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**INCOME CONVERGENCE PERFORMANCE WITHIN THE EU BEFORE
AND AFTER THE FIRST EASTWARD 2004 ENLARGEMENT**

THE ROLE OF COHESION COUNTRIES

Master's thesis

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Name and signature of supervisor.....

Allowed for defence on.....
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I have written this master's thesis independently. All viewpoints of other authors, literary sources and data from elsewhere used for writing this paper have been referenced.

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(signature of author)

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Abstract

This study empirically examines the impact of the first eastward 2004 enlargement of the EU on the convergence process for the 25 member states of the European Union. It also identifies how the poor economic performance of cohesion countries (Spain, Portugal, Greece) has increased the speed of convergence of new EU10 countries towards old EU15. The research is based on conditional beta (β)-convergence and sigma (σ)-convergence of real GDP per capita and covers the period of 1995-2015. Regression analysis is conducted with the use of system GMM method to deal with endogeneity problem in the model, whereas standard deviation is used for testing the sigma convergence phenomenon. The results lead to the increased speed of convergence between the new EU10 and old EU15 member states during the post-accession period. Even though the convergence of EU10 turns to happen at a lower level of per capita income, as the Spain, Portugal and Greece accelerated the process of EU10 countries convergence by reducing the average economic growth rate of the EU15 countries.

Keywords: Income convergence, Economic growth, European Union, Panel approach

JEL Classification: C13, C33, O47, O52

1. Introduction

Economic integration is a process that contributes to economic growth. This contribution comes through the static (allocation) and dynamic (accumulation and location) effects associated with regional integration¹. There are different types of regional economic integration, such as Free Trade Area, Customs Union, Common Markets and the Economic Union. The representative of the latter form is the European Union (EU), which is a powerful economic integration system with centrally controlled harmonised policies. The whole story of this study is also about the economic integration of the EU newcomers that is currently taking place in the EU.

In 2004 the EU welcomed 10 new countries, two Mediterranean states Cyprus and Malta, as well as eight former east bloc nations, namely Estonia, Latvia, Lithuania, the Czech Republic, Hungary, Poland, Slovenia, and the Slovak Republic. The enlarged EU consisted of 25 economies at that time². For the newcomers, the EU membership promised economic growth and prosperity. On the other hand, the old EU member countries were also expected to benefit from the EU accession though using the comparative advantage and specialising in more productive activities, as enlargement would encourage the production of capital-intensive goods in the West, whereas labor-intensive production should be stimulated in the labour abundant Eastern countries. In general, EU enlargement was expected to bring some major benefits, such as larger export markets, higher labour and capital mobility, strengthened institutions and financial integration both for the existing members and the new entrants. Along with all these benefits, the membership also brought a long-term challenge, the convergence of these economies.

There are different factors that influence convergence and divergence processes across economies. Out of the four freedoms (goods, capital, services and labour) of the EU's internal market, free movement of workforce plays a key role in gathering the full benefits from the economic integration, which will be seen in the course of time. Although the trade between new candidate countries and old member states was liberalised in the early 1990s and the barriers to the capital movement were also largely removed before the enlargement, free movement of labour was restricted by most of the EU15 countries until 2006 due to the perceived fear of migration flows and downward pressure on wages³. D'Auria et al. (2008) provided simulation analysis to find the macroeconomic impact of the post-enlargement migration flows that occurred over the 2004-2007 period for both EU15 receiving countries and the sending EU10 countries. When taking into account lower skill content of the jobs taken by the migrants from the EU newcomers, simulation results lead to the increased GDP per capita gains for EU10 member states and to the decreased per capita GDP gains for the receiving EU15 member states, compared to the simulation results obtained with no differences made in the

¹ One of the main static effects of economic integration is trade creation, which impacts on resource allocation efficiency in the member states. Dynamic effects covers the medium and long-run growth effects through accumulation of physical and human capital and technology. See Baldwin and Venables (1995) for discussion.

² Appendix 1 gives the list of sample countries used in this paper.

³Only the UK, Ireland and Sweden opened their labor markets right after the enlargement in May 2004.

skill characteristics of the migrant and native workers. Overall, the paper showed that the re-allocation of labour after the 2004 EU accession positively contributed to the growth of the enlarged European Union (EU25 countries) due to the more productive use of human capital that boosts the productivity and GDP per capita, in turn.

The new EU10 member states' challenge to catch up economically to the old EU15 countries is supported by the financial transfers from the EU structural funds once they join the Union. But this process becomes more challenging, as countries should think about the complementarity of physical and human capital that plays an important role in explaining GDP growth. The optimal combination of these production factors should lead to the better economic results rather than investing in each factor separately.

This paper concentrates on two types of real convergence: conditional beta (β)-convergence and sigma (σ)-convergence. According to Halmai and Vasary (2010), nominal and real convergence tendencies reflect how successful are the new EU member states in their integration process towards the Union. Gligoric (2014) claims that convergence in terms of real GDP per capita is countries' one of the main incentives to join the EU. Hence, research in income disparities and convergence process in the EU member countries has become very popular over the last decades. Taking into account the existence of several recognised candidates⁴ for the future EU membership and the association agreements signed by EU with Georgia, Moldova and Ukraine, this topic will not lose its popularity until the Union exists.

Each enlargement process of the EU is associated with the new member states' commission to consolidate their economic development with institutional and social improvements and experience the convergence process towards the higher level of the older EU member states. Still, there is a little evidence from previous studies that opening the doors for the new countries to the European Union will guarantee the global convergence in the EU⁵.

The quality of the fifth (2004) and the later enlargements of the European Union was much better compared to the previous accession rounds due to the negotiations known as the "acquis communautaire"⁶ that took place between the EU and the candidate members⁷. Under the *acquis*, the new 10 candidate countries were obliged to harmonise their legislation and experience institutional convergence starting already from 1998, while there were no such requirements for the previous enlargement rounds. That motivates the analysis of the EU 2004 enlargement as later one can ask a question on how the pre-accession harmonisation process influenced the convergence after the enlargement.

⁴ Turkey, Macedonia, Montenegro, Albania, and Serbia.

⁵ See, for example, Borsi and Metiu (2014), Chapsa and Katrakilidis (2014).

⁶ The accumulated legislation constituting the body of the European Union law.

⁷ The new 10 countries that joined in 2004 plus Bulgaria, Romania and Croatia which joined a bit later in 2007 and 2013, respectively.

Moreover, the fifth enlargement on 1 May 2004 was the largest ever and the most complex in the history of the European Union in terms of the number of countries with different social, economic and political developments. On the other hand, the convergence of the European countries is a long-term process and therefore is one of the concepts that cannot be examined only a few years after joining the Union. Thus, the latest two accession rounds of the EU should not be informative so far. One of the main contributions of this paper is that it fills existing research gap and analyses longer time interval starting from 1995 till 2015, which should better depict any patterns of convergence, as most of the related empirical studies use the data up to 2010⁸.

The cohesion group of countries joined the EU during the second and the third enlargement rounds⁹. After these accessions, the European Union created quite strong regional policy which was followed by setting up the Cohesion Fund in 1994 aiming to help the less prosperous and the weakest EU periphery countries to reduce their economic and social disparities compared to the EU core member states¹⁰. Greece, Spain and Portugal were countries which got special treatment and support through the Cohesion Fund. It is true that Ireland also benefited from this fund at that time and because of this reason sometimes all these countries are called as “the Cohesion Four”. But as there were no such funds established when it joined the EU¹¹, this paper uses the term of “cohesion countries” for EU3 member states and it does not apply to Ireland.

This study aims to find out if there was an increase in the speed of convergence in conditional terms between current EU25 countries after the first eastward enlargement of the EU, compared to the pre-accession period. Special attention was given to the role of cohesion countries Greece, Portugal and Spain in the accelerating the convergence process of EU10 by reducing the average growth of old EU15 countries.

What is the picture now more than 10 years after the EU enlargement? Is there any evidence of economic speedup in the convergence rate of the EU25 countries after 2004? If this is the case, then what drives this process? Can we view the cohesion countries as a driving force for EU10 new member states to experience faster convergence towards more developed old member states? These are the main research questions that arise in this paper.

In order to achieve the aim, this paper uses two benchmark approach and tests conditional convergence using the endogenous theory of economic growth. The first benchmark model tests the conditional convergence hypothesis in the sample of EU25 countries to see what happens in the enlarged European Union and whether we can see any patterns of convergence inside this group before and after the EU 2004 enlargement. While the membership of the EU does not impose any

⁸Appendix 2 gives the review table of recent studies on the convergence process in the European Union.

⁹ Greece joined the EU in 1981 that was followed by 1986 enlargement round when Portugal and Spain entered the Union. The latter fourth accession of Sweden, Finland and Austria happened in 1995, which was followed by the fifth EU enlargement in 2004.

¹⁰ The paper classifies the periphery consisting of the weak cohesion countries (EU3). The core consists of institutionally strong countries with higher competitiveness (EU12).

¹¹ During the first enlargement round in 1973, Ireland joined the EU together with the UK and Denmark.

conditions on income convergence of the new entrants before joining the Union, it would be interesting to examine how successful was the transformation process of post-communist economies. The latter is likely to exhibit the per capita income convergence with the existing EU member states already before entering the Union. At the same time, the EU membership is expected to speed up the pace of convergence of the new member states towards the old member countries.

For the next step, to know the target towards which the new EU10 member states are likely to converge and how fast they are converging to this point, the questions about the cohesion countries' economic behaviour are asked. During the studied period of 1995-2015, we faced the biggest crisis after the World War II which brought asymmetric shocks to different EU member states. Prolonged deterioration of the economic situation in the peripheral cohesion countries decreased the average level of the old EU15 member states that almost equated to the average level of the new member states. Leading to the fact, the EU newcomers have to hit much lower target now to achieve convergence, though at a lower per capita income level. Whereas, the speed of convergence of the newcomers towards the more advanced EU12 core countries is likely to be lower. This is an interesting problem which arose after the economic crisis and is not addressed yet by other empirical studies which are usually studying the convergence of new member states towards the group of EU15 countries. This paper fills this research gap and introduces the novelty in the literature by analysing the new member states convergence pattern to the EU12 countries as well, through the use of the second benchmark model without the cohesion countries (EU22).

The findings of this paper support the conditional convergence hypothesis in both EU25 and EU22 groups of countries. Increased rate of convergence from 5.6% to 9% in the enlarged European Union (EU25) confirms the existence of convergence pattern during the pre-enlargement period and indicates the positive impact of EU 2004 accession on the speed of convergence. On the other hand, exclusion of the cohesion countries from the sample lead to the lower convergence rate of the newcomers towards the more advanced EU core countries, accounting for 8.7%¹². This finding supports the idea about poorly behaving cohesion countries' "positive" role in accelerating the speed of convergence between the new EU10 and old EU15 member states at a lower level of per capita income.

Another important finding of this paper is that, in general, countries in the European Union became more similar in terms of per capita income. We are facing two phenomena behind this similarity. On the one hand, the new EU10 member states are becoming similar in the real GDP per capita terms and at the same time they are catching up to the old EU15 member states. On the other hand, we see how the peripheral cohesion countries falling apart from the old member states, increasing income variability in the latter group of countries and reducing its average speed of growth.

The rest of the paper is structured as follows. Section 2 introduces the different types of convergence and a review of the literature on convergence process. Section 3 is dedicated to the description of

¹² The coefficient of the initial real GDP per capita in pre-accession period turns to have negative but insignificant effect. Therefore one cannot say anything about the speed of convergence in the EU22 countries before 2004 enlargement.

the data and methodology used. The following sections 4 and 5 describe the results and robustness check. Section 6 concludes.

2. Literature review

Theoretical consideration of convergence process starts from the two main theories – neoclassical growth theory, introduced by Solow (1956) and endogenous growth theory which was introduced decades later by Romer (1986).

Neoclassical growth theory outlines labour, capital, and technology as the driving forces of the economy, accounting technological progress as an exogenous factor which produces the long-run economic growth. With the assumption of diminishing returns to capital, it predicts decreasing cross-country income inequalities. The absence of human capital in the model limit the economic growth and therefore does not allow the constraint of diminishing returns to both unskilled labour and capital to be relaxed. According to the neoclassical growth theory, richer countries with more capital and therefore lower marginal returns to capital should experience slower economic growth compared to poorer countries. This is also known as beta (β)-convergence that is defined as the negative correlation between the initial income level and successive growth rate of the country (Islam, 2003).

Absolute and conditional convergence have been usually used when studying convergence in per capita income terms across countries. Unconditional (absolute) beta convergence occurs when economies converge to each other regardless of their initial conditions. In other words, not controlling other explanatory variables except for initial income level, does not have an impact on convergence process. Conditional beta convergence, in contrast, occurs only after taking into consideration countries' structural characteristics. According to Galor (1996), it makes no assumption about the shared equilibrium and implies that irrespective of their initial conditions, countries with the same technology, preferences, government policies and other characteristics might converge to their own steady states. Another quite popular type of convergence discussed in Islam (2003) is sigma (σ)-convergence, leading to the reduction of income level dispersion across countries. For sigma convergence to be achieved, (β)-convergence is required but the latter is not sufficient condition for that, as countries' growth rate may be affected by random shocks to their income level, as Barro and Sala-i-Martin (1990) claim.

One of the classical studies about convergence was conducted by Baumol (1986) who investigated absolute convergence. When studying a wide range of countries, including industrialised, centrally planned and other countries from all over the world during 1950-1980 years, the author found no evidence of absolute convergence. Nevertheless, the author's findings for a smaller group of 16 industrialised countries confirmed unconditional convergence phenomena for the studied period from 1870 to 1979. Using the framework of the neoclassical growth model, Barro and Sala-i-Martin

(1992) provided the evidence of absolute convergence in per capita terms across the 48 contiguous U.S. states over different periods between 1840 and 1988 years, assuming the similar steady state values and the same rate of technological progress for studied U.S. states. The findings of the following study completed by Barro (1996) for a sample of 98 countries from 1960 to 1990 contrasted the one found for the U.S states in the aforementioned paper. The empirical findings for such a large group of countries confirmed the inverse relationship between the initial level of GDP and economic growth only after conditioning on different determinants of economic growth, therefore supported the conditional convergence hypothesis.

