Matkowski, Zbigniew; Prochniak, Mariusz; Rapacki, Ryszard

Conference Paper — Manuscript Version (Preprint)

Real Income Convergence between Central Eastern and Western Europe: Past, Present, and Prospects

PAPER PRESENTED

at the 33rd CIRET

(Centre for International Research on Economic Tendency Surveys)

Conference

on *Economic Tendency Surveys and Economic Policy*

Copenhagen, Denmark, September 14 - September 17, 2016

Real Income Convergence between Central Eastern and Western Europe: Past, Present, and Prospects

Zbigniew Matkowski, Mariusz Próchniak, Ryszard Rapacki

Warsaw School of Economics, Poland

e-mail: zme2@sgh.waw.pl, mproch@agh.waw.pl, rrapacki@sgh.waw.pl

Abstract

The paper presents an analysis of real income convergence between the 11 countries of Central Eastern Europe which have joined the European Union (EU11) and 15 countries of Western Europe (EU15) in the period 1993-2015. The evolution of the income gap between the two groups of countries in terms of GDP per capita at PPP reveals a clear-cut tendency towards income convergence over the analyzed period, confirmed also by the results of β- and σ-convergence tests. However, the catching-up process was not continuous, showing some breaks and divergence episodes. The most intensive convergence appeared in the years 2000-2007, just before and after the EU's major enlargement. This suggests that the increasing economic integration stimulated the convergence process. But the global economic crisis, along with financial perturbations in the euro area, have slowed down the convergence in most CEE countries, as reflected by changes in the income gap observed in the years 2007-2015.

The paper also presents some projections of the convergence prospects, with three scenarios as to the future economic growth. The first two scenarios assume the continuation of past or current growth trends and the maintenance of positive growth rate differentials, indicating the probable length of the period needed by the individual CEE countries to attain the average GDP per capita level seen in Western Europe. The third scenario, based on a long-term economic forecast for the EU economies, warns that economic growth in the region may slow down due mainly to unfavorable demographic trends, with the resulting deceleration of the convergence process, up to its total halt or reversal into divergence. Proper social and economic policies are needed, both on the country level and in the framework of the common European policy, in order to assure a healthy economic growth in the CEE area and to maintain the convergence process within the EU.

Key words: economic growth, income convergence, European Union, forecasting (simulation)

JEL classification: C21, F15, F17, F43, F47, O52

Introduction

This paper tries to assess the past and current trends, as well as possible future prospects, of real income convergence between the 11 countries of Central and Eastern Europe (CEE) which have accessed the European Union (EU11) and the 15 countries of Western Europe (EU15) which represent the EU's "old core". The paper is a follow-up study to our earlier analyses on the same subject, but it extends significantly the discussion and brings new results based on updated statistical data.[1]

The paper is composed of four parts. Section 1 depicts the theoretical background and brings a concise overview of the previous empirical research. Section 2 describes the convergence process between the EU11 countries and the EU15 group in the period 1993-2015 by comparing the GDP growth rates, and shows the evolution of the income gap measured by the ratio of GDP per capita calculated at PPP; it also shows the basic difference between the GDP per capita estimates made at purchasing power parity (PPP) and at current exchange rates (CER) for the countries concerned. Section 3 brings a formal analysis of β- and σ-convergence over the whole period and in three subperiods distinguished in order to assess the impact of the EU enlargement on convergence and the effects of the global crisis. Section 4 presents some simulative forecasts of the possible future course of income convergence between the CEE countries and the EU15 group. The conclusion summarizes main findings.[2]

1.Theoretical background and empirical evidence

1.1. Theoretical background

Income-level convergence is the main aspect of economic convergence among countries and regions. Income convergence between economies occurs if poorer countries grow more rapidly than the richer ones. The *convergence hypothesis* assumes that less developed countries, with lower per capita income, tend to grow faster than do the more developed ones, with higher per capita income. As a result, the income gap between the rich and poor countries will narrow over time. In its strongest version, the convergence hypothesis posits that, in the long run, all economies will converge to the same development level, with equal average output per worker and equal average income per inhabitant.

[1] Some of the results have been already presented in a pilot study published elsewhere (Matkowski, Próchniak, Rapacki 2016), but in a different and shorter form.

[2] The concept of the paper was developed by all the three authors who share the responsibility for its contents, but the exact labor division in preparing the paper was as follows: part 1 – Z. Matkowski and M. Próchniak; part 2 – Z. Matkowski, M. Próchniak and R. Rapacki; part 3 – Z. Matkowski and M. Próchniak; part 4 – Z. Matkowski; this introduction and conclusions were written collectively.

Income convergence, or more precisely conditional income convergence, is directly implied by the neoclassical growth models (Solow 1956, 1957; Swan 1956). These models suggest that, given the same exogenous technology, savings rate and population growth, countries with lower per capita income and lower capital per worker (but with enough labor and other resources) will grow faster because they offer higher returns to capital, which attracts foreign investments, assuring thereby a higher accumulation rate and faster output growth. The negative relationship between the initial income level and the growth rate has been confirmed for a large sample including about 100 countries by Barro (1991), and the theoretical explanation of convergence in the framework of the neoclassical growth model was given by Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996). The validity of its predictions about income convergence was also confirmed by Mankiw, Romer and Weil (1992) who augmented the Solow model by including human capital.

The convergence is conditional because it takes place only if the countries concerned are endowed with the same technology and characterized by the same behavioral and structural parameters. Another necessary condition is that all the economies are open. If these conditions are not fully met, there is no common long-term equilibrium (*steady state*), and different countries or country groups may reveal specific growth trajectories, converging to different steady states. The result may be so-called "club convergence", meaning the existence of multiple long-run equilibria (cf. Baumol 1986; Ben David 1994; Quah 1996). The degree of homogeneity in the analyzed group of countries is therefore crucial for empirical results.

The endogenous growth models (e.g. Romer 1986, 1990; Lucas 1988) reject the assumption of diminishing returns to capital and question a direct negative relationship between the initial income level and the growth rate. By treating technology as endogenous and dependent on R&D outlays, these theories emphasize the capacity of the highly developed countries to cumulate the benefits of technological progress and a limited ability of the less developed countries to generate and absorb new inventions. Some endogenous growth models entirely exclude the possibility of convergence and suggest that output growth in the highly developed economies may accelerate with rising income and wealth while some poorest economies may be stuck in the poverty trap. Differences in income levels between rich and poor countries can persist infinitely, or even increase.[3]

[3] The newer concept of the "middle-income trap" (controversial and still not enough founded theoretically), which is more relevant for the CEE countries, suggests that some hitherto rapidly growing medium developed economies may also face a development barrier, slowing down or stagnating at the income levels already achieved after the exhaustion of the traditional competitive advantage based on cheap labor and abundant raw

On the other hand, some other endogenous growth models emphasize positive effects of the diffusion of knowledge and technology on economic growth of less developed countries. Taking advantage of know-how spill-over, the less developed countries can allocate more resources on building up their production potential and, as a result, they can develop more quickly. Barro and Sala-i-Martin (1997) constructed an endogenous growth model in which long-run economic growth is driven by discoveries, but followers (imitators) can converge towards leaders by copying foreign technologies, which is cheaper than inventing something new.

The views on the impact of globalization and economic integration on income convergence differ as well. The traditional trade theory (e.g. Viner 1950) implied that trade liberalization and economic cooperation would lead to more convergence, but newer development theories (e.g. Krugman 1991) warn that integration and globalization may also petrify the existing international labor division, resulting in rising income disparities. A similar suggestion is embodied in some newer theories of economic growth, which point at the hermetic nature of modern technologies, institutional and financial constraints to start output growth, and negative effects of the "brain-drain", or a massive outflow of well-educated, skilled man-power from less developed countries. Empirical results as to the link between international trade and income convergence are mixed. Some studies (e.g. Ben David 1996; Frankel and Romer 1999) suggest that trade has a strong positive effect on economic growth, but some other (e.g. Slaughter 2001) do not find any systematic link between trade liberalization and income convergence. The same can be said about the impact of international economic integration on the speed of convergence.

In the traditional neoclassical model, convergence is driven by capital flowing from rich to poor countries. Endogenous growth models emphasize the flow of new ideas and techno-logical knowledge as the main driver of economic growth and eventual convergence. The transfer of new technology occurs through FDI or international trade. Labor mobility and migration may also contribute to income equalization. The fundamental handbook by Barro and Sala-i-Martin (2004) gives a comprehensive overview of various growth models and their implications for income convergence.

Summing up, there are different views as to the existence of a tendency to economic convergence in a broad international context. Income convergence between the less developed and more developed countries should be perceived as a potential chance, but it cannot be

material resources, because graduating to the high income group requires another kind of competitiveness, based on human capital, modern technology and managerial skills (see e.g. Felipe et al., 2012; Aiyar et al., 2013).

taken for granted. Both traditional and modern theories of economic growth and development indicate various factors that may be conducive to income convergence, but also many factors that may hamper the catching-up process and widen the existing income gaps. The very fact that a country is poorer does not guarantee that it can successfully catch up with richer countries.

In the empirical analysis of income convergence, two methodological concepts are used: absolute convergence and conditional convergence. The first approach (used in this paper) tests the direct relationship between the initial income levels (usually expressed as real GDP per capita at PPP) in a given sample of countries and their growth rates over a given period. If there is a strong negative correlation between the two variables, the existence of convergence is confirmed. The rationale behind this procedure is the assumption that all the economies included in the sample converge to the same steady state. The second approach tests the same relationship upon controlling for the impact of other factors which determine the growth rate, but are not fully reflected in the initial income level. The assumption behind this procedure is the recognition that the country's growth rate depends not only on the initial income or productivity level, but also on many behavioral and structural characteristics (e.g. saving rate, population growth, education, institutions, infrastructure, financial system, government policies, etc.), which differ across countries. While absolute income-convergence is rarely seen in large, highly differentiated country samples, conditional income-convergence is often confirmed by the studies which take account of various additional factors that differentiate the analyzed sample.

The empirical research on income convergence employs a variety of methods and analytical tools, ranging from simple correlation and regression analyses based on cross-sectional or panel data, various dispersion measures, unit root tests, up to advanced econometric models and spatial cluster analysis. Two most common measures of income convergence (used in this study) are β- and σ-convergence coefficients, introduced by Barro and Sala-i-Martin (1992). The β-coefficient calculated in a regression equation tests the existence of a negative relationship between the initial income level and the growth rate. The σ-coefficient tests the evolution of income dispersion over time. It should be noted that β-convergence is a necessary but not sufficient condition for σ-convergence.

1.2. Empirical evidence

The debate about the past and current trends in income distribution in the world and the existence or non-existence of the tendency to income convergence among countries is far

from being closed. In his comprehensive empirical analysis on global scale, covering 152 countries in the period between 1950 and 1985, Ben David (2000) concluded that income dispersion in the world tended to rise rather than fall in the long run, and the distance between the highly developed and less developed countries had not been visibly reduced. But in another study, covering 138 countries in the period between 1970 and 2000, Sala-i-Martin (2006) suggested that global inequality had decreased, as evidenced by various measures of income inequality. In a recent analysis covering 122 countries over two periods, 1970-1990 and 1990-2010, Kane (2016) finds that income divergence observed in the former period has shifted to convergence in the latter. In his famous book on the global rise in well-being, Deaton (2013) indicates that the spread of average income in a broad country-by-country comparison is not shrinking over time; in the period from 1950 till 2010 the income distance between the wealthiest and poorest countries in the world has remained about the same, and the dispersion of average incomes has actually increased, especially among the poorest countries of the world. Several authors suggested already in the 1990s that the world moved towards a bimodal ("twin-peaked") income distribution (e.g. Quah 1996; Jones 1997).

The results of the empirical analyses that tested income convergence within the European Union and between Central Eastern Europe and Western Europe differ depending on the period covered, the country group considered, the kind and source of data used, and the method employed. The literature on the subject is quite abundant, and we can indicate only some selected contributions. Our review will be confined to the studies that deal directly with income convergence within the EU and between the CEE countries and Western Europe. The complementary literature on income convergence on regional level will not be quoted for the lack of space. The analyses of internal convergence within the CEE group or within Western Europe will also be omitted. The studies on nominal convergence (e.g. equalization of wage and price levels, interest rates, etc.), as well as analyses of cyclical pattern conformance (synchronization of business cycles), will be mentioned only if they were combined with the research on real income convergence. The review is confined to the studies written in English, with the exception of some contributions by the Polish authors.

