ambiguous and even contradictory results. From the optimistic belief in ubiquitous convergence and first cross-section regressions growth empirics have gone a long way. Growth research went through less optimistic and more realistic results from panel data methods to the time-series approach where convergence was usually rejected and finally reached advanced, comprehensive and unconventional methods for investigating convergence. The newest approaches concentrate on proper definition of convergence and emphasize the importance of correct econometric specification of the model. One can expect that there is still much to be improved in growth research and another fresh concept on growth testing will be developed. The next sections will develop on data, sample selection and econometric research itself, and the outcome of this study will be interpreted in light of the results of studies described above.

Section 3 – Descriptive analysis

Opinions on whether the European Union is a homogenous community are varied. Member countries share the common history to a certain extent, but still, some visible differences remain. These dissimilarities stem from a heterogeneous historical, cultural and economic background. Referring to these features, experts on the European Union propose different classifications of EU member countries. Some identify large building blocks, whereas others point at a large dispersion of economies. One straightforward way to classify the countries of the European community is to divide them according to the phases of integration and the time of accession. On the basis of this division two vast groups of countries: CEE countries and the EU-15 countries, will be described. Table in Appendix 1 gives an overview of the history of integration within Europe after the Second World War. Table in Appendix 2 includes a list of countries considered in the research with the years of their accession.

3.1 CEE economies

The term Central Eastern European (CEE) countries refers to Baltic and/or Slavic countries in the Central Europe: the Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovenia and Slovakia. The languages spoken in these countries are either Slavic (the Czech Republic, Slovakia, Slovenia, Poland), Baltic (Lithuania, Latvia) or from Uralic family (Estonia, Hungary) (Ruhlen, 1991). These countries share a similar cultural and historical background, which is partially overlapping with the language distribution. This section will further develop on several facts and common characteristics of CEE countries to justify that they can be considered as a fairly homogeneous group.

To begin with geographical location, Poland, Lithuania, Latvia and Estonia all have access to the Baltic Sea. This specific location has influenced the development of Baltic countries since ancient times both economically and culturally. Furthermore, Poland and Lithuania used to constitute a single country – Polish-Lithuanian Commonwealth (called also the Kingdom of Poland and the Grand Duchy of Lithuania) – for over two hundred years. This period is often referred to as Polish Golden Age as this dualistic state reached a peak of military, political and economic power within Europe. Slovakia and the Czech Republic constituted a single state – Czechoslovakia between 1918 – 1992 and their development was

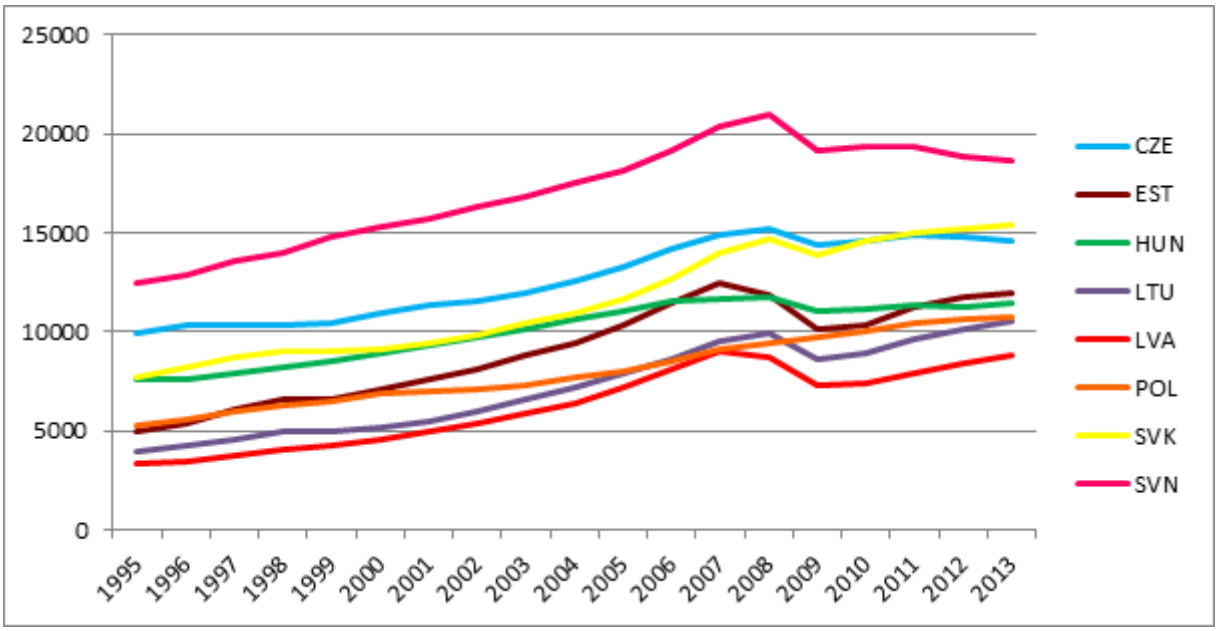
bound together for over 70 years. Nevertheless, it is worth to mention that the Czech part was developing better than the Slovak part and the majority of industry was located there. The relations between Poland and Hungary are often pointed out as a perfect example of a long-lasting friendship. These countries have shown much respect and support for each other and remain in friendly relations since the Middle Ages (Crampton, 2002).

However, the distinction of CEE countries is more pronounced by their most recent history and the implications of WWII. CEE countries were, at that time, referred to as the Eastern Bloc countries. All these states are post-communist countries and still bear the historical burden. They were either a part of Soviet Union (Lithuania, Latvia and Estonia)[8] or were strongly influenced by it[9]. CEE countries were all centrally planned economies and the political system was based on communist ideology: dictatorship of the proletariat and social equality. They were almost entirely controlled by communist or socialist party (e.g. in Poland – *engl.* Polish United Workers' Party, *pol.* Polska Zjednoczona Partia Robotnicza, PZPR). The political dependence on Soviet Union implied that countries own economic policy was largely restricted, not to mention foreign policy.

Although the economic conditions in CEE countries were not entirely the same, these economies started developing at the same point in time. In 1991, after the severance of the USSR, for the first time these economies gained access to the free market. Because of that "common start", nowadays, these countries are on a comparable level of economic development. In 1991, Slovenia seemed the most developed country. One can also identify some "clubs" or pairs of countries that seem to develop in the similar way: Latvia, Lithuania and Estonia – a group of Baltic countries, Slovakia and The Czech Republic, Poland and Hungary. These patterns are also evident in the distribution of GDP per capita of these countries (Fig. 1).

[8] These three countries were Soviet Socialist Republics. The other countries were considered "Satellite countries" – countries dependent on USSR.
[9] Slovenia was at that time a part of Yugoslavia – Socialist Federal Republic of Yugoslavia (SFR Yugoslavia).

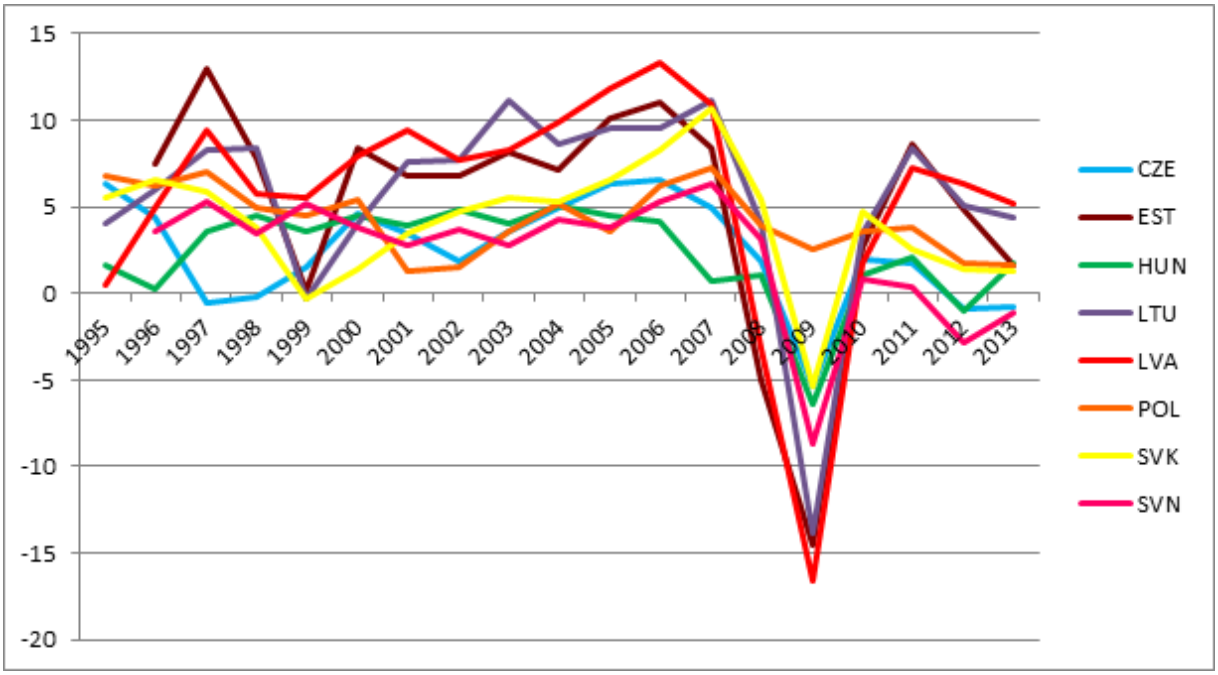
Fig. 1. GDP per capita in CEE countries [in constant 2005 U.S. dollars], years 1995 – 2013.



Source: Own elaboration based on WDI data.

Excluding Slovenia, the level of GDP per capita in 1995 has been in the range of 3 000 – 10 000 €, which reveals a substantial dispersion. In 2013, the range evolved into 9 000 – 15 000 €. Even if the gap between countries has not decreased that much, one can certainly observe that countries grew at a similar pace.

Fig. 2. GDP per capita growth in CEE countries [in percent], years 1995 – 2013.