One of the main characteristics of neoclassical growth theory is the unique equilibrium that all economies reach at a certain point of time. Nevertheless, according to Islam (2003), there are studies which also consider the variability of steady state growth rates across economies under the framework of neoclassical growth theory. For instance, Galor (1996) argues that neoclassical growth model predicts conditional convergence and club convergence hypothesis.

The following paragraphs of the literature review are mostly concentrated on the recent studies that investigate real economic convergence in per capita income terms in the European Union (EU). Many researchers conducted various empirical investigations addressing the issue of income convergence in the EU. However, European countries have been quite heterogeneous concerning the pattern of convergence¹³. The results vary significantly depending on the methods, model specifications, the sample of countries and time periods used. By model specification, I mean the different set of control variables that are used in various works to study their impact on economic growth.

Some of the recent studies¹⁴ with their used specifications of convergence equations are in line with neoclassical growth theory, endorsing the negative correlation between the growth rate and the initial level of real per capita GDP.

Matkowski & Próchniak (2007) investigated the real convergence during the pre-accession period from 1993 to 2004 between the eight Central and East European (CEE8¹⁵) countries and the EU core members. Empirical findings confirm absolute beta (β) - convergence between EU15¹⁶ and CEE8. The latter group of countries also depicted sigma (σ) - convergence toward the former members of European Union. The income-level convergence was present in this analysis accounting for 1.67 and 2.66 percent in 1993–98 and 1998–2004 sub-periods, respectively. Vojinović et al. (2010) analysed

¹³ See again Appendix 2, which gives the short overview of some recent literature on the convergence process in the European Union.

¹⁴ Matkowski & Próchniak (2007), Halmai and Vásáry (2010), Vojinović and Oplotnik (2008), Vojinović et al. (2010), Cavenaile and Dubois (2011), Jelnikar and Murmayer (2006), Gligoric (2014).

¹⁵ Czech Republic, Hungary, Poland, Slovak Republic, Slovenia, Estonia, Latvia, Lithuania.

¹⁶ Austria, Belgium, Denmark, France, Finland, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the UK.

the economic impact of the EU enlargement in 2004 covering the period from 1992 to 2006. The authors studied real economic convergence among 10 new member states (EU10¹⁷) by means of sigma (σ) and beta (β)-convergence. The results revealed conditional convergence, along with the existence of sigma (σ)-convergence, claiming that the poorer new EU member countries grew faster compared to the richer new EU member countries.

Conditional convergence was also confirmed by Cavenaile and Dubois (2011). The authors test whether income convergence process has occurred between EU10 and EU15 country groups and whether there are any differences in the convergence rates between these two samples, using GDP per capita at PPP data from 1990 to 2007. The results show the evidence of conditional convergence in the whole European Union (EU-27) during the entire studied period, however, the authors found significantly different convergence rates within the new and old EU member states. Conditional convergence hypothesis among EU10 and EU15 groups of countries was also examined by Jelnikar and Murmayer (2006). The authors confirmed the significant beta (β)-convergence in both samples, in addition to the convergence of the EU newcomers to the average living standards of the EU core members (EU15).

Conditional convergence of the new EU member states (EU10) towards the EU average per capita income was rejected by the empirical study conducted by Ranjpour and Zahra (2008), supporting the hypothesis of absolute convergence. Gligoric (2014) observed the differences in per capita GDP level before and after crisis period in 2008 for every country pairs from all the EU member states including Norway and excluding Ireland, Greece, Romania, Cyprus, and Malta. Absolute beta convergence was recorded for the pre-crisis period during 1995-2008, confirming the fact that new EU member countries performed successful pre-accession harmonisation process leading to the quick integration and catching-up process with the developed countries of Europe. Though, post-crisis period (2008-2013) was characterised by the existence of the convergence clubs¹⁸. No evidence of real per capita income convergence was found in the enlarged European Union between 1970 and 2010 by Borsi and Metiu (2015), following neoclassical growth theory augmented with endogenous technological progress. Instead, the authors discovered two separate subgroups, CEEC and the old EU member states converging to different steady-state growth levels, pointing to the possible disappearance of real convergence in the future, due to the scarcity of structural reforms carried out in the EU countries.

Exogenously determined steady state growth rate and the absence of absolute convergence in the large group of countries have triggered new growth theories. Endogenous growth theory introduces human capital to the model and no longer treats technology as the exogenous factor. The long-run economic growth is mainly generated by the accumulation of knowledge by economic agents

¹⁷ CEE8 plus Cyprus and Malta.

¹⁸ Namely Baltic (Estonia, Latvia, Lithuania), Visegrad (Poland, Slovakia, Hungary, Czech Republic, together with Slovenia Croatia and Bulgaria) and the third club consisting of more advanced countries split into two subgroups (Italy, Portugal, Greece and others).

(Romer, 1986). The returns to capital are not necessarily decreasing in this framework. Consequently, countries might not converge in terms of per capita GDP levels even in conditional terms. Lucas (1988) emphasised the importance of increasing returns to human capital in economic growth and believed that there would not be any convergence in income levels across countries. Empirical study about convergence completed by Ben-David (2004) states that decreasing income gap is not observed between most of the countries in the world and only a few of them experience income convergence. Capolupo (2005) suggests that we should not assess the validity of new growth theories with the convergence phenomenon. The author claims that it is highly plausible to observe the convergence process, even in the endogenous growth models without decreasing returns to capital, if imitation of innovations is much cheaper for laggard countries than the innovation itself for the leaders.

In some of the recent empirical studies, using the endogenous growth model specifications, there is a mixed evidence of the income convergence in the new and older EU member states. As Capolupo (2005) says, the main drawback of these works is using proxy explanatory variables that are inaccurate measures of essential determinants of economic growth, such as human capital and TFP stressed by new growth theories.

The empirical analysis performed by Amplatz (2003) lead to the existence of convergence within EU accession candidates from Central and Eastern Europe (CEE8) for the time period from 1996 to 2000, but the convergence between them and the EU-western countries was shown to be absent. Vamvakidis (2008) provided also not very optimistic outlook of convergence process in emerging European countries¹⁹. The author confirms that the convergence of these economies occurred rapidly in recent years, but this process is expected to continue at a slower pace.

The empirical study conducted by Varblane and Vahter (2005) discovered both, unconditional and conditional type of beta convergence across the EU newcomers (CEE8 plus Romania and Bulgaria) during the period of 1993-2004. The authors also confirmed the existence of sigma convergence leading to the reduction of the income level dispersion in the EU accession countries. Another study that supported conditional convergence in the European Union is the one completed by Prochniak and Witkowski (2014). The results led to the existence of convergence in enlarged EU27 countries during 1993-2010. In the same paper, the higher annual rate of convergence (6 percent) was found in the sample of EU27 member states, compared to the slower one (3 percent per year) found in EU-15 old member states. Based on these figures and official statistics of economic growth, the authors conclude that the convergence process in the EU27 countries is mostly driven by the convergence of central and eastern European countries towards the EU15. Later empirical study completed by Chapsa and Katrakilidis (2014), showed no income convergence between so-called ‘cohesion four’ (namely Portugal, Ireland, Spain and Greece) and other remaining EU advanced member countries

¹⁹ Albania, Belarus, Bosnia & Herzegovina, Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, FYR Macedonia, Moldova, Poland, Romania, Russia, Serbia, Slovakia, Turkey and Ukraine.

during the period of 1950-2010. The results showed the limited evidence of conditional convergence for these countries towards the group (EU14²⁰) average level.

Along with neoclassical and endogenous growth theories there exists a third approach to economic growth known as the evolutionary growth theory. The evolutionary perspective of economic growth depends on trials and errors and the growth is perceived to be a process of perpetual transformation, disregarding the endogenous growth theory's perception of continuing equilibrium.

Nelson and Winter (1974), who pioneered in this field, used the data on total factor productivity for the U.S. provided in Solow (1957) and modelled the same empirical trends with computer simulations to demonstrate the ability of the evolutionary theory to explain the phenomenon of economic growth. Verspagen (2001) stated that the economic growth is a process of transformation and convergence periods can only be observed when technological and institutional improvements allow this. Although the process of economic growth is explained to be more technology driven, the importance of non-economic variables such as cultural, scientific and institutional factors is also underlined in this work. This is not to say that technology and institutions are competing with each other, but rather institutions determine also the technological progress²¹. Apparently, this is the common aspect in the endogenous growth theory as well. Under the evolutionary growth theory, these variables define the economic growth to be a steady state process or constant transformation. The same study provided evolutionary interpretation of OECD growth patterns which led to the possibilities of divergence of GDP per capita and formation of "convergence clubs" in OECD countries in the future.

3. Empirical analysis

3.1. Data

The research hypothesis about unconditional (absolute) and conditional β -convergence during pre and post-EU enlargement periods are verified for the sample of EU25 and EU22 countries over the period of 1995-2015. The limited availability of the data restricts the analysis to be started from the year 1995. Although, since the EU new member states from Central and Eastern European countries became independent at the beginning of the 1990's, it would not reasonable to observe any kind of convergence during their recession period, that was full of economic and political difficulties and changes.

The studied period 1995-2015 mostly covers the stabilisation and accommodation policies of these countries targeting at becoming the members of the European Union, the period of the major expansion of the EU in 2004 and subsequent rounds of two enlargement session in 2007 and 2013,

²⁰ EU15 without Luxemburg.

²¹ See, for example, Acemoglu et al. (2005).

respectively. The data for the three newest EU member states (namely, Romania, Bulgaria and Croatia) should not be representative, due to their shorter EU membership period relative to 10 new member countries that joined the EU in 2004. Therefore, they are not included in the studied samples, considering convergence as a long-run concept.

The analysis for the EU25 countries, which consists of two heterogeneous groups, namely EU10 new member states and well-developed EU15 old member countries should show whether there are any differences in the convergence process within this broad sample before and after the 2004 EU enlargement.

Excluding Spain, Greece and Portugal from the sample of EU25 countries give the group of EU22 member states. Dropping the cohesion countries from the sample has its reasoning. In appendix 3, one can see that the negative impact of the financial crisis extended much longer in this three countries compared to the other ones. That decreased the average level of the old EU15 member states, meaning that, in fact, the EU newcomers have to hit much lower target now to achieve convergence. As a consequence, the cohesion countries may facilitate the convergence process between the latter group of countries and the new EU member states. In order to understand this phenomenon better conditional convergence is tested in two different cases with EU25 and EU22 countries.

In general, during the whole crisis period and before that, there was an issue about a two-speed Europe, the dual-track of the EU growth one sketched by more closely integrated core member states and another track sketched by more loosely linked periphery affiliates. The current paper discovers the same pattern of two-level dynamics of real GDP per capita in EU member states (see Appendix 4.1). It turns out that, the EU15 average level of real GDP per capita is significantly decreased by peripheral cohesion countries throughout the studied period and starting already from 2007 economic crisis it almost overlaps the EU10 average level. While the EU12 average level lies far above the latter groups of countries. The group of EU11 countries will be discussed in section 5.

The old EU member states were not the only group of countries which were affected by the financial crisis. Appendix 3.1 shows that there was an abrupt decline in the real GDP per capita in Cyprus and seven EU new entrants from Central and Eastern Europe²² after 2007, which decreased the average level of the real GDP per capita of the EU10 member states. Out of the EU new entrants, only Cyprus and Slovenia did not manage to recover and continue growing, though the dynamics of the real GDP per capita after the crisis was rather stable in Slovenia. Nevertheless, the two latter countries were kept in the analysis, as excluding them from the sample decreases the real GDP per capita average level of the group of EU10 countries, artificially impeding their convergence towards the more advanced old EU member states (see Appendix 4.2).

This study concentrates on the conditional convergence phenomenon, but from the beginning, the graphical illustration of the unconditional (absolute) convergence is presented based on cross-

²² Estonia, Latvia, Lithuania, Slovenia, Slovak Republic, Czech Republic, and Hungary.

sectional data, while for the regression analysis panel data is used, which is transformed into three-year averages. Construction of the panel involved a trade-off between having enough time periods needed for GMM estimation and not being highly influenced by the business cycles²³. Compared to the annual data, in this case, the results should be more informative and precise while exploring the true relationship between the growth rate and the initial level of income as it is stated in the study completed by Prochniak and Witkowski (2014). The authors claimed that using the annual data gave more stable β -coefficients over the different studied periods, while three-year averaged data slightly increased the coefficient of initial income level. As for the other economic indicators, the differences in annual and three-year averaged data was said to be larger²⁴.

Limited availability of the data on some important explanatory variables, even after its transformation into three-year averages, restricts using GMM method for regression analysis, as the number of observation decreases too much and the model performs poorly. Because of this problem, the missing values were filled by the hotdeck procedure²⁵. Hotdeck imputation method is good in the sense that it preserves the variables' distributional characteristics (Roth, 1994).

3.2. Model and methodology

Typical growth regression model provided by Barro and Sala-i-Martin (2003) based on panel data looks as follows:

$$\Delta \ln(GDP)_{it} = \alpha_0 + \alpha_1 \ln GDP_{it-1} + \eta X_{it} + \mu_i + \varepsilon_{it} \quad (1)$$

Where, $\Delta \ln(GDP)_{it}$ is the change of county i th natural logarithm of GDP per capita at PPP in period t . $\ln GDP_{it-1}$ is county i th natural logarithm of real GDP per capita from the preceding year. X_{it} is the vector of all additional explanatory variables. μ_i represents the country specific time-invariant effects and ε_{it} is an error term.

In order to verify conditional β -convergence hypothesis before and after EU enlargement the following specification of the dynamic growth model is estimated in this study:

$$\frac{1}{N} \ln \left(\frac{GDP_{Tt,i}}{GDP_{0t,i}} \right) = \alpha_0 + \alpha_1 \ln GDP_{0t,i} * D_{T < 2004} + \alpha_2 \ln GDP_{0t,i} * D_{T \geq 2004} + \eta X_{it} + \alpha_3 D_{T \geq 2004} + \mu_i + \varepsilon_{it} \quad (2)$$

²³ Widely used five-year averages of the data would not work for this analysis, as the rule of thumb in case of using GMM methodology is that number of time periods should not be less than five.

²⁴ The difference between the regression coefficients based on annual and three-year averaged data is also confirmed in the current paper, but one should not rely on the estimates based on the yearly data as they are too influenced by the business cycles.