The first empirical studies on income convergence between the CEE countries and the EU, undertaken in early 2000s, assessed the convergence potential of transition economies and their possible gains from trade liberalization and economic cooperation with Western Europe. In one of the first such analyses, covering 26 post-socialist countries of Europe and Asia over the period 1970-1998, Estrin, Urga and Lazarova (2001) have not found any clear-cut evidence of their convergence toward Western Europe (except for Hungary, the Czech

Republic and Slovakia). But Sarajevs (2001), in his analysis of income convergence between 11 CEE countries and the EU15 in the period 1991-1999, found both conditional and absolute β-convergence. Some evidence of income convergence between CEE and Western Europe was also shown by Doyle, Kuijs and Jiang (2001) in their study of economic development in the transition countries. The tendency towards income convergence in Europe was also confirmed by several other authors who compared economic growth trends in Eastern and Western Europe.

With the EU's major enlargement in 2004, interest in the research on economic convergence within the EU, as well as between the new entrants and the "old core", increased considerably. Kaitila (2005) tested the relationships between 8 CEE countries that entered the EU and the EU15 for the period 1993-2002 and found some evidence of conditional convergence in terms of GDP per worker. Dogan and Saracoglu (2007) tested average income ratios between CEE and the EU15 in the period 1990-2004; the unit root test applied to quarterly GDP per capita data did not confirm the occurrence of real income convergence, except for Estonia. The result is not surprising since the authors had not cut off the beginning of the 1990s, marked by a deep transformation crisis in most post-socialist countries. Using the same method to quarterly data for the period 1995-2005, Reza and Zahra (2007) have confirmed the existence of absolute β-convergence with the EU15 for the whole CEE group. In a series of papers, Kutan and Yigit (2004, 2005, 2007) and Kočenda, Kutan and Yigit (2006), when analyzing real and nominal convergence of 10 CEE countries towards the EU in the pre-accession period with the use of various indicators, found significant evidence of convergence and concluded that economic integration would be beneficial for both the old and new EU members. But some other studies on real and nominal convergence in the EU, covering a longer period since about 1980 (e.g. Brada, Kutan and Zhou 2005), brought mixed results.

The report on the effects of the EU enlargement (European Commission 2009) presented the estimates of an income convergence model for the five-year periods before and after 2004; it concluded that the EU's enlargement contributed much to the acceleration of economic growth in the CEE countries, speeding up their convergence with Western Europe. The same conclusion was drawn in several studies which tested real income convergence within the EU and between the new and old EU members (Čihák and Fonteyne 2009; Iancu 2009; Ingiánni and Zdarek 2009; Niebuhr and Schlitte 2009; Vamvakidis 2009; Marelli and Signorelli 2010; Tatomir and Alexe 2012; Czasonis and Quinn 2012; Kulhánek 2012). Most of these studies confirmed strong income convergence of the new EU members to the EU's "old core", though

not all have noted any visible acceleration of the convergence process after the EU-accession. Some authors (e.g. Cavenaile and Dubois 2011) show that the convergence rates among new EU entrants and old members differ, pointing to the existence of two different convergence groups in the EU.

The last few years have brought several new papers on real income convergence within the EU and between CEE and Western Europe, which take account of recent developments, including the effects of global crisis and financial turmoil in the eurozone (i.a. Alexe 2012; Stańisić 2012; Kaitila 2013; Dauerstädt 2014; Nanovsky and Tochkov 2014; Simionescu 2014). These newest studies, based on updated time series, verify the previous analyses of income convergence in the EU, trying to identify main factors that determine the speed of convergence. Most of these papers point to the fact that world economic crisis and debt crisis in the euro area have distorted the previous patterns of economic growth in the EU, slowing down the convergence process and leading to some divergence tendencies. The same conclusion was reached in the report prepared for the tenth anniversary of the EU's major enlargement (Forgó and Jevčak 2015). The report shows that 11 CEE countries which accessed the EU have achieved a significant progress in catching up with the EU15, but real income convergence between most CEE countries and Western Europe weakened after the global crisis. Some other studies (e.g. Borsi and Metiu 2013; Monfort, Cuestas, Ordóñez 2013; Gligorić 2014) question the overall tendency to income equalization in the EU and suggest the occurrence of some "convergence clusters" or "convergence clubs", both in the Western and in the Eastern parts of the EU, which would be driving at different income levels in the long run. The differentiation of convergence patterns within the EU is even more stressed in regional convergence studies, which have been omitted in this review.

Several studies on income convergence in the EU (e.g. Kejak et al. 2004; Schadler et al. 2006; Kaitila, Alho, Nikula 2007; Halmai and Vasary 2010; EEAG 2010) presented also some forecasts of the catching-up process between CEE and Western Europe in terms of GDP per capita measured at PPP. Most of these forecasts were based on the extrapolation of past growth trends or on some more or less arbitrary assumptions as to the future growth rates. The recent papers by Cuaresma et al. (2013, 2015) admit that future economic growth in Europe may slow down as the result of population ageing and decrease, but the authors believe that improvements in education and human capital investments can alleviate the negative effect of demographic barrier on the convergence rate.

There are many research contributions on income convergence made by the Polish authors, but most of them are written in the Polish language, remaining largely unknown to foreign

researchers. Apart from our own contributions on the subject, noteworthy in the context of the theme of this paper are the following studies. Siwiński (2007, 2009) estimated the period necessary to reduce by a half the income gap between the CEE countries and Western Europe, taking as the basis per capita GDP in 2014 and the average GDP growth rates of the period 1995-2004. Soszyńska (2008) tested the conditional β-convergence in the EU in the period 1996-2005, but she did not focus on the convergence between CEE and Western Europe. The book written by Malaga (2004) analyzed the convergence process among the OECD member countries, but the results obtained there are not directly applicable to the convergence within the EU. Wolszczak-Derlacz (2009) tested conditional convergence in the EU in the period 1990-2007 with various control variables, showing that migration might be an important factor conducive to income equalization. In his book on income convergence in the EU and in a follow-up study, Batóg (2010, 2013) applied various econometric methods to verify the existence of income convergence within the EU; while confirming the tendency to convergence, he noted that the time necessary for the full equalization of average income levels in the individual member countries would be very long. Walczak (2012) examined income convergence in the EU in the period 1996-2009, confirming the existence of β-convergence. Głodowska (2012) tested β- and σ-convergence in the EU across countries and regions, finding the evidence of convergence on the national level, but divergence in a regional breakdown. Grzelak and Kujaczyńska (2013) corroborated β-convergence in the EU in the period 2001-2010, yet they pointed out to significant differences among countries in the speed of convergence. The newest book on the subject written by Jóźwik (2016) includes a broad and thorough analysis of real income convergence in the EU on national and regional levels; the author tries to explain the convergence of CEE countries towards Western Europe by institutional changes related to systemic transformation and by economic integration within the EU, with special consideration of the cohesion policy.

Our own research on economic convergence within the CEE region and towards the EU began in 2003 and has been continued until now, including studies on growth patterns and mechanisms, analyses and forecasts of income convergence, and tests of business cycle conformity. The results were included in the bilingual annual editions of *New Europe: Report on Transformation* (e.g. Matkowski and Próchniak 2007a), and *Poland: Competitiveness Report* (e.g. Matkowski and Próchniak 2015; Matkowski, Próchniak and Rapacki 2016). The results of our research on income convergence in the EU, particularly between CEE and the EU15, were also published as chapters in several collective books or articles in domestic and

international journals, and presented at many scientific conferences in Poland and abroad. Our comments on Poland's convergence with the EU appeared also in Polish newspapers and business magazines, and special lectures on economic convergence between Eastern and Western Europe were offered to our students. Apart from the convergence analyses and forecasts published in the above quoted annual reports, our studies on the subject included i.a. the following: Matkowski 2010a, 2010b; Matkowski and Próchniak 2004a, 2004b, 2005, 2007b, 2009a, 2009b; Matkowski, Próchniak, Rapacki 2013, 2014; Próchniak 2006, 2011; Rapacki and Próchniak 2009a, 2009b, 2014. Several papers on income convergence in CEE and between CEE and the EU were also written by Próchniak with other co-authors, using more advanced econometric methods (e.g. Próchniak and Witkowski 2012, 2013, 2014a, 2014b, 2014c, 2015, 2016); Vojinović, Oplotnik, Próchniak 2010). These studies comprised analyses and forecasts of real income convergence, supplemented by the analyses of business cycle conformity, including also some discussion and proposals regarding the methodology of convergence research. For the lack of space, we cannot present here a more detailed information about the content of those papers and main findings.[4]

2. Economic growth and income convergence

2.1. Economic growth

Between 1993 and 2015, the 11 CEE countries that entered the EU (EU11) experienced a pretty fast economic growth. Real GDP in the CEE area grew 3.2% a year on an unweighted average, twice as fast as in the EU15 (1.6%). At the individual country level, Poland was the best growth performer (4.2% annually), followed by Slovakia (4.1%) and the Baltic states (in particular, Estonia and Latvia). On the other end of the spectrum, the relatively slowest-growing economies included Hungary (2.2%), Croatia (2.3%), the Czech Republic (2.6%), and Bulgaria (2.7%). All the 11 CEE economies clearly outdistanced the EU15 group as to the average growth record over the whole period. In the period between 1993 and 2015, the EU11 group taken as a whole has roughly doubled its combined GDP whereas the EU15 group increased its total GDP by some 40%.

However, growth patterns in both groups changed significantly over the analyzed period. For the purpose of this analysis, we will distinguish three subperiods, covering the years

[4] A more comprehensive review of our earlier research on the subject was given in: Matkowski, Próchniak and Rapacki 2013.

1993-2000, 2000-2007, and 2007-2015.[5] Table 1 gives the full account of the growth performance of CEE countries and the EU15 group over the analyzed period.

Table 1. Real GDP growth in CEE countries and in the EU15, 1993-2015

Countries	1993-2000		2000-2007		2007-2015		1993-2015	
	Avg. % growth	Index 1993=100	Avg. % growth	Index 2000=100	Avg. % growth	Index 2007=100	Avg. % growth	Index 1993=100
Bulgaria	0.9	106.7	6.2	152.6	0.9	109.2	2.7	177.8
Croatia	4.2	133.6	4.6	137.4	–1.1	90.7	2.3	166.5
Czech Rep.	2.6	119.3	4.6	136.6	0.8	106.9	2.6	174.2
Estonia	4.7	138.1	7.6	167.3	–0.1	99.0	3.8	228.7
Hungary	2.8	121.0	3.6	128.5	0.4	103.2	2.2.	160.5
Latvia	3.8	130.2	9.0	182.5	–0.5	96.0	3.8	228.1
Lithuania	2.3	117.0	8.1	172.2	0.7	105.8	3.5	213.2
Poland	5.5	145.7	4.1	132.4	3.1	127.9	4.2	246.7
Romania	1.4	109.9	6.3	153.0	1.5	112.5	2.9	189.2
Slovakia	4.2	133.7	6.3	153.3	2.1	118.0	4.1	241.9
Slovenia	4.4	135.2	4.3	134.7	–0.1	98.9	2.7	180.1
EU11[a]	3.3	126.4	5.9	150.0	0.7	106.2	3.2	200.6
EU15[b]	2.8	121.2	2.1	115.6	0.2	102.0	1.6	142.9

[a] Unweighted average.
[b] Weighted average.

Source: Annual data on GDP growth were taken from European Commission (2015a, updated with 2016), supplemented if necessary (for Croatia, Slovakia and Slovenia in 1994 and 1995) by some auxiliary data from IMF (2016). The two indexes and average annual growth rates were calculated by the authors.

The first subperiod (1993-2000) was marked by a moderate growth in most CEE countries, initially hampered by the implementation of major economic reforms connected with systemic transformation and reorientation of external trade links. The average (unweighted) GDP growth rate for 11 CEE countries was 3.3%, not much higher than the average (weighted) GDP growth rate for the EU15 (2.8%). A vigorous output growth was noted in Poland, Estonia, Slovakia, Slovenia, and Croatia (4–5.5% on a yearly average), but Bulgaria and Romania, suffering from the delayed transformation shock, have reported a meagre output growth (1–1.5% per annum).