Note: Data for Estonia and Slovenia start from 1996.
Source: Own elaboration based on WDI data.

As to growth rates of GDP per capita (Fig. 2), the situation is not so clear. What is striking, most of the growth rates before financial crisis were positive and of larger magnitude than those in the well-established European economies (compare with Fig. 4). CEE countries were also less influenced by the financial crisis than the Western economies. Poland was the only one that retained a positive growth rate of GDP throughout the crisis and thus earned herself a title of "green island". One explanation is that a substantial part of these countries have not joined the Euro area at that time[10], and thus could react more effectively to the crisis by adjusting their monetary policy. Nevertheless, it is apparent that the Baltic countries, which had been developing at the fastest rate, experienced the largest drop in GDP per capita growth during crisis. It is a common feature of newly developing economies that their growth is often fragile.

Last but not least, CEE economies joined the European Union at the same time[11], during the biggest enlargement, which took place in 2004. This gave the new member states equal starting conditions. Of course, the process of accession to the EU is lengthy and includes many steps, so the co-operation between a candidate state and the EU authorities starts long before the actual joining of the EU. In most cases, membership is granted 8-10 years after legal application to the EU and negotiations. Not to mention that merely for the application several criteria have to be fulfilled and usually accession agreement is signed (Europa.eu, accessed 19.04.2015). So the actual co-operation between CEE economies and the EU began around 1995-1996.

Another common feature is the fact that, for a long time, the majority of CEE countries retained their currencies. One reason for delaying the adoption of the common currency is that the convergence criteria were not fulfilled.[12] Other explanations include the lack of cyclical correlation with business cycles of the Western economies. Matkowski & Próchniak (2004) show that CEE countries reveal fairly well cyclical convergence among themselves: *"The best conformity is found between the neighbour countries, with close economic ties. This concerns, quite naturally, the Czech Republic and the Slovak Republic (...). Much of the same applies to the Baltic states (...). Poland and Hungary, although weakly or negatively correlated with the other CEE countries, are quite well correlated between*

[10] Slovenia joined the Euro area in 2007, Slovakia in 2009.
[11] Together with Cyprus and Malta.
[12] Convergence criteria were designed in 1992 by the Maastricht Treaty on European Union. These include: price stability, government finances, long term interest rates, exchange rates – ERM II. Criteria have to be fulfilled for two years before accession to the Eurozone (Europa.eu, accessed 19.04.2015).

themselves." As to the correlation with the Euro area, only Poland, Hungary and Slovenia reveal clear cyclical convergence.

On the whole, experts on the EU underline the fact that CEE countries have made a great progress in achieving political stabilization, introducing democratic order and conforming to free market. However, there are still several considerations about differences between CEE countries and "the Old European Union" concerning institutional and economic discrepancies (GDP of CEE countries is still on the level of around 40% of the EU-15 countries). There are still some discrepancies prevailing in other aspects such as democracy, political culture, educational system, standard of living and welfare. Some economists even fear that extension of the European Union may have led to the lack of cohesion and loss of global competitiveness of the EU (Zielonka, 2006).

3.2 EU-15 economies

The EU-15, namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, are often referred to as "the Old European Union". This is because of the fact that they were first fifteen members of the European Union. The last countries belonging to this group joined the EU in 1995 and then a substantial time gap in extending the European Community occurred. Therefore, it is thought that these countries had a sufficient amount of time to synchronize their economies and adapt to the EU regulations. These features have led many economists to the conclusion that EU-15 is quite a homogenous group and thus, is suitable to serve as a benchmark for the newly joined economies. Since then, EU-15 has been used as a reference point in many studies, not only in the field of growth. It is true, that among EU-15 we have six founder countries (see Appendix 2) and that majority of EU-15 countries participated actively in the most important events in the history of the European Union (see Appendix 1). This subsection will provide some evidence in favour of EU-15 homogeneity and suitability to serve as a benchmark in this study. However, one should be aware, that the unity of EU-15 is recently highly debatable, which will be mentioned later.

To begin with cultural and ethnical background, the most widespread groups are those of Germanic and Romance languages. The exceptions are Greek and Finnish, which come from different language families (Ruhlen, 1991). However, cultural divisions are much more dispersed than mere language distribution. Different criteria can be applied to distinguish

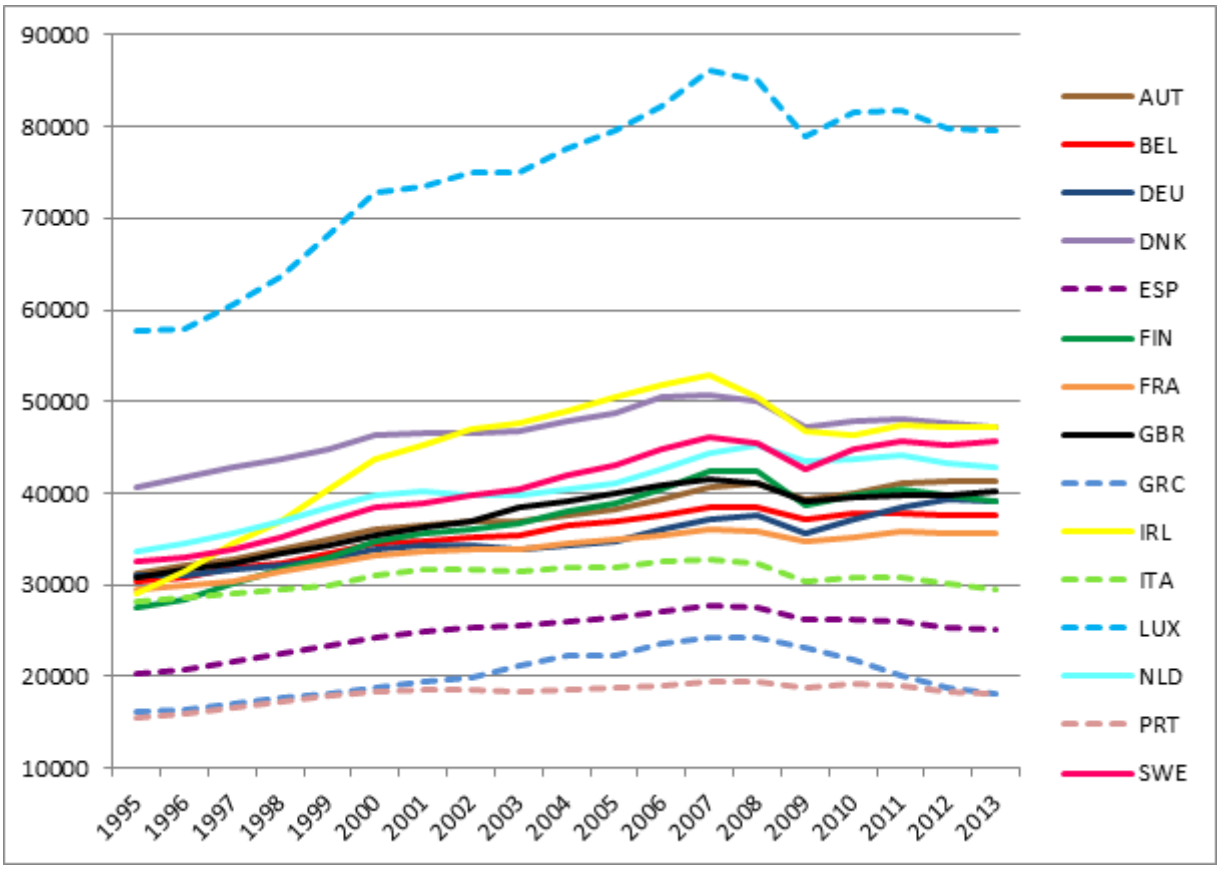
subgroups and clubs within EU-15. Here, the most apparent and intuitive ones will be presented. Great Britain is naturally linked with Ireland. This is determined by their geographical location and a common language.[13] Belgium, Netherlands and Luxembourg are often called Benelux countries and have been connected by political and economic ties long before the formation of the EU (see for example, customs union formation in Appendix 1). Denmark, Finland and Sweden belong to Scandinavian Countries and have been linked with each other and remaining Scandinavian countries throughout the history. All these countries used to be members of EFTA and are characterised by tight economic partnership. Austria and Germany are often linked together because of the common language and close economic co-operation. Turning more to the concept of economic geography, Germany and France are recently put together as "the core of the European Union" and two major political powers (Webber, 2005). Italy, Spain, Portugal and Greece are often seen as southern nations. Although Greece is, as a matter of fact, a Balkan country, all these countries are located in the Mediterranean region.

Historical context of EU-15 is not so explicit. Although these countries share the common history, they were often on the different sides of conflicts. Differences and political clash trace well back in the history and have culminated in the division during the First and the Second World War (for more details see, e.g. Paxton, 2011). Therefore, for the sake of the argument of unity in this economic research, one should concentrate on the second half of 20th Century and the integration processes within the European Union. From Appendix 1 it can be inferred that the first stages involved integration within smaller groups (e.g. Benelux) and combination of particular economic sectors. Further integration processes followed the model of the economic integration (see e.g. Balassa, 1974, 2013) beginning from customs union, through single market, to economic and monetary union.

Nearly all countries suffered severe losses during WWII, but the condition of Western economies were varied. The process of restoration and stabilization was lengthy and advanced with a different pace depending on the country. Nevertheless, nowadays, all EU-15 economies are referred to as developed countries. One obvious justification for this claim is the distribution of GDP per capita and GDP per capita growth rates.

[13] However, one should be aware that the relationship between Ireland and Great Britain has not always been an unproblematic one.