²⁵ Schonlau (2006) implementation for the Stata software.

Where, $\ln(GDP)_{Tt,i}$ is county i th natural logarithm of GDP per capita at PPP in the final year of the given sub-period t ($t=7$)²⁶. The key control variable of interest is given by $\ln GDP_{0t,i}$, representing the county i th natural logarithm of GDP per capita at PPP in the initial year of the given sub-period t . The number of years in each time interval is represented by N ($N=3$)²⁷. Therefore, the dependent variable can be read as the difference between the county i th natural logarithm of real GDP per capita levels in the final and the initial years of the given sub-period divided by three. $D_{T<2004}$ and $D_{T\geq 2004}$ are time dummies controlling before and after first eastward enlargement periods.

The inclusion of the interaction terms in the regression model improves the understanding of the relationships among different variables and makes it possible to test more hypothesis at the same time. In given specification of the model, α_1 represents the coefficient on the interaction term between initial real GDP per capita and dummy for before EU enlargement period, while α_2 gives the coefficient on another interaction term between the initial real GDP per capita and dummy for after EU enlargement period. Negative sign of α_1 and α_2 coefficients confirm the conditional convergence hypothesis, indicating the inverse relationship between the initial level and the growth rate of real GDP per capita. In other words, if $\alpha_1 < 0$ and $\alpha_2 < 0$, the higher is the initial real GDP per capita, the lower is its subsequent growth rate.

Given the estimated coefficients α_1 and α_2 from equation (2), one can calculate the value of the β coefficient for the pre and post-EU enlargement periods by the following formula²⁸ (Barro and Sala-i-Martin, 2003):

$$\beta = -\ln(1 + \alpha_{1/2}) \quad (4)$$

The β coefficient shows the speed of convergence by which the economy is covering the distance towards the steady state in one period. Parameter β will show if there were any changes in the speed of convergence within the samples of EU25 and EU22 countries before and after EU enlargement in 2004.

In the regression equation (2), the term ηX_{it} controls the set of structural characteristics of the economies and allows us to test the conditional convergence hypothesis. This study considers the following indicators as highly important in affecting the path of economic growth: Government consumption, Business enterprise R&D, Secondary education, EU structural funds payment, Government debt, Unemployment, Government effectiveness, Trade openness, Gross fixed capital formation, FDI, Inflation, and Population growth. All these economic growth determinants are transformed into three year averages. The chosen set of control variables are in line with the literature

²⁶ Instead of 21 years, there are only 7 years left after transforming the data into three-year sub-period averages.

²⁷ Due to the tree-year average transformation of the data.

²⁸ In the case of cross-sectional data the formula becomes: $\beta = -\frac{1}{T}\ln(1 + \alpha_1 T)$. For the panel data $T = 1$

review of empirical works. Following the economic theory, all variables are treated as endogenous, except for the population growth and time dummy. The list of all the variables used and their descriptive statistics are available in Appendix 5.

The choice of government consumption of goods and services, gross fixed capital formation, and trade openness is based on demand side effect of GDP equation²⁹. Instead of separately including export and import indicators in the model, the ratio of their sum to GDP is analysed which is a somewhat broader indicator, indirectly showing the size of the economy. Trade openness depicts the mindset of the economic policy of the countries being liberal or protectionist. It also shows how well the country is integrated with the global value chain. Among many authors, Edwards (1993) and Sachs and Warner (1995) were ones who found a positive relationship between economic growth and trade openness.

Other factors of interest, which are emphasised in economic theory as the crucial determinants of economic growth are human capital and R&D³⁰. In the endogenous growth theory, initiated by Romer (1986), new knowledge as a product of research activities turns to be an important indicator in explaining the economic growth. Compared to the other measures of R&D, this paper studies the impact of research and development performed by the business, which, to my knowledge, should better explain the competitiveness of the economy. Human capital is captured by the active population with completed upper or post-secondary education, since in some countries, Germany for example, it is the prevailing level of education, as they have occasional schools, which are preparing highly skilled labour for industry sector and these people rarely go to the university for a higher degree. Moreover, in the case of three levels of education (namely, primary, secondary and tertiary) the difference between the quality of primary and secondary education is bigger than the difference between secondary and tertiary education. In this respect, secondary education should have greater explanatory power on economic growth.

The choice of unemployment is based on a common view that it could negatively affect the long-term economic growth. Daveri and Tabellini (2000) argue that higher unemployment means lower saving and lower aggregate income, which therefore lead to less capital accumulation and lower economic growth. As for inflation, it is just the opposite side of the coin, taking into consideration the well-known Phillips curve, which shows the inverse relationship between unemployment and inflation. But this relationship is not stable in the long-run and these two indicators seem to be independent³¹. In the short-run, the cost of inflation may be compensated by the decrease in unemployment, but in the longer term inflationary processes deteriorates the economic environment through different channels, such as credit tightening, which lowers the investment rate and the economic growth, in turn (Burdekin, 2004).

²⁹ $GDP = C + I + G + (EX - IM)$, where C is private consumption, I- investment, G- government expenditure, EX- export, IM – import.

³⁰ See Aghion and Howitt (1992).

³¹ See, for example, Phelps (1968).

The inclusion of fiscal variable such as government debt to GDP ratio in the analysis is relevant since studied time span covers the economic crisis period, which had a significant impact on the euro area's fiscal sustainability. The euro area average general government gross debt ratio during 2003-2007 years rapidly increased from 68.6 % of GDP to 88.5 % of GDP in 2011³².

Foreign Direct Investments (FDI) is an essential type of capital movement which stimulates the economic growth through the transfer of new technology and knowledge from one country to another. Therefore, it should be controlled in the model. There are several factors that influence the relationship between FDI and economic growth, among them, are financial markets, human capital, openness to trade and political environment of the country (Almfraji and Almsafir, 2014).

The index of government effectiveness is included in the regression equation as an endogenous variable to control countries' institutional framework, which by Rodrick et al. (2004) is also modelled by country's income level and not just by its geography. Rodrik (2008) underlines the supporting role of the institutional framework for the long-term economic development. The importance of high-quality government for economic growth is deep-rooted empirical proposition by many authors³³. The decision of inclusion of this particular variable in the analysis also depends on the correlation table, which shows that the index of government effectiveness has a relatively high correlation between other five governance indicators and therefore should be a good representative of the institutional variables (see Appendix 6).

The study also examines the effect of EU structural funds net payment on economic growth. The European Union offers structural grants to enhance the social and economic integration in the union, hence it should have a positive impact on the process of convergence. A paper by Mohl and Hagen (2010) emphasise the problem of reverse causality between economic growth and structural funds, as the criteria of structural funds payment are connected with regional GDP per capita to the EU average level³⁴. The other factor that causes possible endogeneity according to these authors, is the fact that effective payments of the structural funds hardly depends on the country's capacity to co-finance the projects, which most likely will be influenced by the economic situation of this country itself.

The same paper above provides review table, which describes the previous works done to find the structural funds' impact on economic growth. Most of the papers focus generally on EU NUTS2 regions³⁵. The programming period 2007-2013 has ended and the new 2014-2020 programming period started, which is an advantage of this paper because most of the previous studies use structural funds data up to 2006³⁶. For this indicator, some studies use only dummy variable (1 for a country

³² See European Commission (2010), European Economic Forecast Spring 2010, European Economy 2|2010.

³³ See De Long and Shleifer (1993). See also Knack and Keefer (1995).

³⁴ Regions with real GDP per capita ratio below 75 % are qualified for the highest transfers under the Objective 1 (See also Becker et al., 2010).

³⁵ NUTS2: basic regions applicable for regional policies.

³⁶ Mohl and Hagen (2010) give very nice overview of previous works on the impact of structural funds on growth.

which receives support) instead of actual transfers' data which is their weakness. A couple of studies used data about structural funds divided by categories of expenditures (human capital, infrastructure, etc.). As this paper is based on country-level data, operating budgetary balance as % of GNI is used in the analysis.

The last variable controlled in this paper is population growth rate. From Solow model (1956), in line with neoclassical growth theory, we know this variable as one of the key determinants of economic growth that negatively affects the steady state income level. Population growth is assumed to be an exogenous variable as it influences the economic growth only in the long-term. It can impact on growth rate in the short-term only through immigration policy. After EU enlargement in 2004, only a few countries allowed free movement of labour, while most of the countries used a ban and it took them more than five years to liberalise the immigration policy. Hence, it would be wise to treat population growth as an exogenous variable in this analysis.

At first, unconditional (absolute) beta convergence was tested through graphical analysis. For the next step, the regression equation (2) was estimated for EU25 and EU22 country groups using the System Generalized Method-of-Moments (GMM) to control for country-specific effects and to deal with the highly possible endogeneity problem in the model. According to Blundell and Bond (1998), system GMM is preferred to the first difference GMM estimation, as the later suffers from weak instrumentation in the case of small datasets. One-step robust³⁷ GMM estimations are done according to the procedure described by Roodman (2006).³⁸ Endogenous variables are instrumented with both its lagged values and its differenced lags³⁹. At the bottom of all estimation tables, there are the regression characteristics and calculated values of the β coefficient presented. The latter defines the speed of convergence. Hansen J p-value suggests that the lagged control variables are valid instruments, while a serial correlation-AR(2) test shows that there is no second order autocorrelation in error terms⁴⁰.

In the end of the analysis, the sigma (σ)-convergence was tested and illustrated graphically after investigating the beta (β)-convergence hypothesis. Frequently used measures of sigma convergence are the coefficient of variation and standard deviation⁴¹. While there are not specified any clear preferences of using each method in the literature, this paper uses the standard deviation of the

³⁷ Robust estimates give consistent standard errors with heteroscedasticity and panel-specific autocorrelation in one-step GMM estimation.

³⁸ `xtabond2` with "collapse" option in stata14 is used to avoid over-instrumentation. Rule of thumb is that the instruments should be less than or equal to group number. After "collapse" option the number of instruments is still a bit greater than the number of groups, but the validity of instruments is confirmed by Hansen J statistics in all regression estimations, as the overidentifying restrictions are not rejected.

³⁹ Second lags of all endogenous variables are used as the instruments due to the small sample size.

⁴⁰ There is no collinearity problem in the model as none of the explanatory variables are dropped after running the command `xtabond2`.

⁴¹ See, for example, Simionescu (2014), Sorina and Mihaela (2013), Monfort, (2008) Varblane and Vahter (2005), Jelnikar and Murmayer (2006).

natural logarithm of real GDP per capita to observe the dispersion of income levels across different country groups around certain average. The standard deviation is calculated by the following formula:

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n}}$$

Where x is each value of GDP per capita at PPP in the dataset, \bar{x} is the mean of all these values and n^{42} – number of values in the dataset. As the robustness analysis, the coefficient of variation is also calculated⁴³.

4. Results

Before estimating the regression equation of conditional beta-convergence, discussed above, a graphical illustration of unconditional (absolute) convergence process is presented first. Figure 1 below shows the inverse relationship between the average annual growth rate and the initial level of real GDP per capita based on the cross-sectional data. The result approved the absolute convergence hypothesis in the sample of EU25 member states, stating that the countries with the lower initial level of real GDP per capita grew faster over the studied period. The result is in line with different empirical studies investigating the real convergence process in different groups of EU countries, including the new member states as well⁴⁴.

Two outlier countries, namely Ireland and Luxembourg, can be observed in Figure 1. The reason for Ireland's outstanding behaviour can be explained by the fact that the big part of its GDP is the result of value added produced by the foreign-owned companies located in Ireland. In other EU countries, the role of FDI is much lower, sometimes three-four times smaller and therefore Ireland has so extraordinarily high GDP per capita. Luxembourg is even different. The logic is the same but behind that are multinational financial institutions which are reporting their profits in Luxembourg while locating in different countries. In fact, the revenue generated by these institutions go away from Luxembourg, but it is recorded in the statistical office of this country, as the headquarters of these companies are registered in Luxembourg. The reason for that is low-income tax⁴⁵ and extremely low tax on dividends⁴⁶. This is a reason why Luxembourg is sometimes dropped from the analysis. Luckily, it is a small country and perhaps it should not change the obtained results too much, but as

⁴² In small samples the denominator becomes $n - 1$.

⁴³ The coefficient of variation is the ratio of the standard deviation (SD) to the mean.

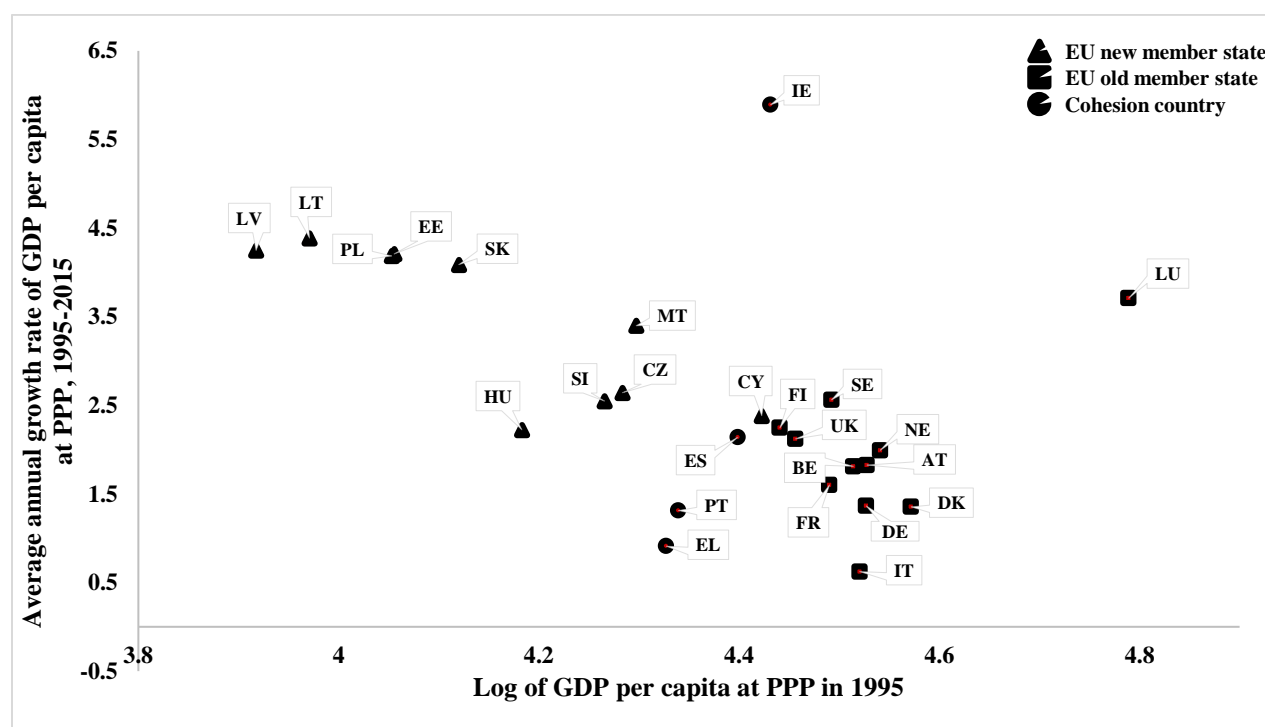
⁴⁴ See, for example, Halmai and Vásáry (2010), Vojinović and Oplotnik (2008), Matkowski & Próchniak (2007), Ranjpour and Zahra (2008), Varblane and Vahter (2005).