The second subperiod (2000-2007) brought a distinct acceleration of economic growth in all the 11 CEE countries, as a result of the completed market-oriented reforms, increasing cooperation with Western Europe, and massive FDI inflows. This was reflected in high GDP growth rates, ranging between 4 and 9% on a yearly average, with an unweighted mean for the whole EU11 group close to 6%, almost three times as high as reported by the EU15 group on a weighted average. The most rapid GDP growth, by 7–9% a year, was reported by the

[5] In the growth accounting employed here, there is no overlapping between the subperiods, since the first year of each subperiod serves as the basis for calculating the GDP growth index while the growth rate recorded in the next year is taken as the first notation for calculating the average rate.

three Baltic republics: Latvia, Lithuania, and Estonia, but all the remaining CEE countries except Hungary have also raised their GDP volume very significantly. With a massive emigration to Western Europe, launched by the free labor movement, high GDP growth in CEE translated into even higher growth in per capita terms, yielding a big growth rate differential against the EU15 group, which boosted the income convergence process.

The third subperiod (2007-2015) was marked by a deep recession or a visible slowdown in both the CEE region and Western Europe, caused by the global economic crisis and financial perturbations in the euro area. The average (unweighted) GDP growth rate in the EU11 group fell to 0.7% per annum, and the average (weighted) GDP growth rate in the EU15 was 0.2%, meaning a complete stagnation. Several CEE countries have also noted no output growth over that period, and some of them (Croatia and Latvia) experienced a considerable decline in their output volume. Only three CEE countries – Poland, Slovakia, and Romania – have achieved a substantial output growth over the last eight years, since the outbreak of global crisis.

2.2. Changes in the income gap

As a result of a better growth performance of CEE countries as compared with the EU15 in the period 1993-2015, the process of real income convergence between the two groups took place. The data shown in Table 2 illustrate the progress of convergence.[6]

In terms of GDP per capita at PPP, the best results in reducing the income gap towards the EU15 have been reached by Estonia (the gain of ca. 40 percentage points over the whole period), Lithuania (36 p.p.), Slovakia (34 p.p.), Latvia (31 p.p.), and Poland (29 p.p.). On the other hand, Bulgaria (14 p.p.), the Czech Republic (16 p.p.) and Slovenia (17 p.p.) were the slowest to catch up with the EU15.[7] Despite the different speed of convergence, all the new EU members from the CEE region succeeded in shortening their income distance to more advanced West European countries, represented by the EU15 average.

However, the process of income convergence between the CEE countries and the EU15 was not continuous. While the general trend of income convergence held in the long run for all countries in our sample, in the short term individual CEE countries experienced substantial departures from the trend line or witnessed a temporary divergence.

[6] The income gaps and their changes shown in Table 2 and Figure 1 are based on the GDP per capita data taken at PPP presented in the quoted edition of EU statistics (2015a). The newer data from the same source (2016) include some minor revisions, which would not change significantly the whole picture.

[7] The ranking of the best performers in narrowing the income gap does not fully coincide with a similar ranking in terms of GDP growth. For example, Poland's economy grew most rapidly over the whole period, but it was only ranked fifth as to the progress of real income convergence. The differences are mainly due to diverse demographic trends (including migration) and different evolution of the real exchange rates and price levels, which determined the PPP conversion factors.

Table 2. Reducing the income gap: GDP per capita at PPP in CEE countries (EU15 = 100), 1993-2015

Country	1993	1995	2000	2005	2010	2015	Change 1993-2015
Bulgaria	28.9	29.2	24.3	32.2	40.5	42.5	+13.6
Croatia	31.0[a]	38.9	42.2	50.9	53.3	53.9	+22.9
Czech Rep.	63.0	65.8	62.1	70.8	73.7	79.1	+16.1
Estonia	29.4	30.1	37.0	52.5	57.6	68.9	+39.5
Hungary	43.4	43.5	48.2	55.1	58.9	63.7	+20.3
Latvia	28.5	28.5	31.2	44.9	47.6	59.3	+30.8
Lithuania	32.6	29.5	33.2	46.7	54.9	68.7	+36.1
Poland	33.9	36.5	40.5	43.9	56.3	63.3	+29.4
Romania	25.5	27.2	21.9	30.5	45.3	50.2	+24.7
Slovakia	37.9	40.4	42.5	52.4	66.5	71.5	+33.6
Slovenia	60.2	63.2	68.3	76.0	75.4	76.9	+16.7

[a] Own estimate based on IMF data.
Source: European Commission (2015a).

Table 3. Income convergence vs. divergence between the CEE countries and the EU15

Countries	Period covered	Convergence			Divergence		
		Years	No. of years	%	Years	No. of years	%
Bulgaria	1991-	1995, 1998, 2000-09, 2011-12, 2014-15	16	64	1991-94, 1996-97, 1999, 2010, 2013	9	36
Croatia	1995-	1995-97, 2000-08, 2011-13	15	71	1998-99, 2009-10, 2014-15	6	29
Czech Rep.	1990-	1993-96, 2001-07, 2009, 2011, 2013-15	16	62	1990-92, 1997-2000, 2008, 2010, 2012	10	38
Estonia	1993-	1995-2007, 2010-15	19	83	1993-94, 2008-09	4	17
Hungary	1991-	1994-95, 1997-2005, 2008-11, 2013-15	18	72	1991-93, 1996, 2006-07, 2012	7	28
Latvia	1990-	1994, 1997-98, 2001-08, 2011-15	16	62	1990-93, 1995-96, 1999-2000, 2009-10	10	38
Lithuania	1990-	1995-98, 2000-08, 2010-15	19	73	1990-94, 1999, 2009	7	27
Poland	1990-	1992-99, 2002-15	22	85	1990-91, 2000-01	4	15
Romania	1990-	1993-96, 2001-13, 2015	18	69	1990-92, 1997-2000, 2014	8	31
Slovakia	1992-	1992-98, 2001-08, 2010-15	21	87	1999-2000, 2009	3	13
Slovenia	1990-	1993-99, 2001-08, 2014-15	17	65	1990-92, 2000, 2009-13	9	35

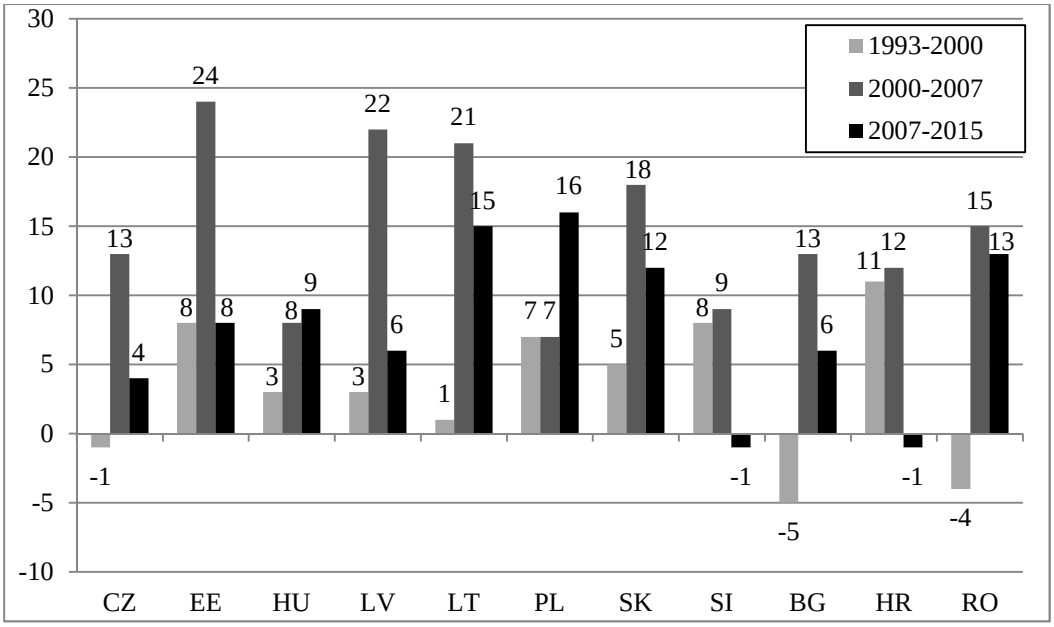
Note: No change in the income ratio at the end of its rise or fall was qualified according to the tendency observed in the previous year.

Source: Own elaboration based on the data taken from: European Commission (2015a).

As can be seen from Table 3, since 1990 (or later dates, depending on data availability) all CEE countries have undergone episodes of the real income divergence of varying intensity and length. The catching up process was most volatile in the Czech Republic and Latvia (10 years of divergence in each country, or 38% of the whole transition period), closely followed by Bulgaria and Slovenia (9 years of divergence, or 35-36% of the whole period). On the other hand, Slovakia (3 years of divergence, or 13% of the whole period), Estonia and Poland (4 years of divergence, or 15-17% of all the period) ranked among the best performers in this respect. However, even in the countries with the highest growth volatility, income divergence

in ‘bad’ years was more than outweighed by income convergence in ‘good’ years. As a result, the net balance of the convergence process over the period between 1993 and 2015 proved positive, as documented in Table 2.

Figure 1. The reduction of the income gap toward the EU15 in the three subperiods



Note: Changes in the income gap are expressed in percentage points. Sum totals of changes in the three subperiods may differ slightly from the figures shown in the last column of Table 2 due to rounding.

Source: Own calculations based on Eurostat data (European Commission 2015a).

Figure 1 shows changes in the income gap between the individual CEE countries and the EU15 in the three subperiods distinguished here.

The first subperiod (1993-2000) brought a relatively small progress in income convergence between CEE and EU15, due to the moderate growth record of the CEE countries. The best results in convergence were reached by Croatia, Slovenia, Estonia, and Poland; all these countries reduced their income gaps towards Western Europe quite considerably, by 7–11 p.p. On the other hand, the Czech Republic and Lithuania did not reduce visibly their income distance to the EU15, while Bulgaria and Romania experienced a widening of the income gap.

The second subperiod (2000-2007), marked by a strong acceleration of economic growth in the CEE region, brought a big progress in income convergence between CEE and the EU15. The best results in this respect were reached by the three Baltic states: Estonia, Latvia, and Lithuania, which developed most vigorously and shortened their income distance to the EU15 by more than 20 p.p. But all other CEE countries also reduced significantly their income gaps to Western Europe, by 7–15 p.p.

The third subperiod (2007-2015), including the effects of the global crisis and financial

turmoil in the euro area, was characterized by a sharp deceleration of income convergence between most CEE countries and the EU15. The most significant progress in income convergence towards Western Europe was reached by Poland, Lithuania, Romania, and Slovakia; in spite of the temporary cease or slowdown in economic growth, these countries succeeded to diminish further their income distance to the EU15 by 12–16 p.p. On the other hand, Slovenia and Croatia, due to a prolonged recession or stagnation, witnessed a renewed widening of the income gap.

It may be interesting to note that Poland was the only CEE country which made the largest progress in reducing its income distance to Western Europe in the last subperiod, i.e. in the years 2007-2015. In each of the first two subperiods, Poland narrowed its income gap to the West by some 7 p.p., while in the last subperiod the remaining income gap was cut by 16 p.p.[8] There are two explanations of this phenomenon. One important factor, which enabled Poland to accelerate its convergence path during the last few years, was the unique resistance of the Polish economy to the adverse effects of the global crisis.[9] The second major factor working in the same direction was a heavy FDI inflow and a generous funding obtained from the EU budget (Poland was one of the main recipients of EU funds from the 2007-2013 budget). The EU's budget for 2014-2020 sets aside more structural funds for new member states. This may prove to be a major driver of further convergence of CEE countries toward Western Europe in the coming years.

2.3. Measuring the income gap

In the empirical research on income convergence in the international context, income gaps between the poorer and richer countries are usually measured by comparing per capita GDP values calculated at the purchasing power parity.[10] Even if there is no better measure to be employed in our analysis, we should be aware of its shortcomings.

Per capita GDP, regardless of the conversion factor, is probably the best available single measure of the development level, but it is only a tentative and crude yardstick when applied to compare living standards. This is not only because it is an average, concealing differences in income distribution, but also because it does not reflect correctly the disposable income of

[8] Hungary has also succeeded to cut its income gap most in the last subperiod, but the difference in not so spectacular (9 p.p. compared with 3 and 8 p.p. in the first two subperiods).

[9] Poland was the only economy in the EU11 group and in the whole EU which was not faced with GDP contraction during the global crisis.

[10] The artificial currency unit employed in global national accounts data published by the World Bank and the International Monetary Fund is called "international dollar"; it represents the purchasing power of US dollar in the US market. A similar unit used by the Eurostat for the EU member states is called "purchasing power standard" (PPS); it can be interpreted as the average weighted purchasing power of euro in the whole EU market. For simplicity, it might be also called "international euro", considered in the European context.

the average citizen. Certainly, a better approximation would be net national income per inhabitant. Unfortunately, comparable GNI and NNI data at PPP for the EU countries are not directly available.