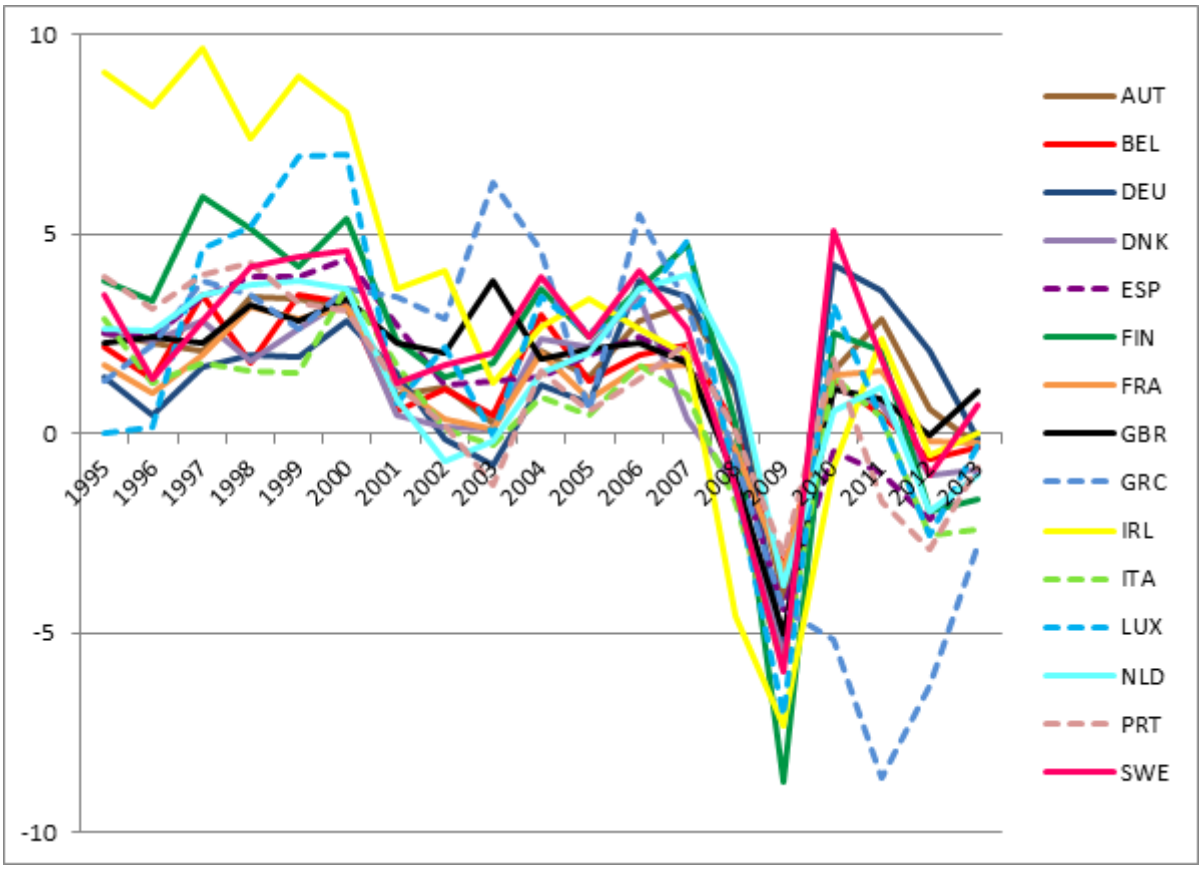
Fig. 3. GDP per capita in EU-15 countries [in constant 2005 U.S. dollars], years 1995 – 2013.



Source: Own elaboration based on WDI data.

The graph (Fig. 3) reveals that GDP per capita was in the range between 15 000 and 40 000 € in 1995 and increased towards roughly 19 000 – 47 000 € in 2013. Firstly, GDP dispersion is thrice as big as among CEE countries. Secondly, unlike in CEE countries, the dispersion has been increasing over time. The next issue is the case of Luxembourg. Its GDP per capita soared from 58 000 € to 80 000 € over this period. In that sense, Luxembourg does not fit with the group of EU-15 – it has much higher GDP per capita (3rd highest in the World ref. The World Bank, 2011) and outstanding growth perspectives. This is because of the fact that Luxembourg's economy is dominated by service sector, mainly financial sector. Luxembourg is one of world financial centres, performs as a host country for many banks and is commonly known as a tax heaven. Inclusion of Luxemburg in EU-15 may have some implications in econometric analysis and cause bias in regression results.

Fig. 4. GDP per capita growth in EU-15 countries [in percent], years 1995 – 2013.



Source: Own elaboration based on WDI data.

Analysis of GDP per capita growth (Fig. 4) also provides some evidence on the level of development of these economies. Growth rates are moderate, mostly ranging from 0 to 5% as opposed to CEE countries, where some rates exceeded 10%. The impact of the financial crisis is clearly visible. The magnitude of response was similar to the CEE economies (excluding Baltic countries). Some countries (Belgium, Netherlands, France) experienced a moderate fall in growth rate, whereas others were more affected (e.g. Luxembourg, Ireland). However, there was no single country in the group of EU-15 that maintained a positive growth rate over the crisis. Another issue is, that EU-15 seem to perform worse after the crisis than the CEE countries. Several years after the crisis most of CEE economies returned to significantly positive growth rates, whereas most of EU-15 economies stayed below the zero bound. As mentioned before, the different reaction to the crisis depended partially on whether a country introduced Euro or not. Of EU-15, only Denmark, Great Britain and Sweden have not introduced the common currency. Participation in the Eurozone entails that monetary policy is coordinated at the European Union level by the European Central Bank. As this rules out the possibility of individual reaction of a particular country, that means that countries

must have correlated business cycles for the system to work well. If they respond to an economic shock in a similar way, the same measure can help to improve the situation in all economies. If not, what helps the majority, may actually aggravate the situation in some economies.

On the whole, there certainly is a justification for the use of EU-15 as a benchmark in research. Nevertheless, it would be dishonest not to mention some limitations of this approach. Recently, there have been some doubts about EU-15 homogeneity. First of all, one can identify several more uniform groupings or country pairs within this set. The other problem is the inclusion of Luxembourg in the set, which may have undesirable implications for the sample and research. Recently, there have also been some serious considerations about divergence among European countries. Since financial crisis, economic conditions in Mediterranean countries such as Spain, Portugal, Italy and Greece seem to deteriorate. The situation has not improved much despite various austerity measures and aid from the ECB. These countries have been experiencing high unemployment rates, difficulties in repaying government debt and some of them have actually gone through sovereign debt crisis. This questioned the sustainability of the Eurozone and raised a debate on the fulfilment of convergence criteria. Not all countries abided by criteria when joining the Eurozone and majority of countries do not comply with them now. The biggest problem involves meeting the criterion of max 60% debt-to-GDP ratio. This criterion was fulfilled only by 4 acceding countries (Luxembourg, Finland, Great Britain and France). The serious example is the case of Greece. When joining the Euro area, Greece fulfilled hardly any of the criteria (Wincenciak, 2012). When the situation in Greece started deteriorating after the crisis (see Fig. 3 & Fig. 4) and it turned out that country's accounting reports were fraudulent, the European Union had to face serious decisions on financial aid to Greece. The situation brought closer considerations about "Grexit" (Greece leaving Euro zone).

Section 4 – Empirical results

Having considered various arguments behind homogeneity of CEE and EU-15 and the eligibility of the latter to serve as a benchmark, this section will concentrate on statistical analysis of the sample, specification of the empirical study and the results.

4.1 Descriptive statistics

The sample consists of observations for eight CEE countries and fifteen EU-15 countries (full list provided in Appendix 2) for the time span of 1995 – 2013. The investigated variable is GDP per capita in constant 2005 U.S. dollars. The data were accessed and extracted from World Development Indicators Database provided by The World Bank. Table 1 includes basic statistical analysis for CEE and EU-15 countries separately and the whole sample.

Table 1. Statistical analysis of the sample.

	CEE	EU-15	Whole sample
Min	3305.73	15434.53	3305.73
Max	20987.04	86127.24	86127.24
Mean	10218.41	37109.23	27755.9
Median	9903.28	35943.82	29844.81
Standard deviation	3914.46	13335.22	16898.22
Kurtosis (4)	2.9584	5.9984	3.8106
Skewness (3)	0.5895	1.368	0.7774
Normal distribution[14]	No	No	No
No. of observations	152	285	437

Source: Own calculations based on WDI.

The results confirm the first conclusions from Fig.1 and Fig.2. Dispersion of GDP per capita among EU-15 countries is larger than across CEE economies. Mean for EU-15 is roughly thrice as big as mean for CEE countries. The data are not normally distributed.

[14] Jarque-Bera test for the normality of distribution based on kurtosis and skewness. At the 5% level of significance, the null hypothesis of normal distribution has been rejected in all cases.

Histograms of GDP per capita variable with frequencies and overlaid normal density curve for CEE and EU-15 are provided respectively in Appendix 3 and 4.

4.2 Hypotheses

To assess whether there is convergence among CEE and EU-15 countries and investigate convergence patterns the following hypotheses were stated (Table 2).

Table 2. Hypotheses.

	Hypothesis
H_1	There is convergence within a group of CEE countries.
H_2	There is convergence within a group of EU-15 countries.
H_3	There is a catch-up of CEE countries towards EU-15 countries.
H_4	There is a catch-up of CEE countries towards "core economies" of the EU-15 (i.e. Germany, France).