⁴⁵ It starts from 0% and is progressive up to 40%.

⁴⁶ 15% withholding tax on the dividends unless a lower tax rate applies according to an applicable tax treaty.

a sensitivity analysis, the regression equations were built also for the sample of EU24 and EU21 countries (excluding Luxembourg from EU25 and from EU22, respectively). More standard method of outlier detection is presented in section 5, which is devoted to the robustness analysis. The latter also provides a supplementary figure to justify why Ireland is kept in the sample.

Figure 1. Absolute β -convergence in EU25 countries based on cross-sectional data, 1995-2015



Source: Author's own calculation based on the World Bank data

More formal regression analysis of conditional beta convergence follows below. Table 1 gives system GMM estimates of regression equation (2), which tests the conditional convergence hypothesis within EU25 and EU22 countries. Negative and significant coefficients on initial GDP, support conditional convergence hypothesis in the sample of EU25 countries. Moreover, looking at the β coefficients at the bottom of the table, we can say that the speed of convergence in EU25 countries during the pre-EU enlargement period increased from 5.6% to 9.0% in post-EU enlargement period. The finding confirms the fact that the new member state underwent the successful pre-accession harmonisation process and after joining the EU they experienced quicker convergence towards the old member states. Obtained results are quite close to Prochniak and Wirkowski's (2014) finding of 6% annual rate of convergence in the sample of EU27.

The similar process of conditional convergence is observed in the sample of the EU22 countries, depicting the increased rate of convergence from 3.9% to 8.7% after the EU enlargement, though

the coefficient on initial real GDP per capita being insignificant during pre-accession period. On the other hand, the post-EU enlargement period is characterised by the lower speed of convergence of the newcomers towards the more advanced EU core countries. That supports the idea that the convergence process between the new EU10 and old EU15 member states was “stimulated” by the weakest peripheral cohesion countries.

Table 1. Conditional convergence before and after EU enlargement - System GMM

Dependent variable: Growth rate of real GDP per capita	(1) EU25 countries	(2) EU22 countries
Initial GDP before 2004	-0.054* (0.029)	-0.038 (0.033)
Initial GDP after 2004	-0.086** (0.034)	-0.083* (0.041)
Government debt	0.050*** (0.017)	0.046** (0.018)
Business enterprise R&D	-1.332 (1.293)	-0.926 (1.196)
EU structural funds payment	-0.177 (0.320)	-0.834 (0.506)
Government consumption	0.154 (0.346)	-0.067 (0.244)
Secondary education	-0.028 (0.071)	-0.021 (0.067)
Government effectiveness	0.035 (0.021)	0.027 (0.020)
Trade openness	0.023* (0.012)	0.020* (0.011)
Gross fixed capital formation	0.338* (0.181)	0.141 (0.189)
inflation	-0.557*** (0.127)	-0.490*** (0.170)
Unemployment	0.070 (0.151)	0.197 (0.216)
Foreign direct investments	-0.004 (0.013)	-0.008 (0.014)
Population growth	-0.421 (0.719)	-0.884 (0.832)
Time dummy (T ≥ 2004 = 1)	0.311 (0.299)	0.463 (0.316)
constant	0.417 (0.339)	0.334 (0.398)
Number of countries	25	22
Number of Observations	175	154
Number of instruments	29	29
Hansen Jpval	0.103	0.210
AR(2) pval	0.507	0.577
β coefficient before enlargement	5.6%	3.9%
β coefficient after enlargement	9.0%	8.7%

Note: * Significant at 10% ** Significant at 5% *** Significant at 1%. Robust standard errors in parentheses.
All the data are transformed into three-year sub-period averages

As a comparison, the regression equation (2) for the EU25 and EU22 countries is estimated also by fixed effects, random effects and pooled OLS models (see Appendix 7). According to the Breusch-Pagan test pooled OLS model is preferred to random effects model, though these two techniques give the same estimates in dynamic panel data, while F test suggests that fixed effects model is preferred to the pooled OLS model. Two benchmark models of conditional convergence estimated by system GMM and fixed effects model are similar in terms of the main result of the positive impact of the EU accession on the speed of convergence in both samples. Here again, a minor decrease in convergence rates is observed after excluding Portugal, Spain and Greece from the sample. But the scale of the coefficients on initial real GDP per capita, therefore the speed of convergence increased significantly in the fixed effect estimations, as the latter give downward biased coefficients.

Coming back to the main model presented in Table 1, the other control variables, with significant coefficients, mostly have the expected impact on economic growth. In column (1) and (2), significant and positive effect of trade openness is found, which is consistent with many authors' findings⁴⁷, indicating that the trade liberalisation plays an important role in promoting economic growth. More precisely, a one-percentage-point increase in trade openness ratio should result in a 0.02 percentage-point increase in real GDP per capita growth rate. There are different channels through which the openness to trade boost the growth rate and convergence, among them knowledge and technology transfer, increased competition in domestic markets and the possibility to use comparative advantage worldwide (Chapsa and Katrakilidis, 2014)⁴⁸.

Inflation appears to have strongly significant and negative impact on economic growth in both specifications of the model. The negative inflation-growth relationship was also found by Gillman et al. (2004), Vojinovic and Oplotnik (2008), Prochniak and Witkowski (2014) and many others. The importance of domestic investments in the sample of EU25 countries is approved by its positive and significant coefficient (0.338). The result is strongly in line with the findings of Vojinovic et al. (2010), Vamvakidis (2008) suggesting that a country with large domestic investment share grow faster *ceteris paribus*.

As for the government debt ratio, it has a positive and significant coefficient in this paper. It has been claimed that the public debt can influence positively on growth rate in the short-run through stimulation of aggregate demand (Elmendorf and Mankiw, 1999). However, in the long-run, this positive effect is outweighed by worsened economic performance in case of higher interest rates⁴⁹.

Regarding other explanatory variables, the insignificant effect of their coefficients does not necessarily mean that their role in endorsing economic growth and convergence process within EU25 and EU22 samples are irrelevant. Short time period analysed and therefore a small number of observations should have some impact on their coefficient estimates. On the other hand, the insignificant effect of the variable such as the EU structural funds can be explained by no possibility

⁴⁷ See for example Harrison, A. (1996), Prochniak and Witkowski (2014).

⁴⁸ See also Rodriguez (2007) who discusses the link between economic growth and openness.

⁴⁹ See, for example, Baldacci and Kumar (2010), Gale and Orszag (2003).

to distinguish between objectives while using country-level data. As Mohl and Hagen (2010) claim, it is only objective 1 payments that promote EU regions' growth, whereas no positive, nor significant effect of the total amount of other objectives is found on regional economic growth⁵⁰.

Confirming beta (β)-convergence hypothesis opens the door for testing sigma (σ)-convergence phenomenon across studied country groups. This type of convergence is calculated as a standard deviation of the natural logarithm of real GDP per capita in different groups of countries. In the case of decreasing dispersion, the countries are becoming similar in terms of real GDP per capita.

Table 2 below shows the average standard deviation in different groups of the EU member states pre and post-accession periods. Sigma (σ)-convergence is confirmed in all country groups except for the old member states, EU3, EU12, and EU15 countries, meaning that, on average, the old member states became different in per capita income terms in the post-enlargement period compared to the pre-enlargement period⁵¹. The EU12 group of countries is added to the analysis to see if economically poorly behaving cohesion countries, namely Spain, Greece and Portugal actually had an impact on the income variability in the old EU member states. It turns out that, indeed, they had an effect on it, as the group of EU15 countries is characterised by a higher level of the real GDP per capita dispersion compared to the EU12 countries. At the same time, the increased standard deviation from 0.09 to 0.10 in the group of EU12 countries hints at the existence of other sources of increasing income variability.

Table 2. Sigma (σ) – convergence within the EU before and after enlargement in 2004

Average std. dev of the ln (GDP per capita at PPP)		
Country group	1995-2003	2004-2015
EU3	0.04	0.05
EU10	0.14	0.07
EU12	0.09	0.10
EU15	0.11	0.12
EU22	0.21	0.15
EU25	0.20	0.15

Source: Author's own calculation based on the World Bank data

The dispersion of real GDP per capita in the new EU10 member states was halved after joining the EU⁵². The latter effect outweighs the increased standard deviation of real GDP per capita in older

⁵⁰ Objective 1 promotes the adjustment and development of laggard regions (the areas with a GDP to the EU average ratio less than 75%).

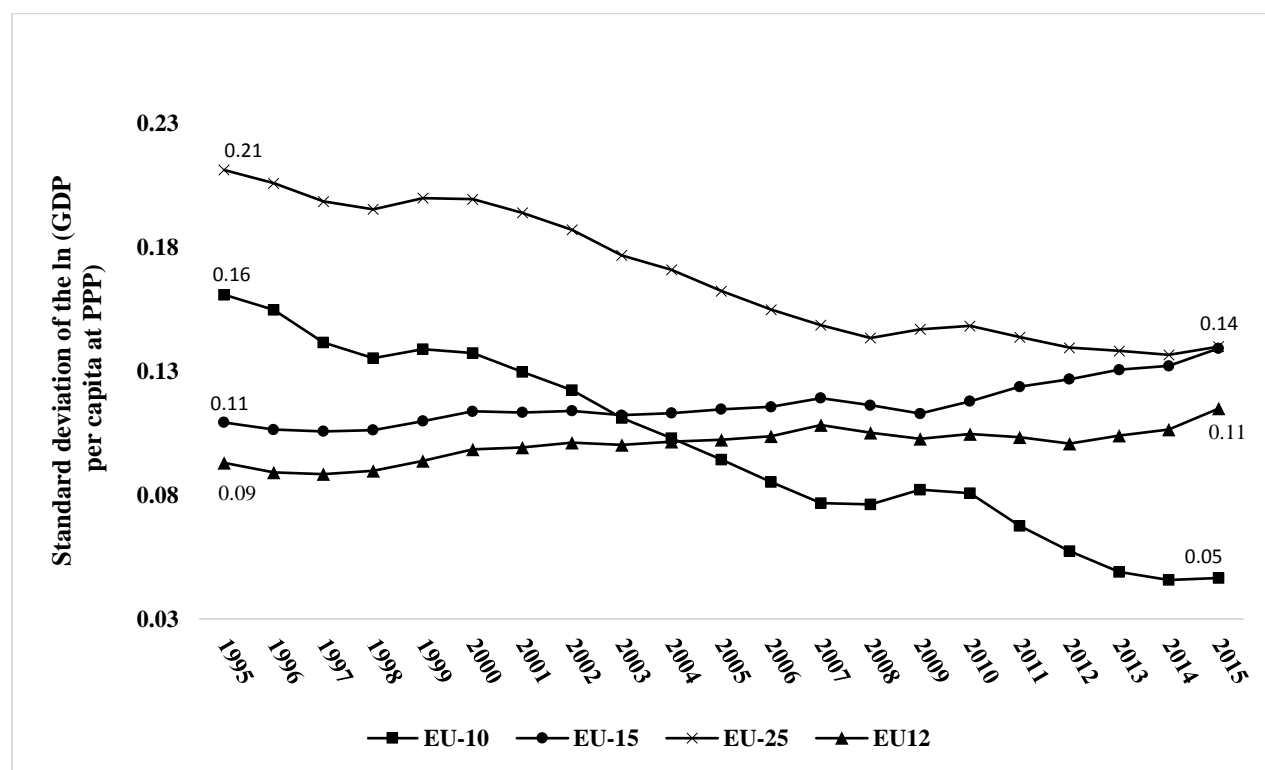
⁵¹ In this paper, the term "income per capita" applies only to per capita national income that can be used as a synonym for per capita GDP.

⁵² The result is consistent with the empirical findings of Vojinović et al. (2010), Varblane and Vahter (2005), Jelnikar and Murmayer (2006).

member states and results in decreased real income dispersion in the whole sample of EU25 and EU22 countries.

For better understanding, the dispersion of the real GDP per capita in some groups of countries given in Table 2 is also illustrated graphically for the whole studied period, 1995-2015. Looking at Figure 2 below, the opposite dynamics of the standard deviation of real GDP per capita in EU15 and EU10 countries results in sigma (σ)-convergence in EU25 countries. This leads to the conclusion that the new and old EU member states became similar in terms of the real GDP per capita. Comparing the groups of the old member states (EU15 and EU12), one can say that the cohesion countries increased the income dispersion level in the EU15 countries, as the latter lies above the EU12 level. On the other hand, increasing income dispersion in the group of EU12 countries indicates that it is not only the cohesion countries which made EU15 member states different in real GDP per capita terms. Intuitively, there are different types of random shocks that push the old member states apart.

Figure 2. Sigma (σ)-convergence in different groups of countries, 1995-2015



Source: Author's own calculation based on the World Bank data

5. Robustness check and breakdown analysis

The robustness analysis of the findings of unconditional and conditional convergence process is done in a number of ways. First, graphically confirmed absolute (unconditional) convergence was tested through a regression analysis based on equation (3):

$$\frac{1}{N} \ln \left(\frac{GDP_{T,t,i}}{GDP_{0,t,i}} \right) = \alpha_0 + \alpha_1 \ln GDP_{0,t,i} * D_{T < 2004} + \alpha_2 \ln GDP_{0,t,i} * D_{T \geq 2004} + \alpha_3 D_{T \geq 2004} + \mu_i + \varepsilon_{it} \quad (3)$$

Regression equations (2) and (3) differ in the set of explanatory variables included in the regression. None of the economic growth indicators other than initial income level is controlled in the equation (3), while equation (2) includes a different set of structural characteristics of the economy together with the initial income level. Negative sign of α_1 and α_2 coefficients in equation (3), confirm the absolute convergence hypothesis, indicating the inverse relationship between the initial level and the growth rate of real GDP per capita.