Another problem is the conversion factor used to make the GDP value data comparable. For the needs of inter-country comparison, GDP total or per capita values expressed in local currencies can be converted into a single currency (e.g. dollar or euro) using current exchange rates (CER) or purchasing power parities (PPP) as conversion factors. The GDP calculated at PPP is believed to better represent the true value of the output produced or income earned in a given country, with the consideration of different price levels in the local markets for goods and services; it is also less susceptible to exchange rate fluctuations. For these reasons it is widely used in broad international comparisons. However, the PPP conversion factors calculated by international data sources are often imprecise and, in our opinion, they tend to overestimate the value of total and per capita GDP for some less developed countries. Due to the uncertainty as to the adequacy of the PPP conversion factors for some CEE countries, in our own comparisons of total and per capita GDP data for EU countries, we often use both alternative data sets, calculated at PPP and CER, as to allow a more comprehensive comparison.

Table 4. GDP per capita at PPP and CER in the selected EU countries, 2015 (€)

Country	GDP per capita at PPP (1)	GDP per capita at CER (2)	Ratio (1):(2)
Bulgaria	13 300	6 200	2.2
Croatia	16 700	10 400	1.6
Czech Republic	24 500	15 500	1.6
Estonia	21 400	15 700	1.4
Hungary	19 800	11 100	1.8
Latvia	18 500	12 500	1.5
Lithuania	21 500	12 800	1.7
Poland	19 600	11 000	1.8
Romania	15 600	7 900	2.0
Slovakia	22 200	14 400	1.5
Slovenia	23 800	18 600	1.3
EU11	19 300	11 200	1.7
EU15	30 900	32 900	0.9
EU28	28 500	28 500	1.0

Source: Calculation based on GDP and population data from: European Commission (2015a).

When analyzing the past evolution of the income gap between the CEE countries (EU11) and Western Europe (EU15), we focus on the relation of GDP per capita measured at PPP. But in projecting the possible future course of the convergence process, we shall give two alternative estimates of the initial income gap and of the catching-up period needed to close the income gap, based on both conversion factors: PPP and CER. The estimates of the initial

income gap based on GDP per capita data calculated at PPP will be treated as the basic reference point, which, combined with the assumed future growth rate, can indicate the possible minimal length of the catching-up period, whereas the alternative set of estimates based on GDP per capita data calculated at CER will be used as a controlling device, indicating the possible upper limit of the catching-up process.[11]

The big difference between the two alternative estimates of GDP per capita for CEE countries is evidenced by the data presented in Table 4, which refer to 2015, the last year covered by our historical analysis of the convergence process and the starting point of our forecasts.[12] For the EU15 group, the average per capita GDP measured at PPP is 10% lower than the alternative figure converted with CER. On the other hand, for all the CEE countries, per capita GDP calculated at PPP is significantly higher than per capita GDP calculated at CER. The difference tends to be the higher, the lower is the development and income level in a given country, though this is not a strict rule. The ratio of GDP per capita calculated at PPP and CER ranges from 1.3 in Slovenia to 2.2 in Bulgaria. Of course, if the initial income gap measured at CER is twice as large as the initial income gap measured at PPP, then the respective catching-up period needed to close the income gap calculated at CER, will also be twice as long as the period suggested by GDP per capita data taken at PPP. When analyzing the income convergence process on the basis of GDP per capita data, we should be aware of the significance of the conversion factor used. Unfortunately, this basic question is largely ignored or overlooked in most empirical studies on the subject.

3. Testing β- and σ-convergence

This section intends to assess income convergence between the 11 CEE countries that joined the EU (EU11) and the 15 old EU members (EU15). An analysis of intra-group convergence among the new EU member countries from CEE was presented elsewhere (see e.g. Rapacki and Próchniak 2009a).

Our analysis covers the 1993-2015 period. All calculations were also made for three subperiods, 1993-2000, 2000-2007 and 2007-2015, in order to assess the stability of the catching-up process over time and to check the impact of the global crisis. The calculations made in this part of the paper are based on the time series of real GDP per capita at PPP ($),

[11] As a matter of fact, both the current PPP factors and the current market exchange rates are not good yardsticks for the purpose of forecasting the future course of the convergence process because of future changes in price ratios and exchange rates, which are difficult to predict.

[12] For the sake of simplicity, the GDP per capita data measured at PPP, originally given in PPS units, are directly compared here with GDP per capita data measured at CER and expressed in euro.

extracted from the International Monetary Fund database (IMF 2016). When converting nominal GDP per capita at PPP (in current prices) into real GDP per capita at PPP (in constant prices), we used the GDP deflator for the United States.

3.1. Methodological remarks

Our analysis refers to two concepts of income convergence: absolute β-convergence and σ-convergence. Absolute β-convergence occurs when less developed economies (with lower GDP per capita) grow faster than more developed ones (with higher GDP per capita). σ-convergence appears when income differences between economies decrease over time. Income differentiation can be measured by standard deviation, variance, or a coefficient of variation of GDP per capita levels.

In order to verify the absolute β-convergence hypothesis, we have estimated the following regression equation:

$$\frac{1}{T}\ln\frac{y_T}{y_0} = \alpha_0 + \alpha_1 \ln y_0 + \varepsilon_t . \tag{1}$$

The explained variable is the average annual growth rate of real GDP per capita between period 0 and T; the explanatory variable is log of GDP per capita in the initial period, while ε_t is the random factor. If parameter α_1 is negative and statistically significant, β-convergence exists. In such a case we can calculate the value of coefficient β, which measures the speed of convergence, from:

$$\beta = -\frac{1}{T}\ln\left(1+\alpha_1 T\right). \tag{2}$$

In order to verify the σ-convergence hypothesis, we estimated the trend line of dispersion in income levels between countries:

$$\mathrm{sd}\left(\ln y_t\right) = \alpha_0 + \alpha_1 t + \varepsilon_t . \tag{3}$$

The explained variable is the standard deviation of log GDP per capita between the economies, the explanatory variable is time (t = 1,…, 23 for the 1993-2015 period), while ε_t, as previously, is a random factor. If parameter α_1 is negative and statistically significant, σ-convergence exists.

3.2. The β-convergence

The results of testing β-convergence are presented in Table 5 and Figure 2. The convergence is analyzed among 26 EU countries as well as between the EU11 and EU15 regions.[13] The

[13] Malta and Cyprus have been excluded from the sample as to facilitate the subdivision of European Union into two regions, but this omission does not affect significantly the results for the whole EU28.

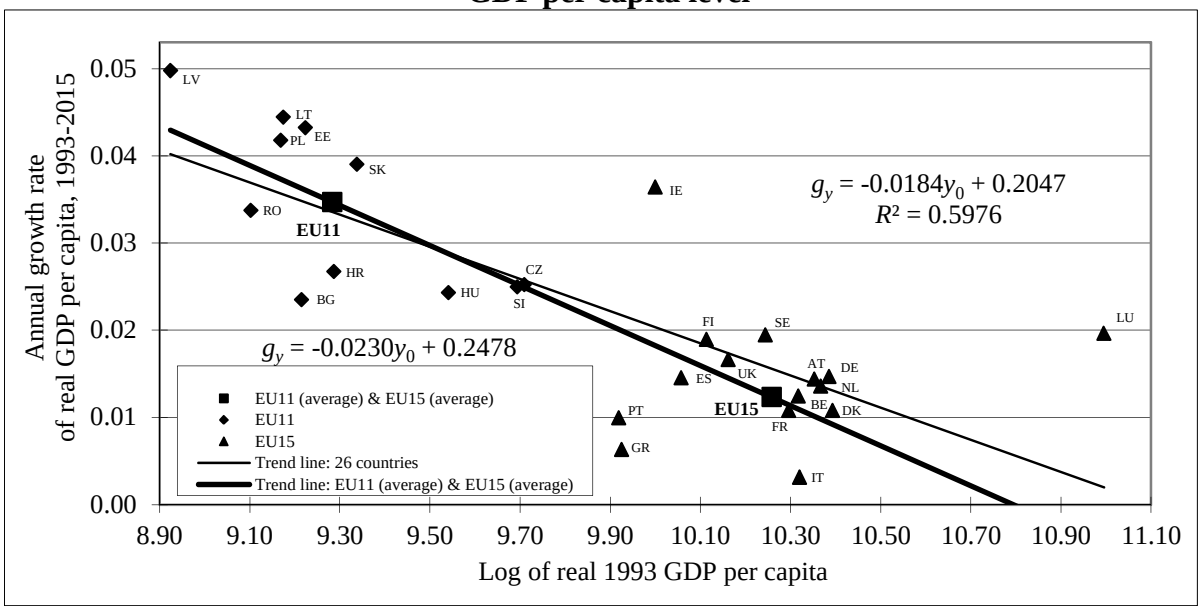
aggregate data for the two regions, EU11 and EU15, are weighted averages with variable weights reflecting the population of a given country in a given year.

Table 5. Regression results for β-convergence

Period	α_0	α_1	*t*-stat. (α_0)	*t*-stat. (α_1)	*p*-value (α_0)	*p*-value (α_1)	R^2	β-convergence	β
26 countries of the enlarged EU									
1993-2015	0.2047	–0.0184	6.72	–5.97	0.000	0.000	0.5976	yes	0.0186
1993-2000	0.0722	–0.0039	1.14	–0.61	0.265	0.548	0.0152	no	–
2000-2007	0.4229	–0.0383	7.69	–7.03	0.000	0.000	0.6729	yes	0.0390
2007-2015	0.1673	–0.0160	2.64	–2.62	0.014	0.015	0.2228	yes	0.0162
2 regions (EU11 and EU15)									
1993-2015	0.2478	–0.0230	.	.	.	.	1.0000	yes	0.0232
1993-2000	0.1390	–0.0111	.	.	.	.	1.0000	yes	0.0112
2000-2007	0.4287	–0.0396	.	.	.	.	1.0000	yes	0.0404
2007-2015	0.3380	–0.0322	.	.	.	.	1.0000	yes	0.0328

Source: Own calculations based on IMF data (IMF 2016).

Figure 2. GDP per capita growth in the 1993-2015 period and the initial GDP per capita level



Source: Own calculations based on IMF data (IMF 2016).

The results confirm the prevalence of a clear-cut income-level convergence of the EU11 countries with the EU15 over the 1993-2015 period. The catching-up process took place both among the 26 countries of the whole examined sample and between the two regions, EU11 and EU15. Countries with lower initial income levels recorded more rapid economic growth on average than those with higher initial income levels. Since all the EU11 economies were less developed compared with the EU15 at the starting point, these results demonstrate an evident catching-up process between CEE and Western Europe.

The positions of most EU member countries on the graph are located not far away from the

negatively sloped trend line for the whole sample, which confirms income convergence within the EU. This is also reflected by the relatively high value of *R*-squared (0.60), which means that differences in the initial income level account for almost two-thirds of the differences in the average growth rates of GDP per capita for the analyzed period.

Aggregate data for the two regions also confirm the existence of income convergence between the EU11 and EU15 in the 1993-2015 period (in Figure 2, the points representing these two regions are marked by squares). The EU11 group as a whole recorded more rapid economic growth than the EU15 area, whereas the group's initial income level was much lower.

The β-coefficients, measuring the speed of convergence, stand at 1.86% for 26 countries and at 2.32% for two regions. These coefficients allow us to estimate the time needed to reduce the income gap between the examined countries by a half. If the average growth patterns observed in 1993-2015 continued, the countries of the enlarged EU would need about 30-35 years to reduce the distance to their hypothetical common steady state by a half.[14] These results point to a relatively slow catching-up process between the CEE countries and Western Europe. Based on these estimates, it cannot be expected that CEE countries will reach the income levels seen in Western Europe soon.

A closer look at the stability of the convergence process over time reveals that the speed of convergence during the three subperiods distinguished here was highly differentiated. In 1993-2000, in the sample of 26 EU countries, there was no statistically significant decrease of the income gap between the EU11 and EU15 (on average for the whole sample). The slope of the trend line for this subperiod is negative but statistically insignificant, which suggests a lack of convergence. The convergence accelerated strongly between 2000 and 2007,which was undoubtedly driven by the EU major enlargement.[15] The clear-cut income convergence that occurred in the second subperiod slowed down after 2007, as reflected in a significant decrease in the β-coefficient value, both for all the whole sample and for the two regions. This was largely due to the global crisis.[16]

3.3. The σ-convergence

The σ-convergence within the EU as well as between the EU11 and EU15 areas is measured

[14] It was calculated as follows: –ln (0.5)/0.0186 = 37.3 years and –ln (0.5)/0.0232 = 29.9 years.