These hypotheses will be tested empirically by means of relative transition parameters and convergence *log t test*. Apart from these claims, during the analysis, this study will seek to answer some supplementary research questions:

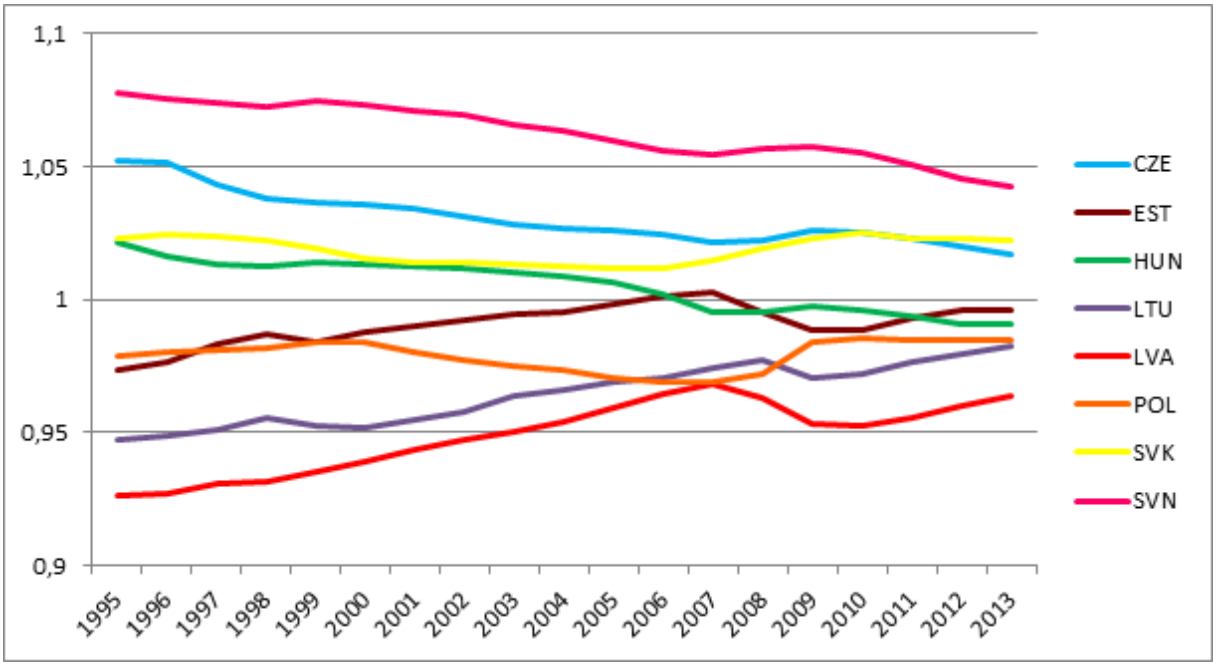
1. What can be inferred from the evolution of transition curves of particular countries?
2. Are there smaller clubs (pairs) of convergence among CEE countries? Does their formation stem from historical/cultural background? Is there economic justification behind this?
3. Are the results different from previous studies?
4. Are the results robust to different specifications of the model?

4.3 Relative transition

The analysis of transition paths reveals trends in behaviour of economies over time. This subsection contains charts with the relative transition parameters specified in Section 1 calculated for various combinations of countries and plotted over time. The observation of transition curves provides first conclusions on whether economies converge or diverge within the group. Since the relative transition parameter compares the output per capita of a

particular economy to the cross-section average, the values of the parameters oscillate around one. If the economies are converging within the group, one should observe their transition curves moving asymptotically towards one. More developed countries within the group may converge "from above" (from high initial state) – their growth rates of GDP per capita are slowing down, whereas less developed countries within the group may converge "from below" (from low initial state), if their growth rates are still above the average.

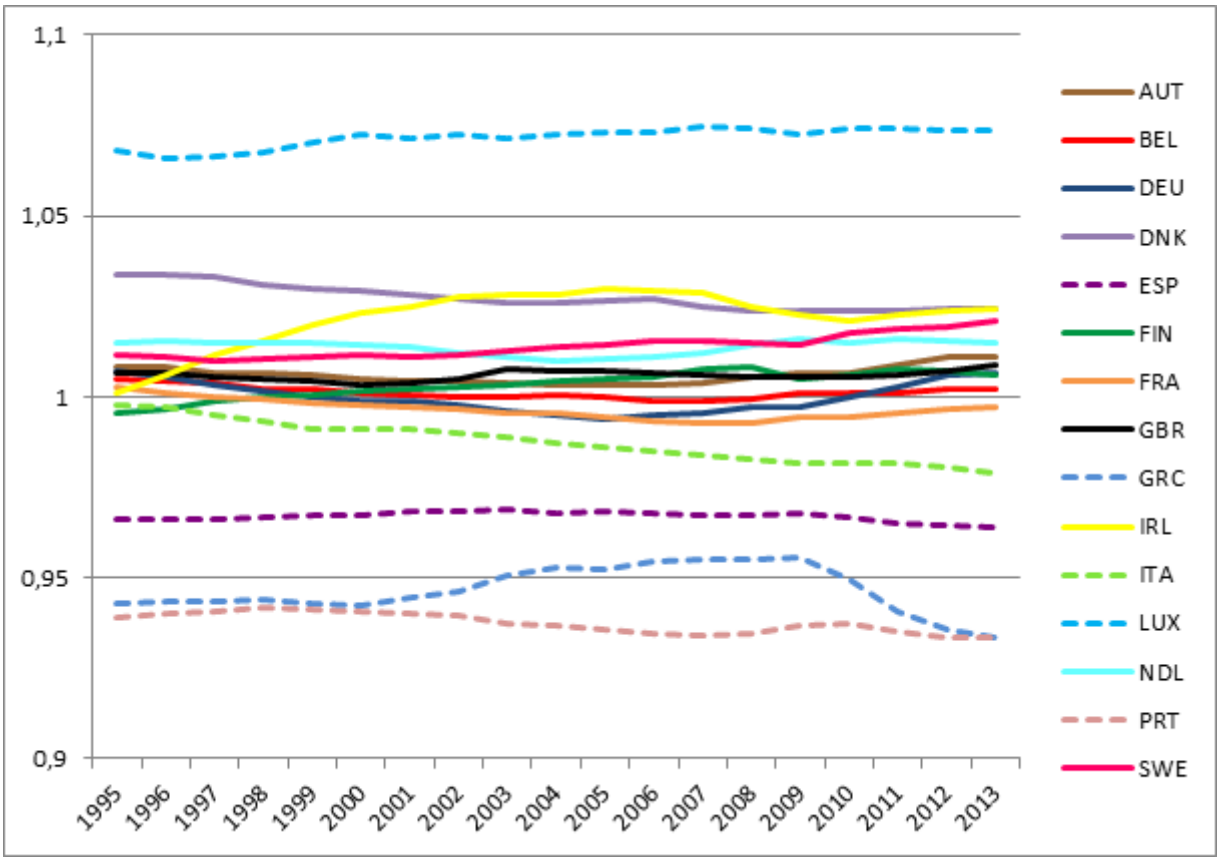
Fig. 5. Relative transition curves for CEE countries – transition within the group.



Source: Own elaboration based on WDI data.

Fig. 5 represents transition curves for CEE countries for convergence within their group. Convergent pattern for the whole group is clearly visible. Slovenia – the richest and the most developed economy, the Czech Republic, Slovakia and Hungary converge from above. It means that their level of development is higher than the average of the group. One can also observe that several transition curves seem more correlated than the others, for example in case of Estonia, Lithuania and Latvia. Thus, these three countries and the country pairs: Slovakia and the Czech Republic, Poland and Hungary seem to be converging to their own steady-states.

Fig. 6. Relative transition curves for EU-15 countries – transition within the group.

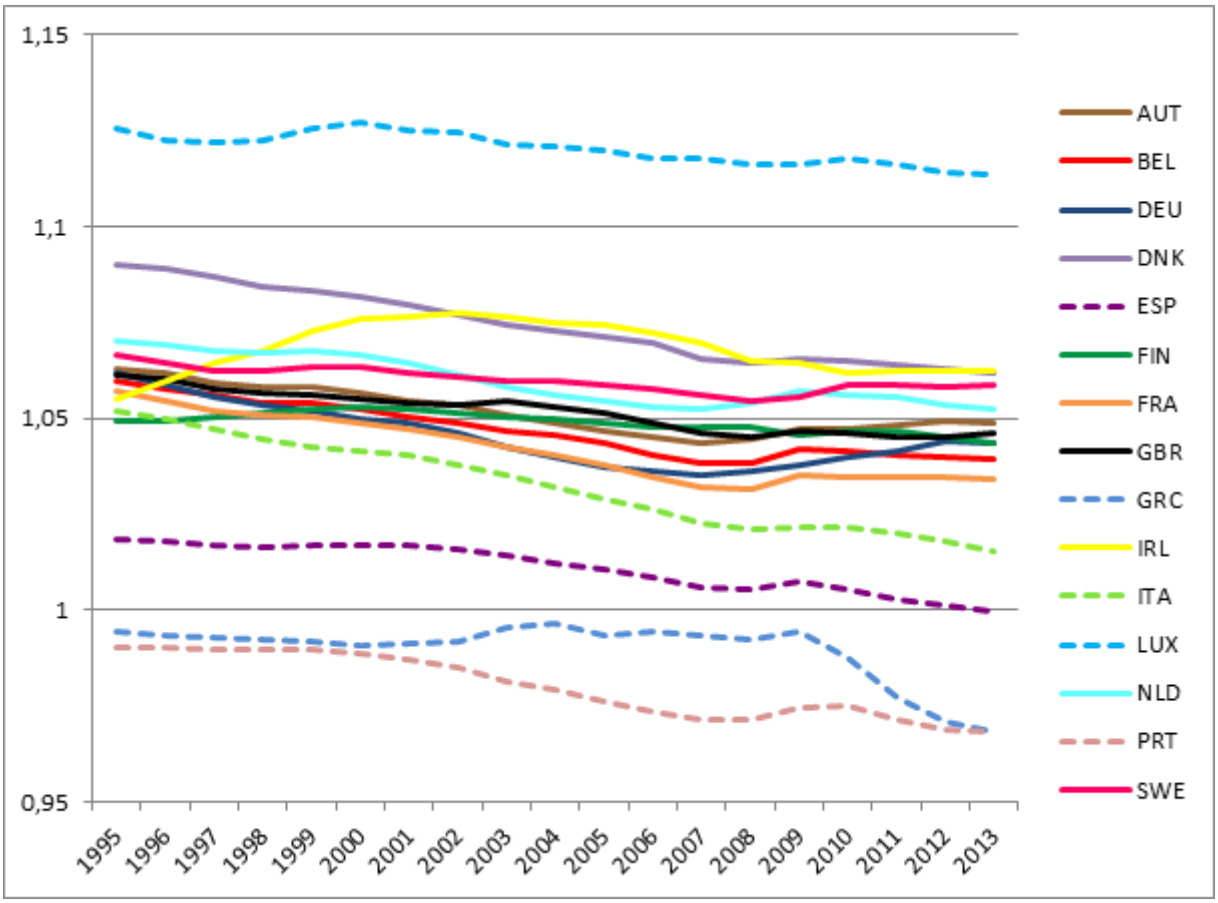


Source: Own elaboration based on WDI data.