Second, the conditional convergence hypothesis with neoclassical Solow model's specification was tested, meaning that only population growth rate and domestic investments are controlled together with the initial real GDP per capita. That was followed by the regression analysis of equation (2) using the whole set of control variables presented above in line with endogenous growth model.

Appendix 8 shows system GMM estimates of all these three specifications of absolute and conditional convergence for EU25 and EU22 country groups. Absolute (unconditional) convergence was confirmed through regression analysis as well. In EU25 countries, the speed of convergence accounted for 1.6% and 2.4% before and after the EU enlargement, respectively. Very similar figures of absolute convergence are obtained for the sample of EU22 countries, where the speed of convergence increased from 1.6% to 2.6% after the EU 2004 enlargement.

Testing conditional convergence with Solow's specification leads to quite similar estimates of the initial real GDP per capita compared to absolute convergence model. Here again, higher speed of convergences is observed in both samples after the EU accession in 2004, confirming the positive effect of the fifth EU enlargement on the speed of convergence between the new and old member states.

Estimates of convergence coefficients in absolute and Solow's specifications of the model is quite close the uniform rate of convergence (2% per annum) stated by Quah (1996), but the same author is skeptical of this kind of uniformity across different economies and argues that the standard convergence findings of many researchers could be misleading, providing many examples through Monte Carlo simulation.

Turning to the main model of the conditional convergence with the endogenous specification, one can observe that the scale of coefficients of initial GDP per capita, therefore the speed of convergence are increased significantly in both samples of countries. EU25 countries experienced the increase in convergence rate from 5.6% to 9.0% during pre and post-EU enlargement periods, while in EU22 countries these figures accounted for 3.9% and 8.7%, respectively. It is evident that the convergence process is mainly stimulated by the knowledge-based aspects, human capital, proper institutional framework and many other economic indicators relevant for economic growth, which are not controlled in previous two model specifications. Even though, some of them have insignificant coefficients in this paper, dropping them from the analysis should yield omitted variable bias and reduce the speed of convergence.

For the next step of robustness analysis, Luxembourg as an outlier country is excluded from the samples of EU25 and EU22 countries⁵³ (see Appendix 9). The results still support the unconditional convergence hypothesis and once again demonstrate the positive impact of the EU enlargement on the speed of convergence. Though, dropping the outlier country increased the convergence coefficients for the studied samples in both periods, before and after the EU accession, respectively. The estimates for the groups of EU24 and EU21 countries, approves the validity of the idea about the poorly behaving cohesion countries' "positive" role in speeding up the convergence process between the new and more advanced old EU member states, as the coefficients of initial real GDP per capita decreased after excluding them from the sample.

Along with the results from the standard method of outlier detection, the study provides a supplementary figure to explain why Ireland was kept in the sample. After the crisis Irish economy started to recover in 2014 and demonstrated an extremely high increase in real GDP per capita level in 2015. Appendix 4.1 shows the dynamics of real GDP per capita average levels of the older member states, namely EU15, EU12, and EU11 countries in logarithmic scale. One can observe that EU12 average level, which is the group of old EU member states without cohesion countries, is far above EU15 average level, while EU11, the old EU member states excluding Ireland and the cohesion countries, almost overlaps the EU12 average level till 2014 and after that, it lays below the latter. Put differently, dropping Spain, Greece and Portugal from the sample actually increased the average level of EU old member states, whereas excluding Ireland from the analysis decreased the latter and it should be a wise decision to keep it in the sample of EU core countries.

For the following analysis, Italy is excluded from the sample of EU25, as it seems quite similar to the cohesion countries in terms of the real GDP per capita dynamics (see Appendix 3.1.). Thus, there is a doubt that along with Spain, Greece and Portugal it can also accelerate the speed of convergence between EU10 and EU15 member states. Increased estimates of the initial real per capita GDP coefficients after excluding Italy from the sample, eliminates the latter country's possible role in speeding up the convergence process between the new and old EU member states (see Appendix

⁵³ Applying the standard method of outlier detection, the lower and upper 5% quantiles showed that Luxembourg was the clear outlier in all studied periods, while Ireland was the outlier country only in two periods.

10). Particularly, dropping Italy from the analysis increased the speed of convergence from 5.6% to 6.7% and from 9% to 9.7% during the pre and post-EU 2004 enlargement, respectively. These results suggest keeping Italy in the sample of the old EU12 core countries.

For the robustness check of sigma (σ)-convergence in EU15, standard deviation of real GDP per capita was calculated separately for the countries belonging to the Eurozone⁵⁴ (with and without cohesion countries) and countries which are not in the euro area⁵⁵ to see if we can accuse euro in increasing income dispersion of the EU core member states (see Appendix 11). Indeed, the countries which are using euro as their national currency experienced increasing dispersion of real per capita income with some fluctuations starting from 1998 even without the cohesion countries, but the latter significantly increases the dispersion inside this group, making the Eurozone countries more different in terms of real GDP per capita. Whereas, the countries outside the Eurozone depicted decreasing dispersion of income.

The reason for increasing income variability could be the vulnerability of the Eurozone countries to different types of shocks. The European sovereign debt crisis in the cohesion countries plus Ireland and Cyprus which started since the end of 2009, should definitely have an impact on bad shock propagation in the rest of the Eurozone countries that could imply an increased income dispersion. More convincing argument belongs to Buscher (1999) who mentioned that EU15 countries did not meet the optimum currency area criteria⁵⁶ while participating in European Economic and Monetary Union (EMU). In particular, business cycles in these European countries was said to be similar in the timing, but substantial differences were found to exist in the degree of its dispersion around the mean.

Furthermore, under the common monetary policy implemented in EMU, the participating countries cannot use national instruments against the foreign shocks anymore. Instead, there are alternative adjustment mechanisms, such as labour and capital mobility along with wage and price flexibility that play an important role of shock absorbers. But as the same author claimed, European labour market mobility was rather low compared with the United States. The results of the above-mentioned paper lead to the high probability of asymmetric shocks associated with the EU15 countries. Hence, the common monetary policy under EMU could adversely affect the development of some smaller economies and lead to the higher variability of their DGP per capita levels.

This result supports the findings of section 4 and confirms that along with the cohesion countries there exist different forces that drive the EU old member states diverse in real GDP per capita terms. But one should be cautious not to mix the possible causes of the average real GDP per capita reduction and the income level diversity in the old member states. Put it differently, a variation of

⁵⁴ Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain.

⁵⁵ Denmark, United Kingdom, and Sweden.

⁵⁶ The often cited four criteria of OCA are: openness to increased labor mobility across the region; capital mobility and price and wage flexibility; currency risk sharing system between participants; similar business cycles.

countries' real GDP per capita levels around its mean value, does not necessarily reduce the average real GDP per capita level of these countries.

The robustness of sigma (σ)-convergence analysis in all country groups already discussed above is confirmed by the coefficient of variation, measuring the degree of variability of the real GDP per capita, which coincides the findings of the standard deviation (see Appendix 12).

6. Concluding remarks

This paper investigates the impact of the EU major 2004 enlargement on the pace of income convergence among EU25 countries through the means of beta (β) and sigma (σ)-convergence analysis. One of the main findings of this paper is that EU enlargement enhanced the speed of convergence within EU25 countries, as the convergence rates accounted for 5.6 % to 9.0 % during pre and post-enlargement periods, respectively. Convergence process was mainly stimulated by the knowledge-based aspects, human capital, proper institutional framework and many other economic indicators relevant for economic growth. The obtained results confirm the new EU member states' successful pre-accession harmonisation process as a result of seven years of negotiations with the EU under the "acquis communautaire", which lead to their quicker integration with the old EU15 countries after joining the Union.

In general, convergence analysis considers two groups of the "poor" and "rich" countries, where the convergence process of the poor towards the rich is measured. But now the issue is whether the target of the poor countries is changing. The analysed time span covers the economic crisis period, during which the weakest peripheral cohesion countries, namely Spain, Greece and Portugal experienced more prolonged deterioration of the economic situation. These countries were all the time growing at the declining pace after 2007, leading to the significant reduction in the average per capita income level of the old EU15 member states. The latter, which was always exceeding the average level of the real GDP per capita of the new EU10 member states, almost equated to it which, in turn, was also significantly decreased after the crisis. Under all these circumstances, the target for the EU newcomers was lowered, making it easier for them to converge faster to the old EU15 member states.

Using the first benchmark model for testing convergence hypothesis in the sample of EU25 countries gives the possibility to detect the new member states' convergence pattern in the enlarged EU during the pre and post-accession periods. The second benchmark model uses the sample of EU22 countries, that allows differentiating between the post-enlargement convergence rates characterised to the EU newcomers while converging towards the EU15 and more advanced European core countries (EU12). In this case, the findings of the role of the fifth EU enlargement on the convergence process

will be more or less free from the cohesion countries' influence and contribute to the previous literature in this sense.

System GMM estimates of conditional convergence hypothesis for EU22 countries give the lower convergence rate (8.7%) during the post-EU accession period, compared to the same estimate (9%) for the sample of EU25 countries, and therefore supported the weakest cohesion countries' "positive" role in accelerating the speed of convergence between the new and old EU15 member states.

Considered as a whole, European countries became more similar in real GDP per capita terms over the studied period. But the process somewhat differs for the new and old EU member states leading to two different phenomena behind this similarity. While, sigma convergence is found in the new EU10 countries, which were also catching up to the old member states, the latter countries experience sigma divergence, meaning that they became different in per capita income terms. At the same time, they are reducing the average speed of growth as the cohesion countries are falling back. Considering other forces of the old member states' income variability associated with the asymmetric shocks in the euro area, the dispersion of the real GDP per capita in the old EU15 member states was found to be mainly increased by the peripheral cohesion countries.

Confirming beta and sigma convergence in the samples of EU25 and EU22 countries is definitely positive but not very favourable outcome of this study, in the sense that the new EU10 and old EU15 member states are converging at a lower level of per capita income. It seems that there is still a long way left for the EU newcomers to cover towards the more advanced core members of the Union.

In the future, we can theoretically think about beta (β)-convergence without the real growth. In the conditions where the growth of the old member states is very slow or even disappearing the convergence may happen with the very minimum growth of the new member states, as the level of convergence target is decreasing. It is hypothetical situation but it seems to be possible in the future. If we think about the economic growth that is slowing down in many countries nowadays there could be some periods when this kind of aspect would be the main phenomenon. At the same time, it contradicts the whole theory around the beta convergence for which to be achieved the faster growth of the "poor" countries is needed compared to the "rich" countries' growth rate.

Regarding studied economic growth determinants, estimated coefficients turned out to be sensitive to different methods and model specifications used. The insignificance of some important indicators enhanced through the endogenous growth theory, such as human capital, for example, could be explained by the bad proxies used for measuring it. In particular, human capital represents more than just secondary or tertiary education and quality is not controlled via school enrolment rates⁵⁷. This comes as one of the limitations of the present paper. For improved analysis, future researchers should

⁵⁷ Tertiary education, for example, was found to have not significant and negative effect on economic growth in the study conducted by Prochniak and Witkowski (2014).

outline the better proxies for human capital, as far as the latter also includes the aspects of social capital and health, along with education.

Another constraint of this paper is an available time period for analysis. Despite the fact that more than 10 years already passed after the EU major enlargement in 2004, the larger is the time span used, the better it is for the analysis of the impact of the EU enlargement, as the integration is a dynamic process and some of the benefits of the membership come in later years after joining the Union.

Some of the possible extensions of this paper could be undertaken in the future. First, it would be interesting to conduct the similar analysis in addition with two following EU 2007 and 2013 enlargements which increased the number of Central and Eastern European countries in the EU. Latest three new entrants, namely Bulgaria, Romania and Croatia are quite similar to the EU10 countries and in the future, it makes sense to see how this groups together converge to the old EU member states and what is their role in enhancing the convergence pace in the European Union.

As for the previous enlargements, they were mostly political stories without any pre-harmonization process required before accession. Some countries, for instance, Greece, Spain and Portugal which came from dictatorship joined the Union very shortly right after becoming democratic countries. Background conditions of the previous enlargements are so different that it gives us less valuable information for analysing.

Furthermore, since the Eurozone countries from EU15 sample were found to have increasing income dispersion trend in this study, the future analysis could also consider the links between nominal and real convergence within the same sample. Looking at the relationship between these two types of convergence processes, one can observe both favourable and unfavourable effects of each process on another one. In particular, while the convergence in terms of income level stimulates the economic growth leading to the increased revenues and reduced public debt and budget deficit, at the same time, it can imply an increase in the price level that may start the inflationary process, which contradicts the Maastricht criteria⁵⁸ to maintain the price stability. Here one can ask questions on how the European Monetary System (EMS) and its rescue instruments are supporting countries to survive under heavy indebtedness and restore their economic growth. Observing all possible links between the real and nominal convergence should help to explain any delays or promptness in the process of real convergence and the other way round.

⁵⁸ The Maastricht convergence criteria was introduced in 1992 for the applicant EU member states willing to enter the Economic and Monetary Union, imposing strict control over the price and fiscal stability (Afxentiou, 2000).