[15] See also Rapacki and Próchniak (2009b). A more recent study by the same authors (2014) confirmed the positive impact of EU membership on economic growth and real convergence of the CEE countries, suggesting that the main channels of this effect were: (i) the increase in economic freedom, (ii) improvement in governance, (iii) market reforms, (iv) the inflow of EU funds, (v) international trade, and (vi) the FDI inflow.

[16] Próchniak and Witkowski (2013, 2014a) applied more advanced econometric models – based on the Bayesian model averaging method – to analyze the time stability of conditional β-convergence in the EU.

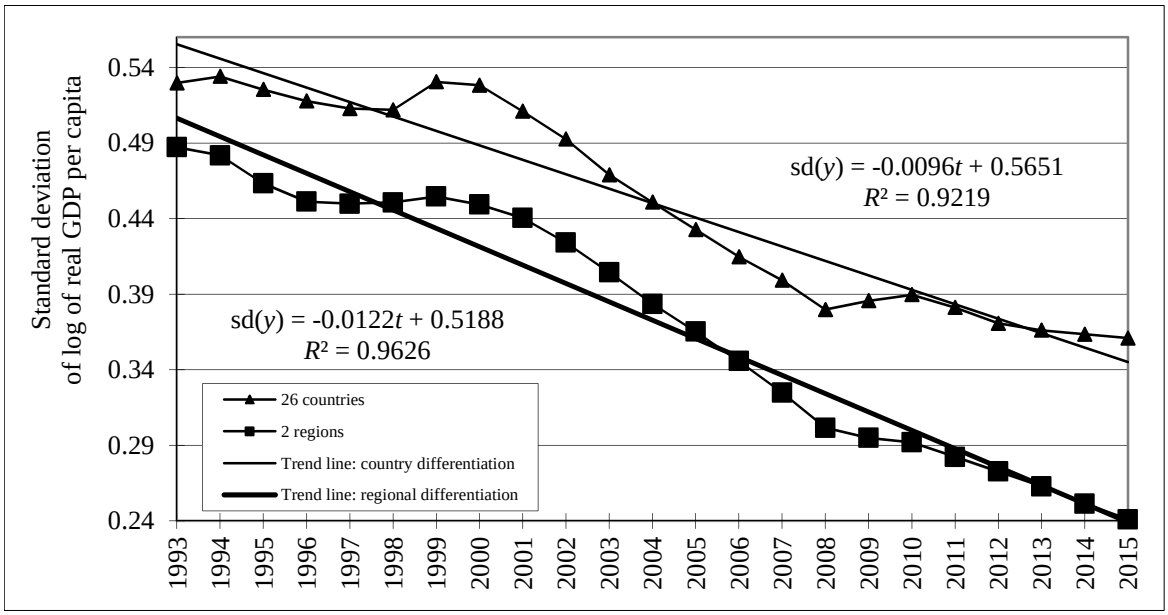
by changes in the standard deviation of GDP per capita. The results of the trend line estimation for standard deviations are presented in Table 6. Figure 3 offers a graphical illustration.

Table 6. Regression results for σ-convergence

Period	α_0	α_1	*t*-stat. (α_0)	*t*-stat. (α_1)	*p*-value (α_0)	*p*-value (α_1)	R^2	σ-convergence
26 countries of the enlarged EU								
1993-2015	0.5651	–0.0096	67.87	–15.74	0.000	0.000	0.9219	yes
1993-2000	0.5278	–0.0009	76.02	–0.64	0.000	0.548	0.0634	no
2000-2007	0.5471	–0.0188	323.38	–56.24	0.000	0.000	0.9981	yes
2007-2015	0.3991	–0.0043	96.74	–5.91	0.000	0.001	0.8330	yes
2 regions (EU11 and EU15)								
1993-2015	0.5188	–0.0122	72.31	–23.23	0.000	0.000	0.9626	yes
1993-2000	0.4846	–0.0052	69.99	–3.82	0.000	0.009	0.7087	yes
2000-2007	0.4749	–0.0184	152.87	–29.85	0.000	0.000	0.9933	yes
2007-2015	0.3279	–0.0095	104.60	–17.04	0.000	0.000	0.9765	yes

Source: Own calculations based on IMF data (IMF 2016).

Figure 3. Standard deviation of GDP per capita, 1993-2015



Source: Own calculations based on IMF data (IMF 2016).

The data in Table 6 show that there existed σ-convergence both among the 26 EU countries and between the EU11 and EU15 areas over the period 1993-2015. The slopes of the two estimated trend lines are negative and statistically significant at high significance levels (with *p*-values standing at 0.000). The high values of the *R*-squared coefficients (exceeding 0.90) reflect a very good fit of empirical points to the trend line.

Figure 3 shows the evolution of the standard deviation of log of real GDP per capita over the whole period. As we can see, income differences within the EU and between the EU11

and EU15 groups displayed a downward trend. Income differentials decreased most obviously and consistently in the second part of the analyzed period, i.e. in the years 2000-2007. In 2009-2010, due to the effects of the global economic crisis and a slowdown or recession in many EU countries, income disparities among the 26 countries in our sample increased, although the average data for the two regions do not reflect that.

The results of σ-convergence for the consecutive subperiods confirm our earlier observations made in the context of β-convergence. From 1993 to 2000, in the sample of 26 EU countries, there was no statistically significant decrease in income differentiation (despite a downward dispersion trend). A fast decline in income differentials took place in the middle of the analyzed period, from 2000 to 2007. Since the outbreak of the global crisis, in 2007-2015, income differences among the individual EU countries and between the two regions have been also diminishing, but not as rapidly as in the previous years.

These findings evidence that income convergence between the more and less developed countries, even within an integrated economic area, is by no means an automatic process. Thus, income differences between the EU countries may not necessarily diminish in the future; divergence tendencies may also appear. Such shocks as global crisis or other potential disruptions may hamper the convergence process in Europe. Proper economic policies are needed, combined with institutional reforms, in order to keep the process of income convergence within the EU on track.

4. Closing the income gap: a forecast

4.1. The three scenarios

This section presents a simulative forecast of the catching-up process between the CEE countries (EU11) and Western Europe (EU15). Our forecast (or, more precisely, simulation) will be made according to three hypothetical scenarios, which update our earlier forecasts based on the same scheme.[17]

The first scenario is a simple extrapolation of past growth trends. It assumes that individual CEE countries and the EU15 group as a whole will maintain in the future the average yearly growth rates of per capita GDP noted in the 1993-2015 period.[18] For most CEE countries, and particularly for Poland, this is a very optimistic scenario form the point of view of the period needed to close the income gap to Western Europe.

[17] See e.g. Matkowski and Próchniak 2015; Matkowski, Próchniak, Rapacki 2013, 2014.

[18] The GDP per capita growth rates quoted here refer to the growth of real GDP measured at constant prices in national currencies (euro in the case of EU15); they differ slightly from the growth rates calculated from PPS GDP data, which were used in the calculations made in part 3.

The second scenario is more analytical in nature. It is based on the medium-term GDP forecast elaborated by the IMF (2016) and on the long-term demographic forecast published by the Eurostat (2016). It assumes that during the next five years, CEE countries and the EU15 group as a whole will develop in line with the GDP growth forecast given by the IMF, and from 2021 on they will continue to grow at the constant growth rates foreseen by the IMF for 2020. The assumed growth rates of total GDP have been transformed into per capita terms using the Eurostat population projections until 2080.[19] Compared with the first scenario, this second scenario seems to be more realistic, though the assumptions about the future GDP growth in the CEE countries are also quite optimistic.

The common feature of both these scenarios is the assumption that all the CEE countries will maintain some lead over the EU15 group as regards per capita GDP growth and, as a result, the catching-up process will continue. We shall focus on calculating the probable length of the period required to close the income gap (against the average per capita GDP level in the EU15). The basic difference between the two variants is that the ratios of the GDP per capita growth rates between the CEE countries and the EU15 group in the first scenario are assumed to remain constant, at their average levels recorded in the 1993-2015 period, while in the second scenario these ratios may change, in line with the assumed future GDP growth and the expected population change.

In both the above scenarios, the reference point in our forecast is the relative level of GDP per capita in 2015. The initial income gaps (relative per capita GDP levels against the EU15 average) have been determined according to the estimates given by the European Commission (2015a).[20] The period necessary to close the income gap depends on the initial income gap and the future growth rate of per capita GDP. The algorithm used to calculate the length of the catching-up period is presented and discussed below.

Our calculations have been made in two versions as regards the estimation of the initial income gap and the expected length of the catching-up period. In the first version, the income gap is measured by the relative level of per capita GDP calculated at the purchasing power parity (PPP). In the second version, the income gap is measured by the relative level of per capita GDP converted at current exchange rates (CER). Although such calculations are usually made with per capita GDP taken at PPP, in this analysis we will consider both

[19] Due to the lack of comparable demographic data, we have assumed no further change in population numbers after 2080.

[20] Some minor differences between the individual country data on GDP per capita at PPP and CER in 2015 given in the quoted edition of EU statistics and the revised data included in the newest edition of the same source (no more than 1 p.p.) do not affect significantly the results.

alternative measures of the initial income gap (at PPP and CER) because we are not sure whether the estimates of per capita GDP at PPP for CEE countries given by the available data sources are adequate and not overestimated. In interpreting the results, we shall focus on the estimated length of the catching-up period based on per capita GDP at PPP, but the alternative estimates based on per capita GDP at CER will be considered as controls, showing the possible upper limit of the length of the complete convergence process.

Scenario 3 is completely different. It does not assume that future GDP growth in the CEE countries and in the EU15 will be a simple continuation of past or present growth trends, and that the income convergence process between the two groups will proceed continuously until a full equalization of per capita GDP levels is reached. This scenario is based on a long-term economic forecast till 2060, prepared on behalf of the European Commission (European Commission 2015b), which takes account of unfavorable demographic trends that may slow down significantly the future economic growth in the CEE countries, stopping their convergence with the EU15 and/or reversing it into divergence.[21]

It should be remembered that the EU15, used here as a reference group to represent the average income level in Western Europe, is composed of 15 countries that were included in the EU before its enlargement in 2004 and later (it does not coincide exactly with the group of 15 West-European countries that belong to the euro area, usually denoted as the EA15). The growth rates of per capita GDP for the EU15 group used in the first scenario refer exactly to this group, but under the second and third scenarios, because of the lack of the respective data for this group, we used the GDP growth rates given by the indicated data sources for the euro area (EA19), which do not differ much from those for the EU15 group and are an acceptable substitute.

4.2. The convergence algorithm

In scenarios 1 and 2, which assume the continuity of the convergence process up to the full closing of the income gap, our calculation of the expected catching-up period was based on the following formula:

$$x(1+g)^t = 100(1+h)^t, \tag{4}$$

where x – the initial relative per capita GDP level in a CEE country (measured against the

[21]The future demographic trends were also included in the convergence forecast prepared under scenario 2, but the impact of the expected decline in population numbers was taken into account only when transforming the assumed GDP growth rates into per capita terms, without considering the adverse effect of population aging and diminution on output growth (at least not after 2020, beyond the time horizon of the IMF GDP growth forecast underlying our convergence projection). Thus, paradoxically, the expected fall in population and labor force translates into a higher growth of per capita GDP (with given total GDP growth rates), this being one of the main weaknesses of the long-term convergence projection made under that scenario.

EU15 average taken as 100), g – the average annual growth rate of GDP per capita in the given CEE country, h – the average annual growth rate of GDP per capita in the EU15 area, t – number of years needed to attain the same GDP per capita level as seen in the EU15 area. The aim of our calculation was to determine the value of variable t, according to the formula:

$$t = \frac{\ln 100 - \ln x}{\ln(1+g) - \ln(1+h)}. \quad (5)$$

In scenario 3, we did not indicate the length of the full convergence period due to the expected discontinuity of the convergence process.

It should be noted that, according to the above convergence algorithm, the speed of the catching-up process, as well as the length of the period required to close the income gap, depend on the growth rates of GDP per capita in both groups of countries, but the relationship is non-linear. For instance, if future growth rates in both groups of countries decreased by a half compared with the past trends, the period necessary for income equalization under a simple extrapolation-based forecast would lengthen, despite the constancy of the growth rate ratio. In order to accelerate the catching-up process, it is not sufficient to speed up economic growth in less developed countries (or to slow down economic growth in more developed ones); it is necessary to raise the relationship between the growth rates of both groups, or the growth rate differential.