Fig. 6 presents transition curves for the EU-15 countries for convergence within the group. In this case, the situation is not so clear. The majority of transition paths concentrates around the range of 1 – 1.03. This could be interpreted as a common steady-state. However, trends for these countries do not seem to change a lot over time. Moreover, the distance between countries from the most uniform subgroup: Sweden, Netherlands, Finland, Austria, Great Britain, Germany, Belgium and France increased slightly. Apart from that, there are some worrisome trends visible. For example, Luxembourg seems to be developing parallel to the mainstream economies of EU-15, but on a higher level – its transition curve is equidistant to those of the other countries. Furthermore, Mediterranean economies: Italy, Spain, Portugal and Greece seem to be diverging completely from the group. These two examples confirm previous concerns about the homogeneity of EU-15. Fig. 7 and 8 show transition curves for all countries, for convergence within the whole sample[15]. Fig. 8 is particularly interesting, because it can reveal whether there is convergence of CEE economies towards EU-15.

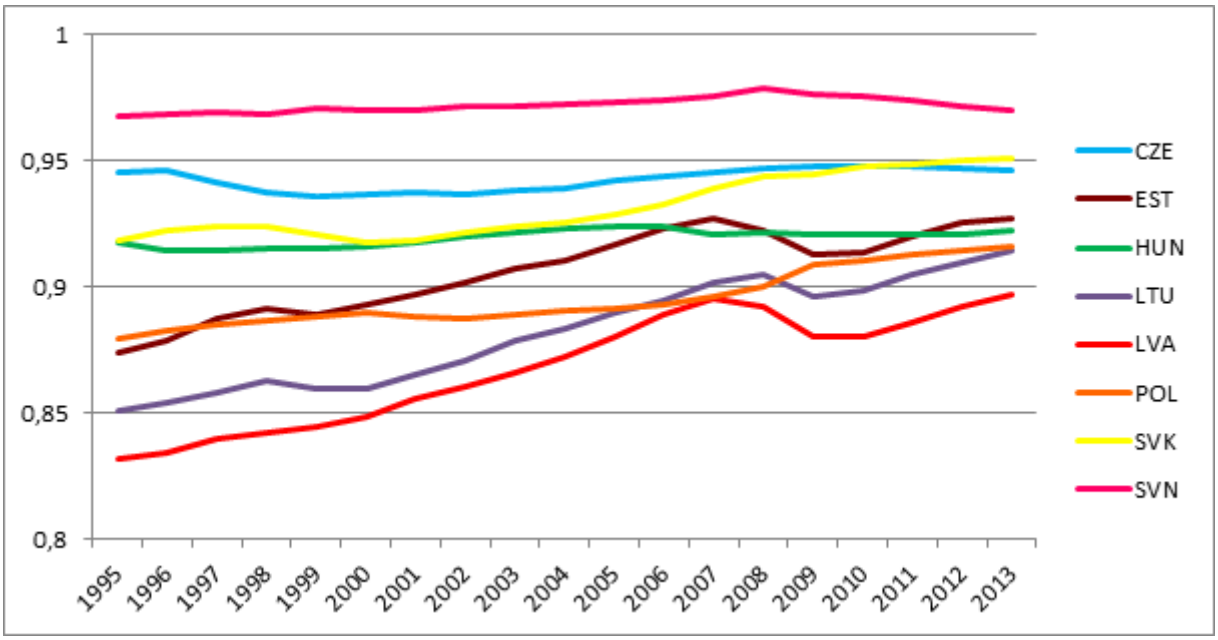
[15] One line-graph has been divided into two independent ones to increase the clarity and separate the CEE and EU-15 economies.

Fig. 7. Relative transition curves for EU-15 countries – transition within the whole sample.



Source: Own elaboration based on WDI data.

Fig. 8. Relative transition curves for CEE countries – transition within the whole sample.

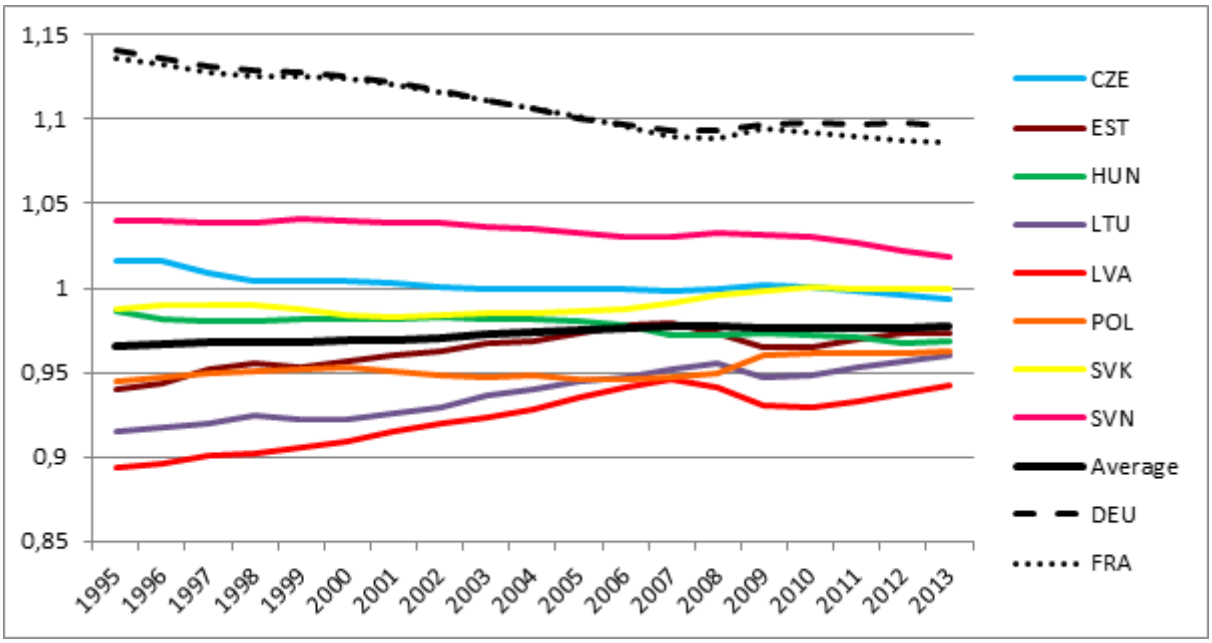


Source: Own elaboration based on WDI data.

There appears to be a weak and ambiguous pattern of overall convergence within the sample (apart from Luxembourg, Greece and Portugal). CEE economies converging from below seem to be moving faster towards the unity than the majority of EU-15 economies. This may be a sign of catching-up of CEE countries towards EU-15. Such interpretation would be consistent with the theoretical predictions and with the data from section 3 – GDP per capita growth rates in EU-15 are slowing down, whereas CEE countries retain high growth rates to catch up. However, seeing this picture as convergence towards two broad steady-states is probably even more reasonable. This is because of the fact that there is still a large gap in wealth and development levels between CEE and EU-15.

An interesting case is also a comparison of CEE economies to Germany and France treated as "the core of the EU". Fig. 9 shows transition paths of CEE countries with relation to Germany and France average.

Fig. 9. Relative transition curves for CEE countries in relation to Germany and France.



Source: Own elaboration based on WDI data.

It is visible that CEE economies move closer towards unity. Even the average for these economies resembles this common trend. Germany and France (whose transition paths seem to be almost perfectly correlated) also appear to be approaching this level. Their transition parameters decreased substantially – from around 1.13 to 1.08. However, a large disparity between CEE economies and "the core of the EU" still remains so the existence of clear

convergence patterns in this case is dubious again and one may still interpret this picture as convergence towards two separate steady-states.

Analysis of transition paths cannot give a precise answer on convergence, nevertheless, it is a useful tool for preliminary analysis and can provide a lot of intuition in the interpretation. A similar procedure can be applied to further subgroups of the sample, especially within the EU-15 group, to investigate divergent patterns. This is, however, beyond the scope of this study.

4.4 Convergence testing

To formally verify hypotheses and assess the results of graphical analysis, econometric convergence tests are applied. Table 3 includes estimated coefficients $\hat{b}$ with Newey-West standard errors, *t*-statistics, and estimates of the speed of convergence parameters $\hat{\alpha}$. Coefficients $\hat{b}$ were obtained from the series of OLS regressions of the form introduced in Section 1:

$$\log\left(\frac{H_1}{H_t}\right) - 2logL(t) = a + blogt + u_t$$

Where $L(t) = \log(t+1)$ and t starts from the observations in the sixth period (because of the rule $t = [0.3 \times 19]$). *t*-statistics were calculated on the basis of Newey-West standard errors[16]. Coefficients $\hat{\alpha}$ were derived from $\hat{b}$ estimates, which are of the form $\hat{b} = 2\hat{\alpha}$. The last column presents the results of the test, based on Phillips & Sul (2007b) rule: the null of convergence is rejected at 5% significance level if $t < -1.65$.

Before the interpretation of the results it is worth to take a closer look at the mechanics of the test and its implications for the results (Phillips & Sul, 2007b). Under the convergence hypothesis (null) several conditions must hold true as $t \rightarrow \infty$ (see Fig. 10).

[16] These are HAC standard errors, precisely, Eicker-Huber-White/"Sandwich" robust variance estimators with an autocorrelation correction added by Newey-West. This allows to obtain consistent estimates for OLS regression in the presence of autocorrelation and heteroskedasticity (Newey & West, 1987; White, 1980 cited in Stata).

Fig. 10. Conditions true under the null hypothesis of convergence.