Appendix 1. Sample countries

EU3	EU10	EU11	EU12	EU15	EU22	EU25
Greece (EL)	Estonia (EE)	Austria (AT)	Austria (AT)	Austria (AT)	EU25 countries excluding Greece, Spain and Portugal	(EU10 + EU15)
Portugal (PT)	Latvia (LV)	Belgium (BE)	Belgium (BE)	Belgium (BE)		
Spain (ES)	Lithuania (LT)	Denmark (DK)	Denmark (DK)	Denmark (DK)		
	Slovenia (SI)	Finland (FI)	Finland (FI)	Finland (FI)		
	Slovak Republic (SK)	France (FR)	France (FR)	France (FR)		
	Czech Republic (CZ)	Italy (IT)	Italy (IT)	Italy (IT)		
	Hungary (HU)	Sweden (SE)	Sweden (SE)	Sweden (SE)		
	Poland (PT)	Germany (DE)	Germany (DE)	Germany (DE)		
	Malta (MT)	Luxembourg (LU)	Luxembourg (LU)	Luxembourg (LU)		
	Cyprus (CY)	Netherlands (NL)	Netherlands (NL)	Netherlands (NL)		
		United Kingdom (UK)	United Kingdom (UK)	United Kingdom (UK)		
			Ireland (IE)	Ireland (IE)		
				Greece (EL)		
				Portugal (PT)		
				Spain (ES)		

Appendix 2: Main Results of the recent literature on the convergence process in the European Union

Paper by	General conclusions	Control variables used	Time period	Sample	Methods used
Vojinović et al. (2010)	Conditional convergence and sigma (σ) convergence	Log of GDP p.c. at PPP from the previous year; Gross fixed capital formation (% of GDP); Final consumption expenditure (% of GDP); General government balance (% of GDP); Exports of goods and services (% of GDP); Inflation rate (annual %).	1992–2006	EU10 ⁵⁹	Panel: FE; Coefficient of variation
Prochniak and Witkowski (2014)	Conditional convergence in EU27 and EU15	Lagged log GDP per capita at PPP (2005 constant prices); Interest rate (%); Inflation (annual %); Annual change (in percentage points) of domestic credit provided by the banking sector in percent of GDP; Money growth (in constant prices); Monetization ratio (broad money/GDP); Gross fixed capital formation (% of GDP); General government consumption expenditure (% of GDP); Openness ((exports + imports)/GDP); Net foreign direct investment inflow (% of GDP); Average years of total schooling (population ages 15+); Percentage of population (ages 15+) with completed tertiary education; Education expenditure (% of GNI); Services value added (% of GDP); Index of economic freedom; Democracy index: average of civil liberties and political rights; Log of life expectancy at birth (years); Log of fertility rate (births per woman); Population ages 15–64 (% of total); Log of population, total; Population growth (annual %); Log of population density (people per square kilometre).	1972–2010; 1993–2010	EU15; EU27	BMA; SYS-GMM
Gligoric (2014)	Absolute convergence before crisis; Club convergence after crisis;	Quarterly GDP p.c. at PPP	(1995–2008); (2008–2013)	EU23 + Norway	Panel unit root tests
Cavenaile and Dubois (2011)	Conditional convergence within the EU27; Significant β -convergence but different convergence rates within EU15 and EU10;	Initial GDP p.c. at PPP Population growth rate Investment (share of GDP)	1990–2007	EU27; EU15; EU10.	Panel: FE
Varblane and Vahter (2005)	Both unconditional and conditional type of beta convergence across the EU newcomers along with the existence of sigma convergence. Studied countries also converged toward the EU15 average level.	Log relative GDP p.c. at PPP to the EU15 average in the initial year of each sub-periods; Gross fixed capital formation; Share of people with upper secondary education; Openness of the economy (export to GDP ratio) Euromoney country credit risk ranking; Inflation rate (CPI); Total population completed at least upper secondary education (aged 25–64)	1993–2004;	CEE-8 + Romania and Bulgaria; EU15	Panel: FE; Standard deviation
Ranjipour and Zahra (2008)	EU10 converged towards the EU average income level in absolute terms.	Quarterly GDP p.c. at PPP	1995 - 2005	EU10; EU15; EU25	Panel unit root tests
Vojinović and Oplotnik (2008).	Unconditional convergence within the EU10 countries in the whole period except for the period of 1992–1997. Convergence rate increased over the following periods.	GDP levels from the preceding year/ GDP levels from the beginning of the period	1992–2006.	EU10	Panel: OLS/Cross-section: OLS

⁵⁹ The Czech Republic, Hungary, Poland, the Slovak Republic, Slovenia, Estonia, Latvia, Lithuania, Cyprus, and Malta.

Chapsa and Katrakilidis (2014)	No per capita income convergence between the EU-4 and EU10 country groups. The EU10 countries have already converged conditionally to the group average level, while there is a limited evidence for the EU-4 countries.	Log relative GDP p.c. at PPP to the group (EU14) average; Openness (total trade to GDP); FDI (share of GDP); Total Factor Productivity (index); Investment (% of GDP)	1950-2010	EU10 ⁶⁰ EU4 ⁶¹	Panel unit root tests; OLS
Borsi and Metiu (2014)	No evidence of real income per capita convergence within the EU. Instead, there are two separate subgroups, CEEC and the old EU member states converging to different steady state growth level.	Initial GDP p.c. at PPP; Total Factor Productivity	1970-2010; 1995-2010	EU21 ⁶² ; EU27 ⁶³	Panel: OLS; Panel unit root tests; Clustering algorithm
Amplatz (2003)	Convergence within CEE8 countries, but not between them and Western European countries.	Initial GDP p.c. at PPP; Physical capital stock per capital; Total factor productivity (TFP); The natural logarithm of average general government final consumption expenditure to GDP p.c. at PPP; Unemployment; Human capital per capita is estimated using life expectancy at birth and gross school enrolment (primary, secondary and tertiary)	1996 to 2000	CEE8 ⁶⁴ ;	A unit root test about a standard deviation time series of cross-sectional income per capita; OLS; WLS; WTLS
Jelnikar and Murmayer (2006)	Beta and sigma convergence were discovered in EU15 as well as in the group of EU10 countries. EU10 also converged to the average level of EU-15 countries.	Initial GDP p.c. Savings rate (as the share of GDP p.c.); Population in absolute numbers; Growth of productivity; Depreciation rate;	1995-2007 1950-2000	EU10 ⁶⁵ ; EU15	Standard deviation; Regression analysis (not specified method)
Vamvakidis (2008)	Convergence in emerging European economies occurred rapidly in recent years, but this process is expected to continue at a slower pace.	The logarithm of GDP p.c. at PPP in 1996; Demographic developments (age dependency ratio); Gross fixed capital formation(%of GDP); Foreign direct investment (% of GDP); University enrollment rate (proxy of human capital); Index of economic freedom in 1995 and its change during 1995-2005 (proxy of structural reforms) Regional dummy variables (for European transition economies and for African countries).	1996-2006	107 developed and developing countries	Cross-section: IV

Source: the author's own table

Notes: OLS: ordinary least squares, WLS: weighted least squares; WTLS: weighted two stage least squares; FE: fixed effects model, IV: instrumental variable, FD-GMM: first difference generalized method of moments estimator, SYS-GMM: system generalized method of moments estimator, BMA: Bayesian Model Averaging, CEEC=Central and Eastern European Countries.

⁶⁰ Austria, Belgium, Finland, Denmark, France, Germany, Italy, Sweden, the Netherlands, and the UK

⁶¹ Portugal, Ireland, Greece and Spain

⁶² Austria, Belgium, Bulgaria, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Spain, Sweden, and the United Kingdom

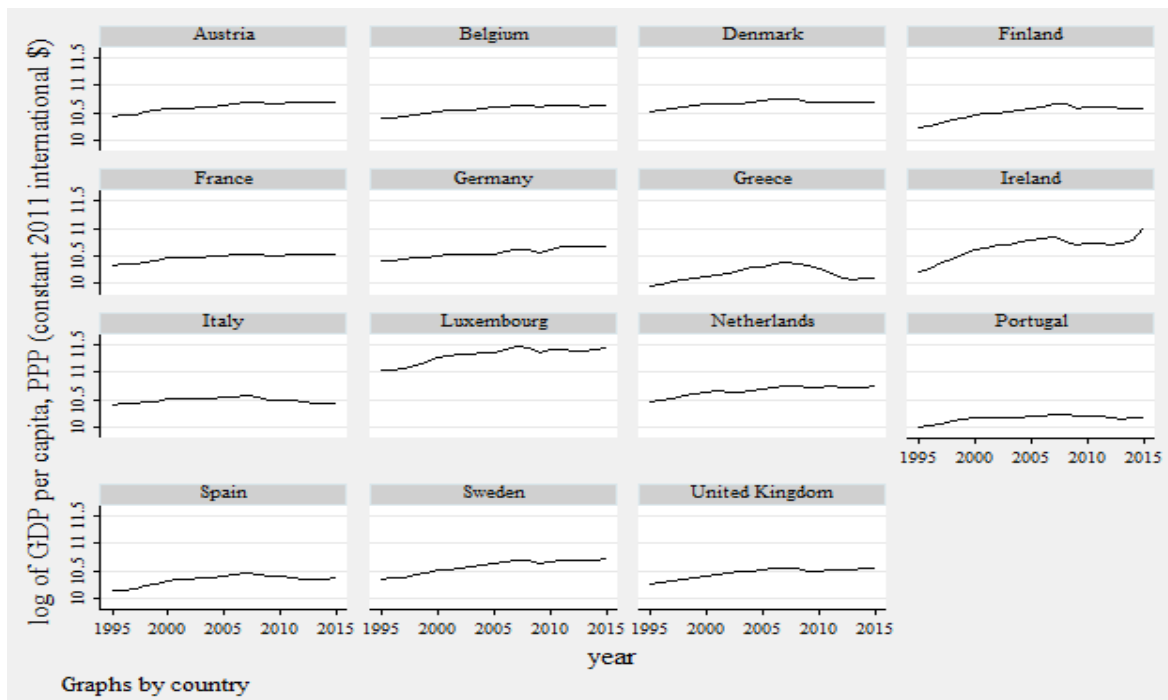
⁶³ EU-21 plus the Czech Republic, Estonia, Latvia, Lithuania, the Slovak Republic, and Slovenia

⁶⁴ The Czech Republic, Hungary, Poland, Estonia, Latvia, Lithuania, the Slovak Republic, and Slovenia

⁶⁵ The Czech Republic, Hungary, Poland, the Slovak Republic, Slovenia, Estonia, Latvia, Lithuania, Cyprus, and Malta

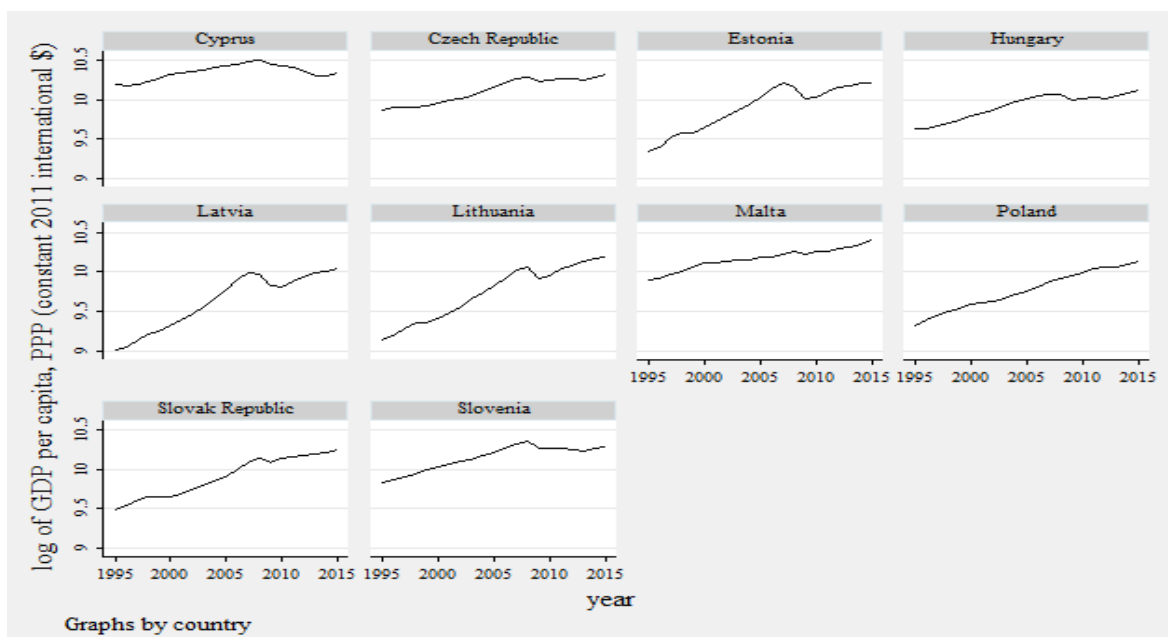
Appendix 3

Appendix 3.1. GDP per capita (PPP) dynamics in EU15 old member states, 1995-2015



Source: Author's own graph based on the World Bank data

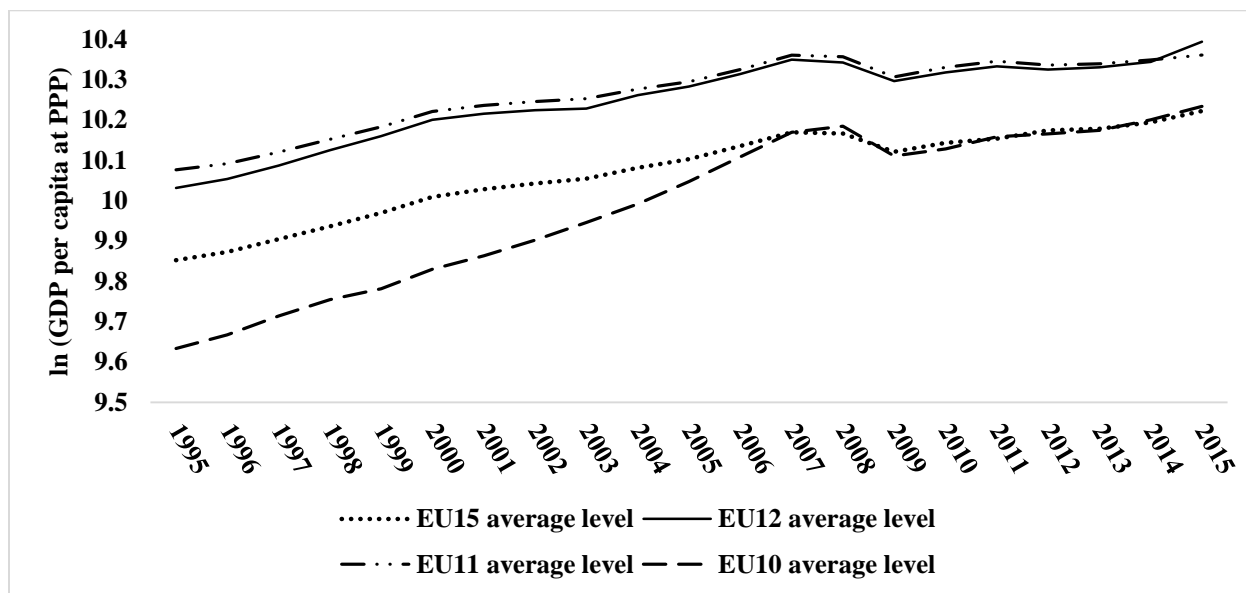
Appendix 3.2. GDP per capita (PPP) dynamics in EU10 new member states, 1995-2015