4.3. Projection results

The assumptions made in the first two scenarios and the results of our calculations are presented in Tables 7 and 8. The first column in both tables shows the assumed growth rates of per capita GDP or total GDP in the individual CEE countries, the next two columns give the initial GDP per capita levels at PPP and CER relative to the average level in the EU15, and the last two columns indicate how many years are needed to reach the average income level in the EU15 if the initial per capita GDP level is measured at PPP or at CER.

In 2015, GDP per capita in all the EU11 countries was much lower than the EU15 average. The lowest per capita GDP was noted in Bulgaria (43% of the EU15 average at PPP and 19% at CER) and Romania (50% and 24% respectively), while the highest levels of this indicator were seen in Slovenia (77% at PPP and 56% at CER) and in the Czech Republic (76% and 47%). In Poland, per capita GDP accounted for 63% of the EU15 average when calculated at PPP, but only 33% in terms of CER. For all the CEE countries, the per capita GDP values calculated at PPP are much higher than those converted at CER (as already discussed before in section 2.3). Consequently, the period necessary to close the income gap calculated at PPP is considerably shorter than the period calculated with CER.

Table 7. Closing the income gap – scenario 1

Country	GDP per capita growth rate (%)	GDP per capita in 2015 (EU15 = 100)		Number of years needed to reach the average level of GDP per capita in the EU15	
	1993-2015	PPP	CER	PPP	CER
Bulgaria	3.4	43	19	39	77
Croatia	2.8	54	31	39	75
Czech Rep.	2.5	79	47	18	59
Estonia	4.5	69	47	12	24
Hungary	2.4	64	33	38	94
Latvia	5.0	59	38	14	26
Lithuania	4.6	69	38	11	29
Poland	4.2	63	33	16	38
Romania	3.5	50	24	31	64
Slovakia	4.0	72	44	12	30
Slovenia	2.5	77	56	20	45
EU15	1.2	100	100	–	–

Source: Own calculations based on the data from Eurostat (2016) and the European Commission (2015a), supplemented if necessary by some auxiliary data from the IMF (2016).

Table 8. Closing the income gap – scenario 2

Country	GDP growth rate (%)		GDP per capita in 2015 (EU15 = 100)		Number of years needed to reach the average level of GDP per capita in the EU15	
	2015-2020	2021-	PPP	CER	PPP	CER
Bulgaria	2.1	2.5	43	19	54	139
Croatia	1.7	1.8	54	31	176	.
Czech Rep.	2.4	2.2	79	47	37	122
Estonia	3.2	3.4	69	47	16	33
Hungary	2.2	2.1	64	33	56	184
Latvia	3.8	4.0	59	38	15	28
Lithuania	3.2	3.6	69	38	10	28
Poland	3.6	3.6	63	33	20	46
Romania	3.4	3.3	50	24	33	70
Slovakia	3.3	3.1	72	44	18	42
Slovenia	2.0	2.0	77	56	47	122
EU15	1.6	1.6	100	100	–	–

Source: Own calculations based on data from Eurostat (2016), European Commission (2015a), and IMF (2016).

Scenario 1 is a simple extrapolation of the past growth trends, assuming that the CEE countries (EU11) and the EU15 group will maintain the average yearly growth rates of per capita GDP recorded in the 1993-2015 period. Under this assumption, individual CEE countries would need 11 to 39 years to reach the average level of per capita GDP seen in the EU15 group if the initial income gap is measured at PPP, but 24 to 94 years if it is computed with CER. The three Baltic states, Estonia, Latvia, and Lithuania, along with Slovakia, would have the best catching-up prospects if they continued to develop according to their past trends. Estonia would need only 12 years to reach the average income level of the EU15 measured at PPP, or 24 years if it is measured at CER. Lithuania would need 11 or 29 years for the same, and for Latvia it would take 14 or 26 years. Poland would require 16 years if the initial

income gap is calculated at PPP or 38 years if it is based on CER. For Slovakia, the respective catching-up periods are 12 or 30 years, for Slovenia they are 20 or 45 years, and for the Czech Republic 18 or 59 years. Hungary, Romania, Bulgaria and Croatia are in the worst position. Keeping up its earlier growth trend, Hungary would need 38 years to achieve the average income level at PPP seen in the EU15, or 94 years if it is measured at CER. Romania would need 31 or 64 years to catch up with Western Europe, and Bulgaria together with Croatia would have to wait 39 or 75-77 years.

The time required to close the income gap towards the EU15 under scenario 2 differs from that obtained in scenario 1 since the future GDP growth rates assumed here differ from past trends. For most CEE countries, the catching-up period turns out to be longer than in the first scenario. The convergence period becomes a little shorter only for Lithuania (10 years at PPP and 28 years at CER). For the remaining countries in the group, the catching-up period does not change much or it becomes longer. For Latvia and Estonia, the expected time to close the income gap rises to 15-16 years at PPP or 28-33 years at CER. For Slovakia, it lengthens to 18 or 42 years respectively, and for the Czech Republic and Slovenia to 37 and 47 years at PPP, but 122 years at CER. For Romania, the catching-up period remains almost the same: 33 years at PPP or 70 years at CER. For Hungary, Bulgaria and Croatia, the prospects of full income convergence with Western Europe are very remote. For Hungary and Bulgaria, the catching-up period is about 55 years at PPS and 140 or 180 years at CER. In the case of Croatia, only the first figure (at PPP) can be indicated: it is 176 years, while the alternative estimate (at CER) extends into a very distant future and may be meaningless. Poland is placed in the middle of the CEE group in this respect, with a chance to close the income gap toward Western Europe within 20 years if the initial income gap is calculated at PPP, or 46 years if it is based on CER conversion.

Summarizing the results obtained in the first two scenarios, and focusing on the estimates of the catching-up period based on per capita GDP measured at PPP, we arrive at the following conclusions. If the CEE countries could sustain their growth advantage over Western Europe noted in the past (scenario 1) or existing at present (scenario 2), the best convergence prospects open up for the three Baltic states, Slovakia, Poland, and the Czech Republic. Estonia could reach the average level of per capita GDP seen in the EU15 in 12-16 years, Lithuania would do the same even sooner, in 10-11 years, while Latvia would wait a little longer, 14-15 years. Pretty good convergence prospects would be witnessed by Slovakia and Poland. Keeping up its previous or current growth record, Slovakia could reach the average per capita GDP seen in the EU15 in 12-18 years, and Poland could do the same in 16-20

years. The Czech Republic and Slovenia are in a less favorable position in the convergence line despite the relatively high income level already attained, this being due to their slower economic growth. Continuing its moderate past or present growth pace, the Czech Republic would come up to the Western income level in 18 or 37 years, and Slovenia could do that in 20 or 47 years (the first figure refers to the continuation of past trends, while the second figure extrapolates the current growth performance). For Hungary, Romania, Bulgaria and Croatia, catching up with Western income standards will last much longer, even if these countries succeed to keep up their past or current growth trends. Hungary would need 38 or 56 years to achieve the same income level as in Western Europe, for Romania it would take 31-33 years, and for Bulgaria 39 or 54 years. Croatia might reach the average income level seen in Western Europe in 39 years if it could restore its past growth record, but with the current, very slow growth it has no chance to do that until the end of this century.

The above estimates of the catching-up period in terms of per capita GDP measured at PPP should be treated as minimal since they have been made at constant prices and exchange rates recorded at the starting point, on the assumption that current price differentials between the CEE and EU15 will not change. In fact, due to the gradual equalization of price levels within the EU28, the purchasing power of the future income earned in any of the CEE countries may prove to be lower than expected on the basis of constant price calculations, with the resulting extension of the period needed to close the income gap.[22]

In addition to the purely extrapolative forecast presented under scenario 1, based on the growth trends observed in the whole transition period of 1993-2015, or instead of it, we could also develop a similar extrapolative forecast of income convergence based on the growth pattern observed in the 2004-2015 period alone, after the EU major enlargement towards the CEE. The retrospective analysis of the catching-up process, presented in the two preceding sections, brings some empirical evidence of the acceleration of income convergence between the CEE countries and Western Europe after their EU accession, though identification of the specific effect of integration on the speed of convergence would require further research.[23] However, growth patterns in Europe in the last ten years, influenced by the global economic crisis and the debt crisis in the euro area, were rather atypical and are unlikely to recur (let us believe so) in the years to come. Therefore, the average growth rates noted by various EU

[22] This was an additional reason for us to enclose the alternative set of catching-up period estimates, based on the initial income gap estimated at CER rather than PPP. Please note that the half-way to the common steady state, calculated in section 3.2, suggested much longer period needed for income equalization, though it was a purely theoretical exercise based on the neoclassical growth model.

[23] The positive effect of the EU enlargement on income convergence within the EU is not easy to be identified because it is damped by the negative effect of the world economic crisis that occurred in the same period.

countries in that period and the resulting growth differentials cannot be directly applied to any reasoning as regards possible future developments.[24]

In our earlier research, we have also analyzed some other scenarios of the future convergence process, including some alternative extrapolation variants with longer and shorter backward observation periods as well as some other variants of analytical forecasts, with different assumptions as to the future growth rates. In all the analyzed variants, the period necessary for Poland to close the income gap towards the EU15 measured at PPP, adjusted for the 2015 starting point, was in the range between 15 and 20 years. We can therefore conclude that, under all realistic assumptions, the minimum period necessary for Poland to catch up with the EU15 in terms of the average PPP income level is now 15-20 years. Thus, expectations voiced until recently by some optimistic authors that Poland could reach the average income level seen in Western Europe within 10 years, were entirely unrealistic. This is simply impossible, both economically and physically (a formal proof is easy to be made). Even if Poland might be capable of liquidating its development and income gap to Western Europe, this would surely require a longer time and much effort. On the other hand, we cannot rule out the possibility of a considerable slowdown in the future economic growth in Poland and other CEE countries, which could lower the rate of the convergence process and eventually reverse it into divergence. Such a possibility is implied by the third scenario, presented below.

Scenario 3, as already mentioned, is based on the long-term growth forecast for EU countries up to 2060, elaborated under the auspices of the European Commission. This forecast is based on a thorough analysis of the unfavorable demographic trends and their impact on employment and labor productivity, as well as on the expected changes in total factor productivity (TFP). Under the forecast, beginning around 2030 or even sooner, economic growth in Poland and most other CEE countries will slow down, mainly as a result of population ageing and the outflow of young working-age people seeking job and better living conditions abroad.[25] This would lead to a gradual decrease in the per capita GDP growth rate

[24] This is especially true for any convergence projections drawn for Poland. Thanks to its continuous output growth, Poland has noted a substantial rise in its GDP volume since 2004, i.e. after its EU accession. This was also reflected in a relatively high GDP per capita growth rate of 3.8% per year, whereas the respective average growth rate for the EU15 group was only 0.3% in the same period, yielding a big growth rate differential of almost 13:1 in favor of Poland. There is no doubt that such a huge disparity of growth rates between member countries of the same integrated economic area cannot be sustained in the long run. Hence, the growth patterns experienced after the EU major enlargement cannot be used as the basis of any reasoning regarding the future course of the convergence process within the EU.

[25] According to this forecast, the growth rate of Poland's potential GDP may fall from current 3.6% in 2015 to 2.6% in 2020, 1.9% in 2030, 1.3% in 2040, 0.6% in 2050, and 0.7% in 2060. A similar slowdown is foreseen for most other CEE countries.

differential between the CEE countries and Western Europe up to the complete disappearance of any growth advantage, or even a reversal of the growth ratio between the two groups, at a very low level of future growth rates. One of the consequences of the changing growth patterns would be a decline in the rate of income convergence between the two groups of countries, up to a complete reversal of the convergence process (at least in some CEE countries) and a switch into divergence, i.e. a renewed widening of the income gap. This forecast is highly pessimistic not only because, for most CEE countries, it practically excludes the chance of closing the income gap toward Western Europe within the lifetime of a single generation, but also because it foresees a very slow rise in real income and wealth (about 1.5-2% a year in terms of per capita GDP) over the next 50 years for both the EU15 and most CEE countries.