1. $h_{it} \longrightarrow 1$
2. $H_t \longrightarrow 0$
3. $\log\left(\frac{H_1}{H_t}\right) \longrightarrow \infty$
4. $y \nrightarrow -\infty$, where y stands for whole left-hand side of the equation

The first fact has already been described in Section 1. $h_{it} \rightarrow 1$ as $b_{it} \rightarrow b$ i.e. distance between GDP per capita of a particular economy and a cross-section average is decreasing. H_t, which is a cross-sectional variance of h_{it}, is supposed to be asymptotically converging to zero. This is implied by the design of H_t parameter: if $h_{it} \rightarrow 1$, then $(h_{it} - 1)^2$ are moving closer to zero. The third fact is equivalent to the second one. If convergence occurs, then H_1 should be the largest value and each subsequent H_t should be smaller. Dividing something relatively large by smaller and smaller numbers yields bigger outcomes. Before discussing the last fact, it is worth to notice that in the regression set-up $-2logL(t)$ is negatively correlated with $logt$. These two terms are placed on the opposite sides of the regression equation. Inclusion of these two expressions in *log t test* increases the power of the test by imposing negative bias on $\hat{b}$. It literally "disturbs" in a positive correlation of $\log\left(\frac{H_1}{H_t}\right)$ and $\log(t)$. However, this has much more significant implications for the method. Authors chose logarithmic form, because *L(t)* needed to be a slowly varying function. It is worth noting that the behaviour of the logarithmic function changes with the increase of arguments of the function. Close to 1 the slope of logarithm is much steeper than around 10, not to mention arguments around 1000 or 2000, where derivative is close to 0. The rule, to start estimation from *[rT]*, where r is suggested to be around 0.3, is most likely included to smooth this bias by eliminating the first observations where values of logarithm change rapidly. Nevertheless, the difference will remain, for example between short series (20 observations) with comparison to longer series (50 – 100 observations). The difference is also visible depending on adopted method of counting years in the sample. One can either enumerate subsequent periods of time, beginning from the earliest to the most recent one, or one can just run the estimation with exact numbers of the years e.g. 1960, 1961, etc. From the notation in the model, it is apparent that authors opt for the first method. Nevertheless, it is very interesting to note that, because of the use of logarithmic functions, the results of estimations may be

completely different. In the first method, negative correlation between $-2logL(t)$ and $logt$ is so strong that it may dominate the primary positive correlation between $\log\left(\frac{H_1}{H_t}\right)$ and $\log(t)$. Thus, a situation when facts 1, 2 & 3 are true (data itself reveal some convergence patterns), but 4 is not, is possible. On the other hand, if exact years are used in the estimation, the influence of logarithm on the data is very weak, and the trends are not overshadowed. Then, one can obtain estimates indicating very strong correlation if 1, 2 & 3 are fulfilled. This study will follow the first method to match the framework presented by Phillips & Sul (2007a, 2007b) as closely as possible.

After this discussion, it is possible to infer that, if all the conditions are fulfilled, one should anticipate to obtain a positive coefficient $\hat{b}$. This is consistent with hypotheses mentioned in the first section. If $H_0: b \geq 0$, there is convergence between countries (or $H_0: b \geq 2$ for absolute convergence). If $H_1: b < 0$ is true, then there is no convergence between some economies.

These implications make it possible to interpret the results from Table 3.

Table 3. Coefficients estimates and t-statistics.

	$\hat{b}$ (St. Er.)		t-statistic	$\hat{\alpha}$	Convergence
Full sample	-0.267	(0.022)	-11.95	-0.134	No
EU-15	-0.871	(0.042)	-20.83	-0.436	No
AUT, BEL, FIN, FRA, DEU, NDL, SWE, GBR	-1.250	(0.100)	-12.54	-0.625	No
CEE	0.057	(0.083)	0.68	0.0285	Weak
LTU, LAT, EST	0.051	(0.065)	0.78	0.026	Weak
SVK, CZE	4.746	(1.378)	3.44	2.373	Strong
POL, HUN	2.236	(0.741)	3.02	1.118	Strong
CEE with DEU, FRA	-0.117	(0.034)	-3.47	-0.059	No

Note: Newey-West standard errors are given in parentheses.
Source: Own calculations based on WDI data.

The hypothesis on convergence has been rejected for the whole sample. This result is not very surprising since convergence hypothesis requires all the countries in the sample to converge to a single steady-state. Null hypothesis failed also in the group of EU-15 countries.

This may be because of the fact that this is still a large and, under several aspects, varied group. The test performed for Austria, Belgium, Finland, France, Germany, Netherlands, Sweden and Great Britain is an attempt to narrow the group of EU-15 on the basis of transition paths analysis (see e.g. Fig 6 & 7). However, in this set-up, the null hypothesis also has to be rejected. Since identification of sub-clubs within EU-15 is not within the primary interest of this study, there are no further deliberations on this topic. As to CEE countries, the hypothesis of convergence cannot be rejected, although convergent behaviour is not very strong. Weak convergence is also identified in a club containing Latvia, Lithuania and Estonia. Ultimate convergence is found in two country pairs: Slovakia and Czech Republic ($\hat{\alpha} = 2.373$), Poland and Hungary ($\hat{\alpha} = 1.118$). It is worth to point out that the existence of this club and pairs is consistent with the predictions from Section 3 – countries belonging to the clubs are tied by common historical, cultural and economic background (economic similarities can be confirmed also by an observation of transition curves, see e.g. Fig 5). The hypothesis is though rejected for a group of CEE countries with Germany and France, which negates the hypothesis that there is a catch-up of CEE countries towards these two "core economies".

4.5 A comment on the results

Having considered all the results from transition paths analysis and formal convergence tests the hypotheses were verified (Table 4). In the case of H_3 and H_4, transition curves analysis gave ambiguous results, whereas econometric tests rejected these hypotheses. In case of H_1 and H_2, both tools gave the same result. The formal convergence tests based on regressions were taken as decisive.

Table 4. Hypotheses verification.

	Hypothesis	Evaluation
H_1	There is convergence within a group of CEE countries	Confirmed
H_2	There is convergence within a group of EU-15 countries	Rejected
H_3	There is a catch-up of CEE countries towards EU-15	Rejected
H_4	There is a catch-up of CEE countries towards "core economies" of the EU-15 (i.e. Germany, France)	Rejected

The main conclusion is that the framework proposed by Phillips & Sul (2007b) did not identify convergent behaviour for the whole sample, but confirmed convergence within CEE group and even ultimate convergence within some further subgroups. It is interesting to locate this result among previous results from the field of growth research. Outcomes from this study are far less optimistic than the findings of the cross-section regression and ASR studies, where convergence was often proved for larger and much more varied set of countries. The results are also more ambiguous than the one from studies on economic integration or purely on economic integration within the European Union (e.g. Matkowski & Próchniak, 2000, 2004; Crespo et al., 2008; Griffith et al., 2000). In those studies economic integration had strictly positive influence on convergence and convergence was usually proved for the whole sample (e.g. whole European Union, all OECD economies). The other observation is that many previous studies tested for convergence together with a set of different control variables, whereas this study focuses purely on the existence of convergence. In its scepticism, this method is probably more related to time-series approach, which often did not confirm convergence (see Pesaran, 2004) or searched for pairwise convergence (Greasley & Oxley, 1997).[17]

With relation to previous studies applying method introducing heterogeneity across countries, results are similar. Transition paths for the majority of EU-15 countries resemble transition paths of developed OECD countries in Phillips & Sul (2009) study. EU-15 economies are starting from high initial state and are in the middle or final phase of convergence (with regard to the whole sample). Some countries seem to be in a divergent phase (Mediterranean countries), however this is most likely a temporary phase.[18]

The results were also similar to the ones obtained by Borsi & Metiu (2013). They did not find overall convergence neither for EU-27 nor for EU-21 sample. Clustering analysis revealed some clubs and for some of them the outcomes are really close to the results of this study, for example Czech Republic and Slovakia, as well as, Poland and Hungary have always been assigned to the same club. Furthermore, the convergence parameter of Poland and Hungary was one of the highest ones and similar to the result of this research (1.200 compared to 1.118). Transition paths also provided similar conclusions and identified a

[17] The difference, however, is that that in time-series studies pairs were derived only on the basis of econometric framework and some pairs identified by this approach seemed artificial (e.g. France and Italy in Greasley & Oxley study). Here, the pairs and clubs are formed on the basis of economic or historical relations.

[18] In their study from 2009, Phillips & Sul used historical data for 1870 – 2001 and found some evidence for a long-lasting divergent phases among European countries (over 20 – 30 years).

divergence of Luxembourg. Conclusions from convergence *log t test* confirmed that *"there is a clear separation between the CEEC and the old members within the EU in the long run. The clubs that include CEEC economies are on predominantly lower transition paths compared to the panel average."*

4.6 Further research possibilities

This study concentrated on identifying convergent patterns among CEE countries and their catch-up towards the EU-15 countries. Nevertheless, there are many possible extensions of this issue and other approaches to the problem. First of all, for some countries the time span could be extended. This is not possible for the majority of CEE countries due to data limitations (unless estimates or historical data are used). One way to solve this limitation is to construct two or more samples with time ranges beginning from the earliest period with available data. This approach was taken by Borsi & Metiu (2013), who constructed two samples: EU-21 with the data available from 1970 and EU-27 with the data from 1995 onwards. However, it is not possible to make one large incomplete sample as this would make calculation of transition parameters impossible. The other obvious extension is an application of clustering procedure with the last income ordering proposed by Phillips & Sul (2007b). It would be interesting to compare the outcome from purely technical device to the outcomes of clustering done in this study – on the basis of historical, cultural and economic background and common knowledge.

It is also possible to modify the set of countries in the sample. From the point of view of CEE countries, one could add Cyprus and Malta and test for convergence of the ten countries from the 2004 extension of the EU. One could also consider different variations of the EU-15 subsample, for example, by excluding Luxembourg or divergent economies. It would also be interesting to search for some clubs within "the Old European Union" or in the whole sample not separating CEE and EU-15 economies.