Source: Author's own graph based on the World Bank data

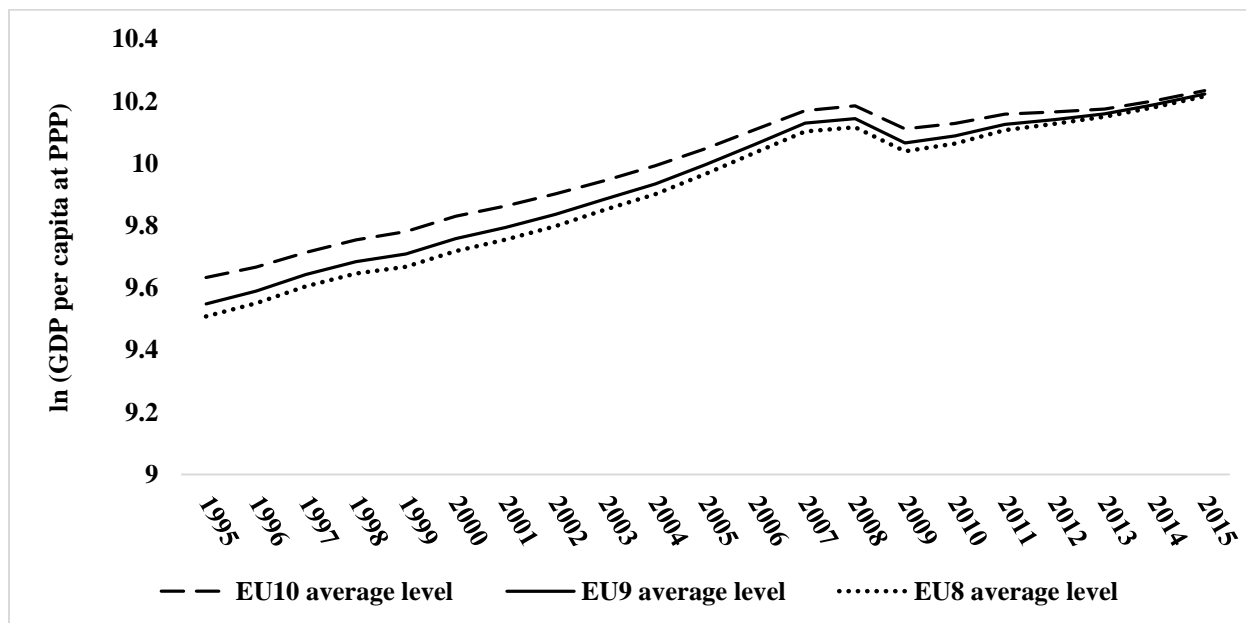
Appendix 4

Appendix 4.1. Dynamics of average real GDP per capita in the old EU member states, 1995-2015



Source: Author's own calculation based on the World Bank data

Appendix 4.2. Dynamics of average real GDP per capita in the new EU member states, 1995-2015



Source: Author's own calculation based on the World Bank data

Note: EU9: EU newcomers excluding Cyprus; EU8: EU newcomers excluding Cyprus and Slovenia.

Appendix 5

Appendix 5.1. Variable description and the data sources

Variable	Description	Source
Dependent variable		
Growth rate of real GDP per capita	The difference between the ln GDP per capita at PPP levels in the final and the first years of the given sub-period divided by three	The World Bank data
Endogenous independent variables		
ln (Initial GDP per capita at PPP)	Natural logarithm of GDP per capita at PPP (constant 2011 international \$) in the initial year of the given sub-period	The World Bank data
Initial GDP per capita before enlargement	The interaction term between the initial GDP and time dummy ($T < 2004$)	Author's calculation based on the World Bank data
Initial GDP per capita after enlargement	The interaction term between the initial GDP and time dummy ($T \geq 2004$)	Author's calculation based on the World Bank data
Government consumption	General government final consumption expenditure (% of GDP)	The World Bank data
Government debt	General government consolidated gross debt (% of GDP)	Eurostat
Business enterprise R&D	Business enterprise R&D (% of GDP)	Eurostat
Secondary education	Percentage of population (Y15-64) with completed upper or post-secondary education	Eurostat
EU structural funds payment	Operating Budgetary Balance (% of GNI). Net payment (EU operating expenditure allocated to the member states minus member states' share of national contribution to the EU budget)	European Commission
Government effectiveness	Measures the quality of public services, the quality of the civil service, and its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance	The Worldwide Governance Indicators (WGI) Dataset ⁶⁶
Unemployment	Unemployment, total (% of total labor force)	The World Bank data
Trade openness	Total trade (export + import) % of GDP	The World Bank data
Gross Fixed capital formation	Gross fixed capital formation (% of GDP)	The World Bank data
Foreign Direct Investment	Foreign direct investment, net inflows (% of GDP)	The World Bank data
Inflation	Inflation, consumer prices (annual %)	The World Bank data
Exogenous independent variable		
Population growth	Population growth rate (annual %)	The World Bank data

⁶⁶ WGI data are gathered through surveys and evaluations conducted with various international and non-governmental organizations, think tanks, public officials, and aid donors. Also, doing business in the country is assessed. The resulting data are then used to evaluate different dimensions of governance, one of which is government effectiveness.

Appendix 5.2. Descriptive Statistics

Variable	Number of Observations	Mean	Std. Dev.	Minimum	Maximum
Growth rate of real GDP per capita	175	0.013	0.023	-0.070	0.102
Initial GDP per capita at PPP	175	33166.19	13964	9424.090	92468.100
Government consumption	175	19.957	2.723	13.071	26.986
Government debt	174	56.457	31.906	4.667	178.167
Business enterprise R&D	168	0.908	0.690	0.030	2.690
Secondary education	167	45.429	14.006	13.400	72.200
EU structural funds payment	160	0.585	1.196	-0.540	5.440
Government effectiveness	150	1.275	0.538	0.060	2.260
Unemployment	175	8.902	4.240	2.300	25.200
Trade openness	175	111.441	62.687	37.959	374.373
Gross fixed capital formation	175	22.440	3.712	11.765	33.805
Foreign Direct Investment	171	10.026	29.036	-4.570	370.337
Inflation	175	3.178	3.770	-1.323	24.384
Population growth	175	0.303	0.721	-1.691	2.696

Note: All the data are transformed into three-year sub-period averages

Appendix 5.3. Correlation table

Correlation table	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Growth rate of real GDP per capita (1)	1													
ln(Initial GDP per capita at PPP) (2)	-0.3595	1												
Government debt (3)	-0.3356*	0.1883*	1											
Business enterprise R&D (4)	-0.2133*	0.5989*	0.0404	1										
Secondary education (5)	0.1712*	-0.3305*	-0.3527*	0.0561	1									
EU structural funds payment (6)	0.0384	-0.3206*	0.0209	-0.3997*	0.1339*	1								
Government consumption (7)	-0.2758*	0.0537	0.1182*	0.4840*	0.0705	-0.2559*	1							
Government effectiveness (8)	-0.1480*	0.7165*	-0.0846	0.7405*	-0.2442*	-0.4999*	0.3069*	1						
Unemployment (9)	-0.0259	-0.4725*	0.2226*	-0.3033*	0.0258	0.3022*	0.0115	-0.4480*	1					
Trade openness (10)	0.0988*	0.2737*	-0.2700*	-0.0703	-0.0298	0.0766	-0.2644*	0.0525	-0.2570*	1				
Gross Fixed capital formation (11)	0.3291*	-0.3033*	-0.4966*	-0.1312*	0.2682*	0.0205	-0.1189*	-0.1551*	-0.1937*	-0.0002	1			
Foreign Direct Investment (12)	0.0016	0.0842	-0.0093	-0.0882	-0.1932*	-0.0065	-0.0847	0.023	-0.1059*	0.3714*	-0.0443	1		
Inflation (13)	0.1945*	-0.4798*	-0.2540*	-0.3077*	0.1938*	-0.0645	0.0144	-0.3137*	0.0813	-0.0600	0.2433*	-0.0268	1	
Growth rate of Population growth (14)	-0.2199*	0.6451*	0.0621	0.2188*	-0.4217*	-0.3917*	-0.1928*	0.4474*	-0.4223*	0.2734*	-0.0682	0.1265*	-0.2513	1

Note: * significant at 5%. Pearson's pairwise correlation.

Appendix 6. Correlation between World Governance Indicators

Correlation table	(1)	(2)	(3)	(4)	(5)	(6)
Government Effectiveness (1)	1					
Political Stability and Absence of Violence/Terrorism (2)	0.6014*	1				
Regulatory Quality (3)	0.8795*	0.5977*	1			
Rule of Law(4)	0.9385*	0.6069*	0.9065*	1		
Control of Corruption (5)	0.9393*	0.5867*	0.8834*	0.9468*	1	
Voice and accountability (6)	0.2512*	0.0711	0.1702*	0.2302*	0.2042*	1

Note: * significant at 5%. Pearson's pairwise correlation.

Appendix 7. Conditional convergence before and after EU enlargement – two benchmark models

Dependent variable: Growth rate of real GDP per capita	EU25			EU22		
	(FE5)	(RE)	(OLS)	(FE)	(RE)	(OLS)
Initial GDP before 2004	-0.153*** (0.016)	-0.042*** (0.009)	-0.042*** (0.009)	-0.150*** (0.017)	-0.039*** (0.010)	-0.039*** (0.010)
Initial GDP after 2004	-0.172*** (0.018)	-0.047*** (0.010)	-0.047*** (0.010)	-0.171*** (0.019)	-0.052*** (0.012)	-0.052*** (0.012)
Government debt	0.006 (0.013)	0.003 (0.007)	0.003 (0.007)	0.013 (0.013)	0.003 (0.007)	0.003 (0.007)
Business enterprise R&D	-0.417 (0.751)	0.192 (0.440)	0.192 (0.440)	-0.316 (0.784)	0.257 (0.457)	0.257 (0.457)
EU structural funds payment	-0.051 (0.277)	-0.253 (0.194)	-0.253 (0.194)	-0.189 (0.293)	-0.492** (0.249)	-0.492** (0.249)
Government consumption	-0.365** (0.141)	-0.248*** (0.074)	-0.248*** (0.074)	-0.415*** (0.152)	-0.248*** (0.077)	-0.248*** (0.077)
Secondary education	0.002 (0.049)	0.007 (0.014)	0.007 (0.014)	0.025 (0.052)	0.008 (0.019)	0.008 (0.019)
Government effectiveness	0.033*** (0.012)	0.018*** (0.006)	0.018*** (0.006)	0.032** (0.014)	0.018*** (0.007)	0.018*** (0.007)
Trade openness	0.046*** (0.010)	0.011*** (0.003)	0.011*** (0.003)	0.041*** (0.011)	0.014*** (0.004)	0.014*** (0.004)
Gross fixed capital formation	0.082 (0.083)	-0.015 (0.049)	-0.015 (0.049)	0.011 (0.088)	-0.055 (0.057)	-0.055 (0.057)
inflation	-0.179*** (0.049)	-0.084 (0.052)	-0.084 (0.052)	-0.167*** (0.051)	-0.070 (0.054)	-0.070 (0.054)
Unemployment	-0.180** (0.082)	0.011 (0.048)	0.011 (0.048)	-0.136 (0.090)	0.058 (0.065)	0.058 (0.065)
Foreign direct investments	-0.002 (0.005)	-0.004 (0.006)	-0.004 (0.006)	-0.004 (0.005)	-0.006 (0.006)	-0.006 (0.006)
Population growth	-1.078** (0.498)	-0.473 (0.343)	-0.473 (0.343)	-1.100** (0.538)	-0.643* (0.366)	-0.643* (0.366)
Time dummy (T ≥ 2004 = 1)	0.203* (0.103)	0.040 (0.101)	0.040 (0.101)	0.241** (0.108)	0.133 (0.113)	0.133 (0.113)
constant	1.568*** (0.163)	0.466*** (0.099)	0.466*** (0.099)	1.543*** (0.179)	0.429*** (0.108)	0.429*** (0.108)
Number of countries	25	25	25	22	22	22
Number of Observations	175	175	175	154	154	154
R-squared	0.576	0.397	0.397	0.583	0.403	0.403
Hausman (p-value)/F test	0.000 / 0.000			0.054/0.000		
Breusch-Pagan (p-value)	1.000			1.0000		
β coefficient before enlargement	16.6%	4.3%	4.3%	16.3%	4.0%	4.0%
β coefficient after enlargement	18.9%	4.8%	4.8%	18.8%	5.3%	5.3%

Note: * Significant at 10% ** Significant at 5% *** Significant at 1%. Robust standard errors in parentheses. All the data are transformed into three-year sub-period averages

Appendix 8. Absolute and conditional specifications of convergence process – system GMM