Table 9. Closing the income gap – scenario 3

Country	GDP per capita growth rate, 2015-2060 (%)	Income gap (GDP per capita at PPP, EU15 = 100)						The minimum income gap
		2015	2020	2030	2040	2050	2060	
Bulgaria	2.0	43	47	53	56	58	58	.
Croatia	1.7	54	55	57	60	63	65	.
Czech Rep.	1.8	79	83	87	90	90	90	.
Estonia	1.8	69	73	81	85	85	84	85 (2046)
Hungary	1.8	64	67	75	78	79	77	79 (2051)
Latvia	2.3	59	66	80	86	87	88	.
Lithuania	2.1	69	75	87	90	93	96	.
Poland	1.9	63	68	79	84	83	79	84 (2044)
Romania	2.0	50	54	60	62	65	65	65 (2054)
Slovakia	2.0	72	78	93	97	95	92	97 (2038)
Slovenia	1.6	77	80	83	84	83	84	.
EU15	1.4	100	100	100	100	100	100	.

Source: Own calculations based on the data from the Eurostat (2016) and the European Commission (2015a, 2015b).

The implications of this scenario for the catching-up process between the CEE countries and Western Europe are shown in Table 9. Unlike the first two scenarios, which indicated the length of the period needed to close the income gap, the third scenario – because of the stopping or reversal of the convergence process within the forecast horizon – indicates only the relative income levels foreseen at the beginning of the consecutive decades and the minimum size of the income gap at turning points from convergence to divergence (for the countries affected by such a switch). For the sake of simplicity and for a lucid presentation of the results, the relative income levels illustrating the size of the income gap in the indicated years are given only in terms of GDP per capita at PPP; the alternative estimates in terms of GDP per capita at CER would be much lower.

Table 9 shows that starting about 2030, due mainly to unfavorable demographic trends (including net effects of the expected migration), for most CEE countries the growth advantage over Western Europe will tend to diminish or will disappear completely. In the second half of the period covered by the forecast, four or five countries in the group, including Poland, will switch from convergence to divergence, while most other CEE countries will stay at about the same relative income level against the EU15 as already reached, without any chance of liquidating the remaining income gap (at least not until 2060). No single country in the CEE group may be able to bridge its income gap toward Western Europe within the next 45 years. Only Lithuania will be close to this target just before 2060. Slovakia will approach the Western income standards much sooner, around 2040, but after that date its income gap to Western Europe will start to widen. The less developed countries in the group – Croatia, Bulgaria, and Romania – will cease reducing their income gap toward Western Europe around 2050 or somewhat later, stopping at 60-65% of the average income level seen in the EU15. Hungary will probably remain at the level of about 80% of the EU15 average, Slovenia and Estonia will reach no more than 85%, and the Czech Republic will stay at 90%. Poland is expected to reach 84% of the average income level in the EU15 in about 2045, but afterwards its income distance to Western Europe will turn to increase. A divergence trend may also appear in Slovakia, Hungary, Romania, and Estonia (though, in the last case, it will be a halt of convergence rather than its reversal). Of course, this scenario does not give any indication as to the further development of the convergence vs. divergence process after 2060, which is beyond the time scope of the economic and demographic forecast underlying this scenario.[26]

4.4. Policy recommendations

One can hope that this depressing scenario, precluding any chance to liquidate the development and income gap between Central Eastern and Western Europe within the lifetime of one generation, will not come true. Nevertheless, the possibility of such undesirable developments, under *laissez-faire* conditions, cannot be ignored. It should be noted that the reliability of the alarming forecast announced by the European Commission is supported by similar results obtained in another long-term growth projection prepared by the OECD (2012). In order to prevent this scenario from coming true, well-coordinated, multi-directional efforts must be made as soon as possible by the governments of the countries

[26] Our former results for this scenario, based on an earlier version of the EC long-term economic forecast, were even more depressive, suggesting a possible reversal of the convergence process in all CEE countries except Bulgaria.

concerned as well as in the framework of common European policy, aimed at overcoming the emerging threats to future economic growth and ensuring continuous and healthy development.

In the case of Poland, a complex long-term development program is needed, as a guideline for current socio-economic policy pursued by the government, dedicated to the maintenance and acceleration of economic growth. Such a program should focus on correcting unfavorable demographic trends, creating better institutional and financial conditions for enterprise development, stimulating investment and job creation, and ensuring more even regional development by taking into account the needs and abilities of local communities. Other priorities include the development of selected modern industries, further expansion and modernization of the infrastructure, better use of the existing labor and material resources, and promotion of education, knowledge and innovativeness as crucial factors of economic growth in a highly competitive international environment. This program must be consistent with the sustainable development strategy adopted by the European Union (cf. Eurostat 2015), but it should focus on solving the most important problems that endanger further development of the Polish economy. The ultimate aim of such a program should be to ensure further satisfactory growth of the economy in order to improve the quality of life and well-being of all citizens. The "Plan for Responsible Development", recently adopted by the Polish government, which defines the long-term strategy of socio-economic development and indicates some concrete policy aims for the next five years, may be a step in the right direction, but it needs to be concretized and made operational, including the specification of necessary funding.

Conclusion

Referring to our previous research on the subject, we have analyzed GDP growth trends and the evolution of the real income gap between the 11 CEE countries that have accessed the EU (EU11) and 15 countries of Western Europe (EU15), representing the EU's "old core", in the period between 1993 and 2015. The income gap was measured by the ratio of per capita GDP at PPP in a given country and the average value of the same indicator in the EU15. The analysis of the respective time series revealed a clear-cut tendency to income convergence between the two groups of countries over the analyzed period, which was also confirmed by the results of β- and σ-convergence tests, both for the whole sample and for the two regions. This was simply the result of a more rapid growth of the CEE economies in the given period, compared with the average growth in Western Europe. However, the catching-up process was

not continuous: there were many shorter or longer breaks in convergence experienced by the individual CEE countries as well as some episodes of divergence, caused by the changing growth rate differentials. The most intensive convergence between the two groups of countries appeared in the first decade of this century, and more precisely in the subperiod 2000-2007, just before and after the EU's major enlargement in 2004, which suggests that trade liberalization, free capital and labor flows and an increased cooperation stimulated the convergence process. However, the negative growth effects of the global economic crisis, together with financial perturbations in the euro area, resulted in a deceleration of the convergence process in most CEE countries in the next subperiod of 2007-2015.

We have also presented some projections of the possible further course of the catching-up process between the two groups of countries, under three different scenarios as regards future economic growth. The first two scenarios, based on the extrapolation of past growth trends or continuation of current growth performance, indicate the possible length of the period needed for individual CEE countries to close the existing gap to the average income level seen in Western Europe, assuming that they succeed in maintaining their growth advantage. The third scenario, based on the long-term economic forecast for the EU countries till 2060, prepared by the European Commission, warns that income convergence within the EU may be stopped or reversed in not too distant future due to a significant slowdown of economic growth, which may be caused by unfavorable demographic trends. As a result, the income distance between Central Eastern and Western Europe can cease to decrease and several CEE countries may be faced with a widening income gap. In order to prevent this scenario from coming true, proper social and economic policies are needed, both on the country level and in the framework of the common European policy, aimed at overcoming the emerging threats, as to assure a healthy economic growth and a continuation of the convergence process.

Even if our analysis of income convergence was largely based on real GDP per capita data calculated at PPP, we have indicated some evident shortcomings of this measure for income convergence research, along with the uncertainty as to its adequacy, especially in measuring the existing income gap between Central Eastern and Western Europe and estimating the possible length of the catching-up period. Since the available GDP per capita data calculated at PPP may be imprecise and, at least for some CEE countries, they may underestimate the existing income gap, when projecting the further evolution of the convergence process, we have included some alternative estimates based on GDP per capita data calculated at CER.

References

Aiyar S. et al., *Growth Slowdowns and the Middle-Income Trap*, IMF Working Paper, WP/13/71, 2013.

Alexe I., *How Does Economic Crisis Change the Landscape of Real Convergence for Central and Eastern Europe*, "Romanian Journal of Fiscal Policy", 2012, no. 3.

Barro R., Sala-i-Martin X., *Convergence*, "Journal of Political Economy", 1992, no. 100(2).

_____, *Technological Diffusion, Convergence, and Growth*, "Journal of Economic Growth", 1997, no. 2.

_____, *Economic Growth*, 2nd ed., The MIT Press, Cambridge and London, 2004.

Batóg J., *Konwergencja dochodowa w krajach Unii Europejskiej*, Wyd. Naukowe Uniwersytetu Szczecińskiego, Szczecin 2010.

_____, *Analiza krańcowej pionowej konwergencji dochodowej typu β w krajach Unii Europejskiej w latach 1993-2010*, „Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania", 2013, no. 31.

Baumol W.J., *Productivity Growth, Convergence, and Welfare: What the Long-Run Data Show*, "American Economic Review", 1986, no. 78.

Ben-David D., *Convergence Clubs and Diverging Economies*, CEPR Working Paper No. 922, 1994.

_____, *Trade, Growth and Disparity Among Nations*, in: *Trade and Poverty*, WTO, Geneva 2000.

_____, *Trade and Convergence Among Countries*, "Journal of International Economics", 2001, no. 55.

Borsi T., Metiu N., *The Evolution of Economic Convergence in the European Union*, Deutsche Bundesbank, Discussion Paper No. 28, 2013.

Brada J.C., Kutan A.M., Zhou S., *Real and Monetary Convergence in the Enlarged EU Area Between the European Union's Core and Recent Member Countries: A Rolling Cointegration Approach*, "Journal of Banking and Finance", 2005, no. 29(1).

Cavenaile L., Dubois D., *An Empirical Analysis of Income Convergence in the European Union*, "Applied Economic Letters", 2011, no. 18.

Čihák M., Fonteyne W., *Five Years After: European Union Membership and Macro-Financial Stability in the New Member States*, IMF Working Paper No. WP/09/68, 2009.

Cuaresma J.C., Havettova M., Labaj M., *Income Convergence Prospects in Europe: Assessing the Role of Human Capital Dynamics*, "Economic Systems", 2013, no. 37(4).

Cuaresma J.C., Loichinger E., Vincelette G.A., *Aging and Income Convergence in Europe: A Survey of the Literature and Insights from a Demographic Projection Exercise*, 2015, www.researchgate.net/publication/284797226 [accessed March 5, 2016].

Czasonis M., Quinn M.A., *Income Convergence in Europe: Catching Up or Falling Behind?* "Acta Oeconomica", 2012, no. 62(2).

Dauerstädt M., *Convergence in Crisis: European Integration in Jeopardy*, Friedrich Ebert Stiftung, International Policy Analysis, Berlin 2014.

Deaton A., *The Great Escape: Health, Wealth, and the Origins of Inequality*, Princeton University Press, Princeton and Oxford, 2013.

Dogan N., Saracoglu B., *Income Convergence of European Union and Candidate Countries: Are They All the Same?* "International Research Journal of Finance and Economics", 2007, no. 12.

EEAG, *Report on the European Economy 2010*, CESifo, Munich 2010.

Estrin S., Urga G., Lazarova S., *Testing for Ongoing Convergence in Transition Economies, 1970 to 1998*, "Journal of Comparative Economics", 2001, no. 29(4).

European Commission, *Five Years of an Enlarged EU. Economic Achievements and Challenges*, "European Economy", 2009, no. 1.

_____, *Statistical Annex to European Economy: Autumn 2015*, ec.europa.eu (2015a) [accessed March 15, 2016].

_____, *The 2015 Ageing Report*, "European Economy", 2015, no.3 (2015b).

_____, *Statistical Annex to European Economy: Spring 2016*, ec.europa.eu (2016) [accessed May 15, 2016].

Eurostat, *Sustainable Development in the European Union: 2015 Monitoring Report in the EU Sustainable Development Strategy*, Luxembourg 2015.

_____, Eurostat Database, ec.europa.eu/eurostat [accessed April 10, 2016].

Felipe J., Abdon A., Kumar U., *Tracking the Middle-Income Trap: What Is It, Who Is in It, and Why?* Levy Economics Institute of Bard College, Working Paper No. 715, 2012, www.levyinstitute.org [accessed May 10, 2016].

Forgó B., Jevčak A., *Economic Convergence of Central and Eastern European EU Member States Over the Last Decade (2004-2014)*, European Economy Discussion Paper 001, 2015.

Frankel J.A., Romer D., *Does Trade Cause Growth?* "American Economic Review", 1999, no. 89(3).

Gligorić M., *Paths of Income Convergence Between Country Pair Within Europe*, "Economic Annals", 2014, no. 201.