Section 5 – Conclusion

In this study convergence patterns among CEE economies and their relation towards EU-15, over the period of 1995 – 2013, were analysed. The highlight of this research was an application of a novel method of convergence investigation allowing for heterogeneity in technological progress across the countries. The framework was derived on the basis of theoretical background and literature review. Reference to cultural, historical and economic origin of the countries in the sample and preliminary graphical analysis justified the logic behind the comparison of CEE and EU-15. Further in the study, an analysis of transition paths for different configurations of countries and formal econometric tests served as a basis for the conclusions. In cases, where results were contradictory or ambiguous, outcomes of a formal econometric test (*log t test*) were decisive.

The main findings of this study can be summarized as follows. There is no overall income convergence within the whole sample. Although CEE economies have undergone profound changes since the beginning of 1990s and have been growing much faster than EU-15 so far, the study did not provide evidence for clear catching-up behaviour of CEE economies towards "the Old European Union". Still, the majority of EU-15 and CEE countries seem to be converging towards their own steady-states. Within the EU-15 group there are no distinct convergent patterns and several economies seem to be in a phase of transitional divergence, which was slightly intensified by the financial crisis in the Eurozone. On the other hand, there is weak, but overall relative convergence within the group of CEE countries. Some further clubs and pairs have been distinguished, of whom country pairs: Poland and Hungary, Slovakia and the Czech Republic exhibit ultimate convergence patterns. The formation of these clubs and pairs stems largely from countries' common history, ethnical background or economic linkages.

The results of this study confirm the fact that integration is a lengthy and non-linear process. With currently available data many questions still remain unaddressed. To clearly evaluate relation of CEE countries towards "the Old European Union" and to "the core economies" this examination should be repeated after several years or even decades. It is worth noting that the EU-15 economies have been in co-operation since 1995, whereas the CEE economies joined nearly ten years later. Even having considered their outstanding growth performance and robustness of their growth rates to economic shocks, 10 years long

membership in the EU was not enough to catch-up to “Western standards” completely. As the well-established economies themselves are far from perfect correlation and ten years remains a relatively short period, it seems more reasonable to abstain from the judgement on the catch-up of CEE economies for some more time.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
ADF	Augmented Dickey-Fuller Unit Root Test
ASR	Augmented Solow Regression
BACE	Bayesian Averaging of Classical Estimates
BAMLE	Bayesian Averaging of Maximum Likelihood Estimates
CEE	Central Eastern European Countries
CPI	Consumer Price Index
EC	European Community
ECB	European Central Bank
ECM	Error Correction Mechanism
ECOWAS	Economic Community Of West African States, comprises Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo
ECSC	European Coal and Steel Community
EEC	European Economic Community
EFTA	European Free Trade Association
EMU	European Monetary Union/Economic and Monetary Union
ERM	Exchange Rate Mechanism
EU	European Union
EU-8	New members of EU from 2004 extension – CEE countries: Czech Republic, Estonia, Latvia, Lithuania, Hungary, Poland, Slovenia and Slovakia
EU-15	15 first members of EU: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom
Euratom/EAEC	European Atomic Energy Community
GDP	Gross Domestic Product
HAC	Heteroskedasticity and Autocorrelation Consistent (residuals)
IMF	International Monetary Fund
KPSS	Kwiatkowski–Phillips–Schmidt–Shin Unit Root Test

LSDV	Least Square with Dummy Variables
MENA	The Middle East and North African countries (Algeria, Egypt, Iran, Israel, Jordan, Morocco, Syria, Tunisia and Turkey)
MERCOSUR	Mercado Común del Sur (Southern Common Market)
NAFTA	North Atlantic Free Trade Agreement
NATO	North Atlantic Treaty Organization
NIE	Newly Industrialized Countries
OECD	Organization for Economic Co-operation and Development
OEEC	Organization for European Economic Co-operation
OLS	Ordinary Least Square
PPP	Purchasing Power Parity
PTA	Preferential Trade Agreement
PWT	Penn World Tables
US	United States of America
USSR	(also Soviet Union) Union of Soviet Socialist Republics
WDI	World Development Indicators (The World Bank Database)
WTO	World Trade Organization
WWII	The Second World War

APPENDIX 1

Date		Event
1948	January	The beginning of customs union between Benelux countries (Belgium, the Netherlands and Luxembourg)
	April	Foundation of Organization for European Economic Co-operation (OEEC) to administrate Marshall Plan
1950	May	Schuman Declaration – first suggestion to merge coal and steel industry in Western Europe
1951	April	Signature of Treaty of Paris and foundation of European Coal and Steel Community (ECSC) (enters into force in July 1952)
1957	March	Signature of Treaty of Rome and foundation of European Economic Community and European Atomic Energy Community (EAEC or Euratom) (enters in force in January 1958)
1967	July	Merger of ECSC, EEC and Euratom into European Community
1968	July	Customs union in European Community
1973	January	Accession of the United Kingdom, Ireland and Denmark
1979	March	Creation of European Exchange Rate Mechanism (ERM)
1981	January	Accession of Greece
1986	January	Accession of Spain and Portugal
	February	Signature of Single European Act, an objective to establish a single market (enters into force in July 1987)
1992	February	Signature of Maastricht Treaty on European Union – formal creation of the European Union
1993	November	Maastricht Treaty enters into force: "four freedoms" of: movement of goods, services, people and money
1995	January	Accession of Sweden, Austria and Finland
	March	Schengen Agreement enters in force in seven countries
1997	October	Signature of Treaty of Amsterdam (enters into force in May 1999) and way towards Economic and Monetary Union (EMU)
1999	January	Common currency – Euro in non-physical form (in physical form from January 2002)
2001	February	Signature of Treaty of Nice (enters into force in 2003)
2004	May	Accession of 10 countries: the Czech Republic, Estonia, Latvia,

		Lithuania, Hungary, Poland, Slovenia and Slovakia, Cyprus and Malta
2007	January	Accession of Bulgaria and Romania
	December	Signature of Treaty of Lisbon (enters into force in December 2009)
2013	July	Accession of Croatia

Source: Own elaboration based on: Cini, 2006; Czarczyńska & Śledziewska, 2003, Europa.eu, 2015 (accessed 10.04.2015).

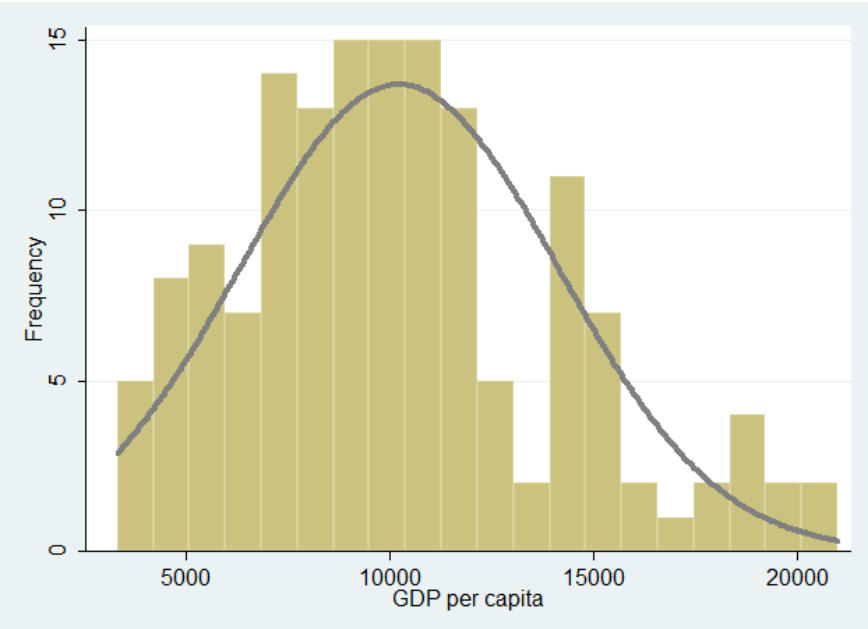
APPENDIX 2

Countries included in the sample

Country	**Abbreviation**	**Accession year**
EU – 15		
Austria	AUT	1995
Belgium	BEL	1958 (Founder)
Germany	DEU	1958 (Founder)
Denmark	DNK	1973
Spain	ESP	1986
Finland	FIN	1995
France	FRA	1958 (Founder)
Great Britain	GBR	1973
Greece	GRC	1981
Ireland	IRL	1973
Italy	ITA	1958 (Founder)
Luxembourg	LUX	1958 (Founder)
Netherlands	NLD	1958 (Founder)
Portugal	PRT	1986
Sweden	SWE	1995
CEE		
The Czech Republic	CZE	2004
Estonia	EST	2004
Hungary	HUN	2004
Lithuania	LTU	2004
Latvia	LVA	2004
Poland	POL	2004
Slovakia	SVK	2004
Slovenia	SVN	2004

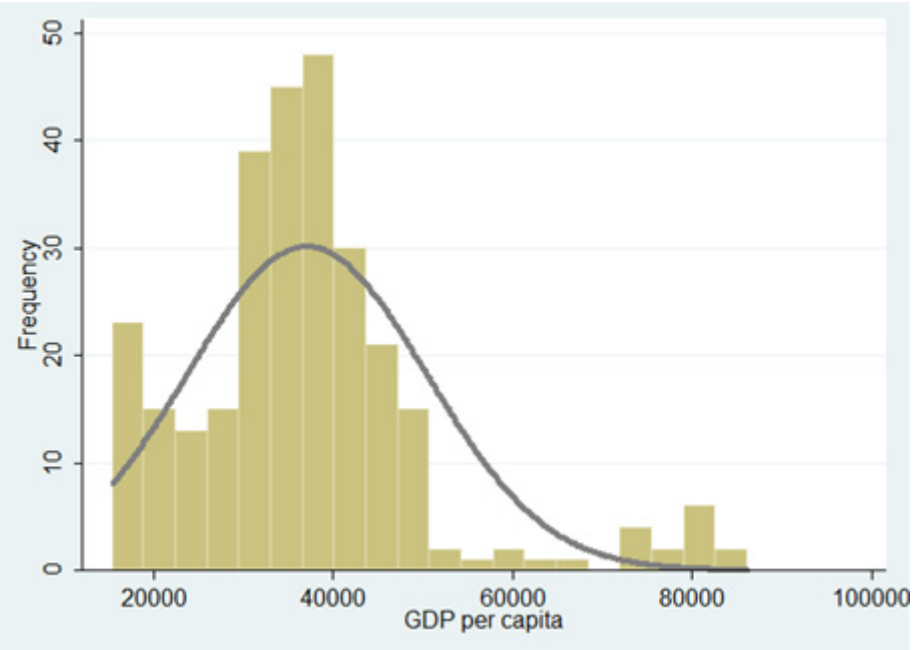
APPENDIX 3

Histogram of GDP per capita variable with frequencies and overlaid normal density curve for CEE countries