Dependent variable: Growth rate of real GDP per capita	EU25			EU22		
	Absolute convergence	Solow's specification of conditional convergence	Endogenous specification of conditional convergence	Absolute convergence	Solow's specification of conditional convergence	Endogenous specification of conditional convergence
Initial GDP before 2004	-0.016*** (0.005)	-0.012** (0.005)	-0.054* (0.029)	-0.016*** (0.004)	-0.015*** (0.005)	-0.038 (0.033)
Initial GDP after 2004	-0.024*** (0.007)	-0.019** (0.007)	-0.086** (0.034)	-0.026*** (0.006)	-0.025*** (0.008)	-0.083* (0.041)
Gross fixed capital formation		-0.050 (0.071)	0.338* (0.181)		-0.161** (0.057)	0.141 (0.189)
Population growth		-0.377** (0.149)	-0.421 (0.719)		-0.394* (0.200)	-0.884 (0.832)
Government debt			0.050*** (0.017)			0.046** (0.018)
Business enterprise R&D			-1.332 (1.293)			-0.926 (1.196)
EU structural funds payment			-0.177 (0.320)			-0.834 (0.506)
Government consumption			0.154 (0.346)			-0.067 (0.244)
Secondary education			-0.028 (0.071)			-0.021 (0.067)
Government effectiveness			0.035 (0.021)			0.027 (0.020)
Trade openness			0.023* (0.012)			0.020* (0.011)
Inflation			-0.557*** (0.127)			-0.490*** (0.170)
Unemployment			0.070 (0.151)			0.197 (0.216)
Foreign direct investments			-0.004 (0.013)			-0.008 (0.014)
Time dummy (T ≥ 2004 = 1)	0.066 (0.041)	0.063 (0.045)	0.311 (0.299)	0.089** (0.034)	0.102** (0.045)	0.463 (0.316)
constant	0.186*** (0.046)	0.157*** (0.052)	0.417 (0.339)	0.186*** (0.045)	0.208*** (0.057)	0.334 (0.398)
Number of countries	25	25	25	22	22	22
Number of Observations	175	175	175	154	154	154
Number of instruments	30	21	29	30	21	29
Hansen Jpval	0.533	0.075	0.103	0.711	0.145	0.210
AR(2) pval	0.517	0.518	0.507	0.366	0.468	0.577
β coefficient before enlargement	1.6%	1.2%	5.6%	1.6%	1.5%	3.9%
β coefficient after enlargement	2.4%	1.9%	9.0%	2.6%	2.5%	8.7%

Note: * Significant at 10% ** Significant at 5% *** Significant at 1%. Robust standard errors in parentheses. All the data are transformed into three-year sub-period averages

Appendix 9. Conditional convergence before and after EU enlargement -System GMM

	(1)	(2)	(3)	(4)
Dependent variable: Growth rate of real GDP per capita	EU25 countries	EU24 countries (excluding Luxembourg)	EU22 countries	EU21 countries (excluding Luxembourg)
Initial GDP before 2004	-0.054* (0.029)	-0.092*** (0.028)	-0.038 (0.033)	-0.073* (0.039)
Initial GDP after 2004	-0.086** (0.034)	-0.125*** (0.035)	-0.083* (0.041)	-0.115*** (0.041)
Government debt	0.050*** (0.017)	0.058** (0.023)	0.046** (0.018)	0.048* (0.024)
Business enterprise R&D	-1.332 (1.293)	-0.918 (1.214)	-0.926 (1.196)	-0.326 (1.213)
EU structural funds payment	-0.177 (0.320)	0.111 (0.380)	-0.834 (0.506)	-0.681 (0.469)
Government consumption	0.154 (0.346)	0.157 (0.400)	-0.067 (0.244)	-0.201 (0.245)
Secondary education	-0.028 (0.071)	-0.035 (0.061)	-0.021 (0.067)	-0.037 (0.048)
Government effectiveness	0.035 (0.021)	0.048* (0.024)	0.027 (0.020)	0.037 (0.025)
Trade openness	0.023* (0.012)	0.004 (0.015)	0.020* (0.011)	0.004 (0.010)
Gross fixed capital formation	0.338* (0.181)	0.329 (0.214)	0.141 (0.189)	0.069 (0.224)
Inflation	-0.557*** (0.127)	-0.579*** (0.129)	-0.490*** (0.170)	-0.494** (0.184)
Unemployment	0.070 (0.151)	-0.011 (0.116)	0.197 (0.216)	0.111 (0.191)
Foreign direct investments	-0.004 (0.013)	-0.009 (0.010)	-0.008 (0.014)	-0.017* (0.008)
Population growth	-0.421 (0.719)	-0.405 (0.689)	-0.884 (0.832)	-1.052 (0.703)
Time dummy (T ≥ 2004 = 1)	0.311 (0.299)	0.335 (0.311)	0.463 (0.316)	0.441 (0.296)
constant	0.417	0.801**	0.334	0.745*
Number of countries	25	24	22	21
Number of Observations	175	168	154	147
Number of instruments	29	29	29	29
Hansen Jpval	0.103	0.085	0.210	0.425
AR(2) pval	0.507	0.768	0.577	0.894
β coefficient before enlargement	5.6%	9.7%	3.9%	7.6%
β coefficient after enlargement	9.0%	13.4%	8.7%	12.2%

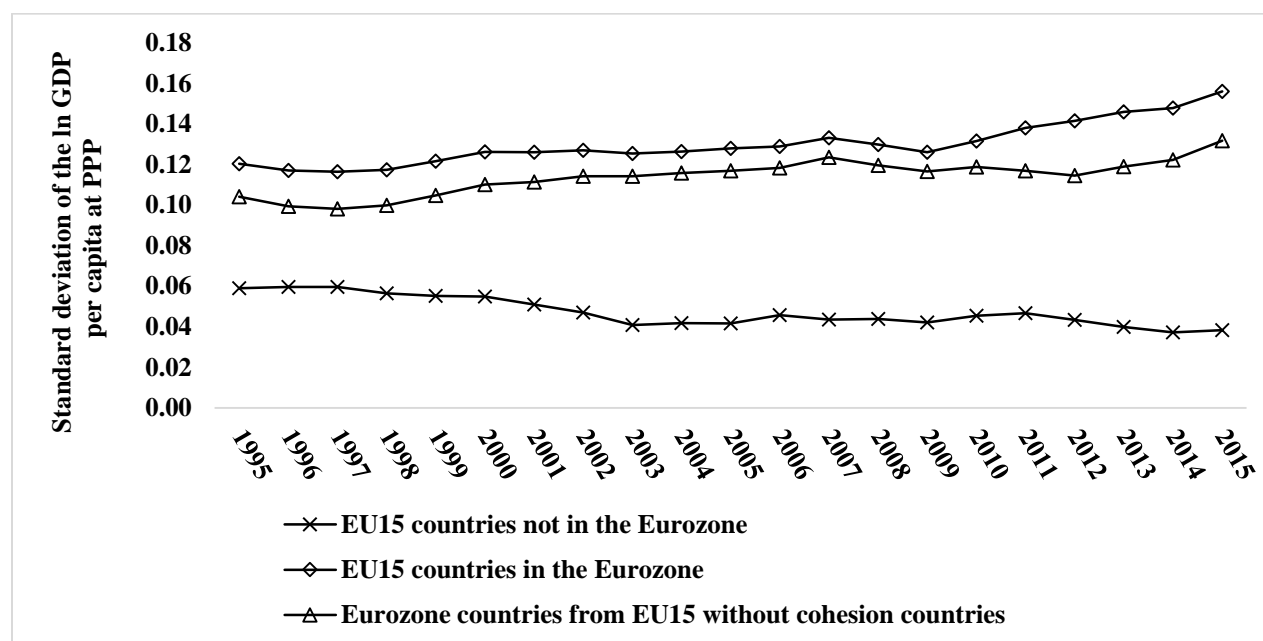
Note: * Significant at 10% ** Significant at 5% *** Significant at 1%. Robust standard errors in parentheses. All the data are transformed into three-year sub-period averages

Appendix 10. Conditional convergence before and after EU enlargement – System GMM

Dependent variable: Growth rate of real GDP per capita	(1) EU25 countries	(2) EU24 countries (excluding Italy)
Initial GDP before 2004	-0.054* (0.029)	-0.065** (0.028)
Initial GDP after 2004	-0.086** (0.034)	-0.092*** (0.032)
Government debt	0.050*** (0.017)	0.038** (0.017)
Business enterprise R&D	-1.332 (1.293)	-0.917 (1.300)
EU structural funds payment	-0.177 (0.320)	-0.155 (0.335)
Government consumption	0.154 (0.346)	0.088 (0.321)
Secondary education	-0.028 (0.071)	-0.044 (0.074)
Government effectiveness	0.035 (0.021)	0.038* (0.021)
Trade openness	0.023* (0.012)	0.024** (0.012)
Gross fixed capital formation	0.338* (0.181)	0.287* (0.164)
inflation	-0.557*** (0.127)	-0.534*** (0.127)
Unemployment	0.070 (0.151)	0.084 (0.158)
Foreign direct investments	-0.004 (0.013)	-0.003 (0.014)
Population growth	-0.421 (0.719)	-0.442 (0.679)
Time dummy (T ≥ 2004 = 1)	0.311 (0.299)	0.275 (0.287)
constant	0.417 (0.339)	0.546* (0.313)
Number of countries	25	24
Number of Observations	175	168
Number of instruments	29	29
Hansen Jpval	0.103	0.237
AR(2) pval	0.507	0.701
β coefficient before enlargement	5.6%	6.7%
β coefficient after enlargement	9.0%	9.7%

Note: * Significant at 10% ** Significant at 5% *** Significant at 1%. Robust standard errors in parentheses. All the data are transformed into three-year sub-period averages

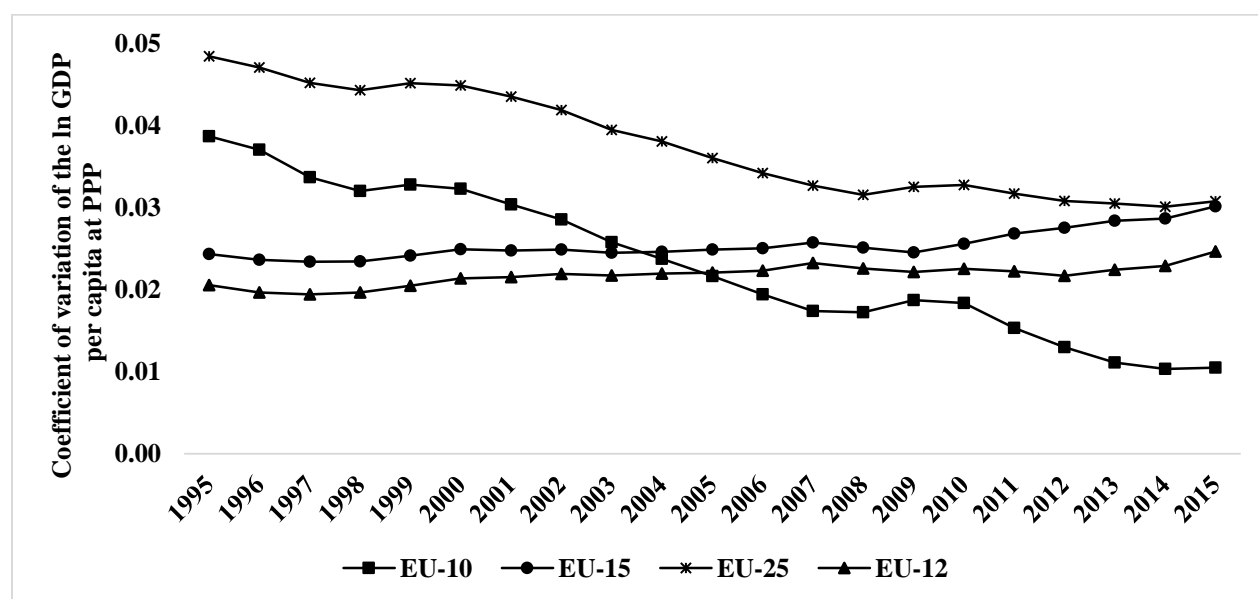
Appendix 11. Sigma (σ)-convergence in EU15 Eurozone and non-Eurozone countries, 1995-2015



Source: Author's own calculation based on the World Bank data

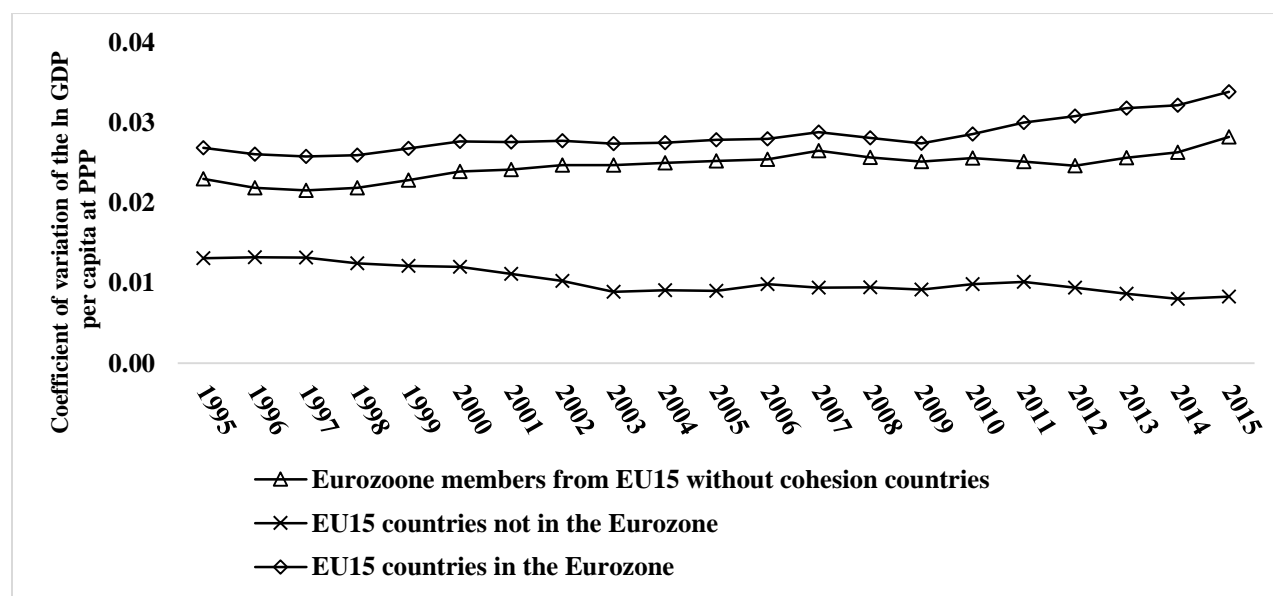
Appendix 12

Appendix 12.1. Sigma (σ)-convergence in different groups of countries, 1995-2015



Source: Author's own calculation based on the World Bank Data.

Appendix 12.2. Sigma (σ)-convergence in EU15 Eurozone and non-Eurozone countries, 1995-2015



Source: Author's own calculation based on the World Bank Data.

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