APPENDIX 4

Histogram of GDP per capita variable with frequencies and overlaid normal density curve for EU-15 countries



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ABSTRACT

The link between convergence and economic integration has gained a substantial amount of attention from growth researchers over time. New tools were designed to analyse this relationship appropriately. The recent largest extension of the European Union from 2004 by 8 Central Eastern European countries, Malta and Cyprus added new questions to the convergence debate. It became natural to compare CEE countries to "the Old European Union". Hypotheses on income convergence and catch-up of less developed countries could be finally tested empirically. Historical, cultural and economic origin of CEE economies is an additional feature that makes this analysis even more interesting. All of these countries have been influenced by socialist or communist ideology, were largely controlled by Soviet Union and confronted free market for the first time in the 1990s. This gave them a comparable starting point and has been influencing their development ever since.

Willing to contribute to this vital debate, this study concentrates on the investigation of convergent and divergent patterns between CEE countries and towards the EU-15 group, which serves as a benchmark of old European Union members. The two main highlights of this research include the choice of time period and an innovative method. It is one of few studies that examine convergence of CEE countries in the most recent period, namely from 1995 until 2013. Such time range makes it possible to capture some actual implications of the EU membership for CEE economies. As to the latter, a very novel and robust method for investigating convergence is used. This framework allows for country-specific heterogeneity in technological progress, which permits exploration of convergence without posing simplifying assumptions on the data. This method builds on transition paths analysis and formal econometric tests, which enable an assessment of the behaviour of particular economies over time.

The main results indicate that there is no overall income convergence in the whole sample. Moreover, clear catching-up behaviour of CEE economies towards the well-established members of the European Union cannot be formally confirmed. Hitherto, the majority of EU-15 and CEE countries seem to be converging towards separate steady-states. As to the EU-15 group, no distinct convergent patterns have been identified, on the contrary, several economies seem to be temporarily diverging. On the other hand, CEE economies do not only exhibit relative convergence within their group, but also some further clubs of convergence exist in their group. Clubs that have been distinguished are consistent with

predictions based on common history, ethnic background or economic linkages. Some clubs, namely, Poland and Hungary, Slovakia and the Czech Republic exhibit even absolute convergence patterns.

These results are less optimistic than results from previous frameworks imposing strong restrictions on the models, but draw attention to several important issues. It appears that, although CEE economies had much higher growth rates of GDP per capita and underwent profound changes after gaining access to free market, they still did not manage to catch up towards the more developed economies of the European Union. However, ten years of membership in the EU does not seem a long period in comparison to the well-established European Union economies. If CEE countries continue to grow at a higher rate than other Western economies, it is highly probable that they will finally reach the similar level of development and thus, it is reasonable to abstain from the judgement for now.

ABSTRACT

Die Beziehung zwischen Konvergenz und wirtschaftlicher Integration wird schon lange in den Wirtschaftswissenschaften untersucht. Weitere neue empirischen Methoden wurden entwickelt, um diese Beziehung angemessen zu analysieren. Nach der letzten größten Osterweiterung der Europäischen Union um acht mittel- und osteuropäische (MOE) Länder, Malta und Zypern wurden neue Fragen der Konvergenzdebatte hinzugefügt. Die MOE Länder wurden natürlich mit den alten EU-Mitgliedstaaten verglichen. Somit können Hypothesen über die Konvergenz der Einkommen und der Aufholeffekte endlich getestet werden. Die historische, kulturelle und wirtschaftliche Herkunft von MOE Staaten ist eine weitere Eigenschaft, die dieses Thema besonders interessant macht. Alle diese Länder wurden von Sozialismus oder Kommunismus stark beeinflusst und von der Sowjetunion weitgehend kontrolliert, sie sind der liberalen Marktwirtschaft erst ab 1990 begegnet. Das hat dazu beigetragen, dass diese Ländern einen vergleichbaren Start im Wachstum hatten.

Um zu dieser wesentlichen Debatte beizutragen, konzentriert sich die vorliegende Arbeit auf die Untersuchung von konvergenten und divergenten Mustern zwischen den MOE Ländern und den EU-15, die als Benchmark für die alten Mitgliedern der Europäischen Union dienen. Die zwei wichtigsten Punkte dieser Arbeit sind die spezifische Zeitperiode und eine innovative Methode. Die Zeitperiode 1995 bis 2013 ist bisher nur von wenigen Studien in Hinblick auf die Konvergenz zwischen MOEL untersucht worden. Dieser Zeitabschnitt ermöglicht, einige tatsächliche Auswirkungen der EU-Mitgliedschaft für MOE Staaten zu entdecken. Es wird eine neue und robuste Methode zur Konvergenzuntersuchung verwendet. Das Modell erlaubt landspezifische Unterschiede in technologischen Wachstumsraten, was eine Konvergenzuntersuchung ohne zu stark vereinfachende Annahmen ermöglicht. Dieser Ansatz basiert auf Übergangsverhaltensanalyse und ökonometrischen Konvergenztests, die die Bewertung des Verhaltens im Zeitverlauf von Volkswirtschaften ermöglichen.

Die wichtigsten Ergebnisse zeigen, dass es keine gesamte Einkommenskonvergenz im ganzen Zeitraum gibt. Außerdem, ein klarer Aufholprozess von MOEL gegenüber den alten Mitgliedstaaten der Europäischen Union kann nicht bestätigt werden. Somit, die Mehrheit von EU-15 und MOE Staaten konvergiert wieder zu eigenen Wachstumsgleichgewichten. In Bezug auf die EU-15-Gruppe lassen sich keine deutlichen Konvergenzmuster identifizieren. Im Gegenteil, es scheint, einige Volkswirtschaften scheinen zeitweise in der Divergenzphase zu sein. Andererseits gibt es nicht nur eine relative Konvergenz zwischen allen MOE

Wirtschaften, sondern auch einige Konvergenzclubs innerhalb der Gruppe. Das Ergebnis dieser Gruppenbildung, die gefunden wurde, stimmt mit den historischen, ethnischen und wirtschaftlichen Verbindungen überein. Einige von diesen Clubs, nämlich Polen und Ungarn, die Slowakei und die Tschechische Republik zeigen sogar absolute Konvergenzmuster.

Diese Ergebnisse sind nicht so optimistisch wie die Ergebnisse aus früheren Studien, die große Einschränkungen auf die Modelle aufgelegt haben. Sie machen auf einige wichtige Probleme aufmerksam. Es scheint, dass MOE Länder mit viel höheren Wachstumsraten von Pro-Kopf-Einkommen und tiefgreifenden großen Veränderungen, nach dem Zugang zum freien Markt, noch nicht gegenüber der entwickelten Volkswirtschaften der Europäischen Union aufgeholt haben. Allerdings, zehn Jahre Mitgliedschaft in der EU scheint kein langer Zeitraum im Vergleich zu den alten Volkswirtschaften der Europäischen Union zu sein. Wenn MOEL weiterhin mit höheren Wachstumsraten als die anderen westlichen Volkswirtschaften wachsen werden, ist es sehr wahrscheinlich, dass sie endlich eine ähnlichen Entwicklungsstufe erreichen. Deswegen es ist sinnvoll, auf das Urteil vorerst zu verzichten.

CURRICULUM VITAE

PERSONAL DETAILS

Full Name	Dominika Róża Wciślik
E-mail	d.wcislik@student.uw.edu.pl

EDUCATON

2014 –	Double Degree Programme at the University of Vienna, CEEPUS Exchange with OEAD Scholarship
2013 –	International Economics Master Studies at the University of Warsaw (awarded Rector's scholarship for excellent results for 2 years)
2013	Erasmus Exchange Programme at the University of Bergen (Norway)
2010 – 2013	Economics & Management Bachelor Studies at the University of Warsaw (awarded with Rector's scholarship for excellent results for 2 years), ended with Bachelor in Economics with very good result and Bachelor in Management with honours, with excellent result (summary average grade 4,9/5)
2007 – 2010	Hoffmanowa High School no. 9 in Warsaw, profile: Mathematics-Geography-History, ended with Polish Matura. Awarded with scholarship for excellent results.

EXPERIENCE

VIII 2014	Summer School of Economics at the University of Economics in Bratislava "New Path of Economic Growth and Social Development for Europe" (Erasmus Intensive Programme)
VII – VIII 2014	Internship at Dürr Systems Spain S.A. (Finance & Controlling, Accounting, Purchasing Department)
VIII 2012	Summer School of Economics at the Georg-August-

	Universität in Göttingen “Relations between EU and Emerging Global Players (BRICS)” (Erasmus Intensive Programme)
VI – VII 2011	Internship at Polish-German Chamber of Commerce and Industry (Deutsch-Polnishe Industrie- und Handelskammer)

ADDITIONAL QUALIFICATIONS

Languages:

- Polish – mother language
- English – fluent (Cerificates: FCE, CAE, IELTS, TOEFL; Advanced English language course in London)
- Norwegian – good
- German – good
- Spanish – basic

Skills/Characteristics:

- diligent
- responsible
- well-organized
- team-working skills

INTERESTS AND ACTIVITIES

- Foreign Languages
- Scandinavian Countries
- Japanese culture
- Dance (Flamenco, Ballroom Dance)
- Literature
- Travelling & Sightseeing