Głodowska A., *Znaczenie konwergencji w aktualnej i przyszłej polityce strukturalnej Unii Europejskiej*, „Nierówności Społeczne a Wzrost Gospodarczy", 2012, no. 24.
Grzelak A., Kujaczyńska M., *Real Convergence of the European Union Member States – Evaluation Attempt*, "Management", 2013, no. 17.
Halmai P., Vasary V., *Real Convergence in the New Member States of the European Union (Shorter and Longer Term Prospects)*, "European Journal of Comparative Economics", 2010, no. 7.
Iancu A., *Real Economic Convergence*, National Institute of Economic Research (Bucharest), Working Papers No. 090104.
IMF, World Economic Outlook Database, www.imf.org [accessed April 10, 2016].
Ingiánni A., Zdarek V., *Real Convergence in the New Member States: Myth or Reality?* "Journal of Economic Integration", 2009, no. 24(2).
Jones C.I., *On the Evolution of the World Income Distribution*, "Journal of Economic Perspectives", 1997, no. 11.
Jóźwik B., *Realna konwergencja gospodarcza państw członkowskich Unii Europejskiej z Europy Środkowej i Wschodniej. Transformacja, integracja i polityka spójności*, Katolicki Uniwersytet Lubelski, Lublin 2016 (in print).
Kaitila V., *Integration and Conditional Convergence in the Enlarged EU Area*, ENEPRI, Working Paper No. 31, Brussels 2005.
_____, *Convergence, Income Distribution and the Economic Crisis in Europe*, ETLA Working Paper No. 14, 2013.
Kaitila V., Alho K.E., Nikula N., *Growth Prospects of Emerging Market Economies in Europe – How Fast Will They Catch up with the Old West?*, The Research Institute of the Finnish Economy, Discussion Paper No. 1115, Helsinki 2007.
Kane T., *Accelerating Convergence in World Income Distribution*, Hoover Institution, Economics Working Paper 161202, Stanford 2016.
Kejak M., Seiter S., Vavra D., *Accession Trajectories and Convergence: Endogenous Growth Perspective*, "Structural Change and Economic Dynamics", 2004, no. 15(1).
Kočenda E., Kutan A.M., Yigit T.M., *Pilgrims to the Eurozone: How Far, How Fast?* "Economic Systems", 2006, no. 30(4).
Krugman P., *Geography and Trade*, MIT Press, Cambridge 1991.
Kulhánek L., *Real Convergence in Central European Member States*, in: I. Honova, L. Melecky, M. Stanickova (eds.), *Proceedings of the 1st International Conference on European Integration 2012, ICEI 2012*, Technical University of Ostrava, Ostrava 2012, p. 161-170.
Kutan A.M., Yigit T.M., *Nominal and Real Stochastic Convergence of Transition Economies*, "Journal of Comparative Economics", 2004, no. 32(1).
_____, *Real and Nominal Stochastic Convergence: Are the New EU Members Ready to Join the Euro Zone?* "Journal of Comparative Economics", 2005, no. 33(2).
_____, *European Integration, Productivity Growth and Real Convergence*, "European Economic Review", 2007, no. 51(6).
Lucas R.E., *On the Mechanics of Economic Development*, "Journal of Monetary Economics", 1988, no. 22(1).
Malaga K., *Konwergencja gospodarcza w krajach OECD w świetle zagregowanych modeli wzrostu*, Wydawnictwo Akademii Ekonomicznej, Poznań 2004.
Mankiw N.G., Romer D., Weil D., *A Contribution to the Empirics of Economic Growth*, "Quarterly Journal of Economics", 1992, no. 107.
Marelli E., Signorelli M., *Institutional, Nominal and Real Convergence in Europe*, "Banks and Bank Systems", 2010, no. 5(2).
Matkowski Z., *Perspektywy wzrostu gospodarczego Polski w latach 2010-2020 i docelowy poziom PKB per capita*, in: U. Płowiec (ed.), *Innowacyjna Polska w Europie 2020. Szanse i zagrożenia trwałego rozwoju*, PWE, Warszawa 2010, p. 99-115 (2010a).
_____, *Perspektywy zmniejszania luki dochodowej między Polską i innymi krajami Europy Środkowo-Wschodniej a Europą Zachodnią*, „Zarządzanie Ryzykiem", 2010, no. 35/36 (2010b).
Matkowski Z., Próchniak M., *Economic Convergence in the EU Accession Countries*, in: Z. Matkowski (ed.),*Composite Indicators of Business Activity for Macroeconomic Analysis*, "Papers and Proceedings", vol. 74, Research Institute of Economic Development, Warsaw School of Economics, Warsaw 2004, p. 405-425 (2004a).
_____, *Real Economic Convergence in the EU Accession Countries*, "International Journal of Applied Econometrics and Quantitative Studies", 2004, no. 1-3 (2004b).
_____, *Zbieżność rozwoju gospodarczego w krajach Europy Środkowo-Wschodniej i w stosunku do Unii Europejskiej*, „Ekonomista", 2005, no. 5.

_____, *Convergence between the CEE-8 and EU-15*, in: D.K. Rosati (ed.), *New Europe. Report on Transformation*, Foundation Eastern Institute, Warsaw 2007, p. 102-106 (2007a).
_____, *Economic Convergence Between the CEE8 and the European Union*, "Eastern European Economics", 2007, no. 45 (2007b).
_____, *Zbieżność poziomów dochodu i wahań cyklicznych w krajach Europy Środkowej i Wschodniej w stosunku do Unii Europejskiej*, in: R. Rapacki (ed.), *Wzrost gospodarczy w krajach transformacji: konwergencja czy dywergencja?* PWE, Warszawa 2009, p. 171-184 (2009a).
_____, *Zbieżność rozwoju gospodarczego Polski i innych krajów Europy Środkowowschodniej w stosunku do Unii Europejskiej*, „Zarządzanie Ryzykiem", 2009, no. 30 (2009b).
_____, *The Impact of the Global Crisis on the Income Convergence of Poland and Other CEE Countries Toward the Average Income in the EU15*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2015*, World Economy Research Institute, Warsaw School of Economics, Warsaw 2015, p. 43-64.
Matkowski Z., Próchniak M., Rapacki R., *Nowe i stare kraje Unii Europejskiej – konwergencja czy dywergencja?* in: K. Walczyk (ed.), „Prace i Materiały", vol. 91, Instytut Rozwoju Gospodarczego, Szkoła Główna Handlowa, Warszawa 2013, p. 63-98.
_____, *Scenariusze realnej konwergencji w Unii Europejskiej – kraje Europy Środkowo-Wschodniej a EU15*, in: M. Gorynia, S. Rudolf (eds.), *Polska w Unii Europejskiej i globalnej gospodarce*, PTE, Warszawa 2014, p. 201-222.
_____, *Income Convergence in Poland vis-à-vis the EU: Major Trends and Prospects*, in: M.A. Weresa (ed.), *Poland. Competitiveness Report 2016*, World Economy Research Institute, Warsaw School of Economics, Warsaw 2016, p. 37-55.
Monfort M., Cuestas J.C., Ordóñez J., *Real Convergence in Europe: A Cluster Analysis*, "Economic Modelling", 2013, no. 33.
Nanovsky N., Tochkov K., *Transition, Integration and Catching up: Income Convergence between Central and Eastern Europe and the European Union*, "Mondes en Developpement", 2014, no. 3.
Niebuhr A., Schlitte F., *EU Enlargement and Convergence: Does Market Access Matter?* "Eastern European Economics", 2009, no. 47.
OECD, *Looking to 2060: Long-Term Economic Forecast*, "Policy Papers", 2012, no. 3.
Próchniak M., *Realna konwergencja typu beta (β) i sigma (σ) w świetle badań empirycznych*, „Zeszyty Naukowe", 2006, no. 20, Kolegium Gospodarki Światowej, Szkoła Główna Handlowa.
_____, *Realna konwergencja w krajach Unii Europejskiej. Próba szacunków funkcji produkcji*, in: K. Walczyk (ed.), *Zmiany aktywności gospodarczej w świetle wyników badań koniunktury*, „Prace i Materiały", vol. 87, Instytut Rozwoju Gospodarczego, Szkoła Główna Handlowa, Warszawa 2011, p. 165-196.
Próchniak M., Witkowski B., *Konwergencja gospodarcza typu β w świetle bayesowskiego uśredniania oszacowań*, „Bank i Kredyt", 2012, no. 43(2).
_____, *Time Stability of the Beta Convergence among EU Countries: Bayesian Model Averaging Perspective*, "Economic Modelling", 2013, no. 30.
_____, *On the Stability of the Catching-up Process Among Old and New EU Member States. Implications from Bayesian Model Averaging*, "Eastern European Economics" 2014, no. 52(2) (2014a).
_____, *The Legendary 2% Convergence Parameter: Flexible or Fixed?* "Roczniki Kolegium Analiz Ekonomicznych SGH", 2014, no. 34 (2014b).
_____, *Alternative Weighting Schemes in Spatial Analysis of GDP Per Capita Convergence*, "Metody Ilościowe w Badaniach Ekonomicznych ("Quantitative Methods in Economics"), 2014, no. 15(2) (2014c).
_____, *Stochastic Convergence of the European Union Countries: A Conditional Approach*, "Roczniki Kolegium Analiz Ekonomicznych SGH", 2015, no. 39.
_____, *On the Use of Panel Stationarity Tests in Convergence Analysis: Empirical Evidence for the EU Countries*, "Equilibrium. Quarterly Journal of Economics and Economic Policy", 2016, no. 11(1).
Quah D., *Growth and Convergence in Models of Distribution Dynamics*, "Economic Journal", 1996, no. 106(437).
Rapacki R., Próchniak M., *Real Beta and Sigma Convergence in 27 Transition Countries, 1990-2005*, "Post-Communist Economies", 2009, no. 21 (3). (2009a).
_____, *The EU Enlargement and Economic Growth in the New Member States*, "European Economy. Economic Papers", no. 367, 2009. [The same results were presented in Polish in: „Ekonomista" 2010, no. 4]. (2009b).
_____, *Wpływ członkostwa w Unii Europejskiej na wzrost gospodarczy i realną konwergencję krajów Europy Środkowo-Wschodniej*, „Ekonomia", 2014, no. 39.
Reza R., Zahra K.T., *Evaluation of the Income Convergence Hypothesis in Ten New Members of the European Union. A Panel Root Approach*, "Panoeconomicus", 2008, no. 2.
Romer P.M., *Increasing Returns and Long-Run Growth*, "Journal of Political Economy", 1986, no. 94(5).
_____, *Endogenous Technological Change*, "Journal of Political Economy" 1990, no. 98(5).

Sala-i-Martin X., *The Classical Approach to Convergence*, "Economic Journal", 1996, no.106(437).
_____, *The World Distribution of Income: Falling Poverty and … Convergence Period,* "Quarterly Journal of Economics", 2006, no. 121(2).
Sarajevs V., *Convergence of European Transition Economies and the EU: What Do the Data Show?* Bank of Finland, BOFIT, Discussion Paper 13, Helsinki 2001.
Schadler S. et al., *Growth in the Central and Eastern European Countries of the European Union,* IMF Occasional Paper No. 252, Washington 2006.
Simionescu M., *Testing Sigma Convergence Across EU-28,* "Economics and Sociology", 2014, no. 7(1).
Siwiński W., *Unia Europejska i wzrost gospodarczy – perspektywy dla Polski i krajów Europy Centralnej,* in: J.J. Michałek, W. Siwiński, M. Socha (eds.), *Polska w Unii Europejskiej – dynamika konwergencji ekonomicznej,* PWN, Warszawa 2007, p. 42-67.
_____, *Wzrost gospodarczy Polski i krajów Europy Środkowo-Wschodniej: czy możliwa jest trwała konwergencja dochodowa z Europą Zachodnią?* in: Z.B. Liberda (ed.), *Konwergencja gospodarcza Polski,* PTE, Warszawa 2009, p. 118-142.
Slaughter M.J., *Trade Liberalization and Per Capita Income Convergence: A Difference-in-differences Analysis,* "Journal of International Economics", 2001, no. 55.
Solow R.M., *A Contribution to the Theory of Economic Growth,* "Quarterly Journal of Economics", 1956, no. 70(1).
_____, *Technical Change and the Aggregate Production Function,* "Review of Economics and Statistics", 1957, no. 39.
Soszyńska E., *Różne podejścia do analizy procesów konwergencji gospodarczej,* „Zarządzanie Ryzykiem", 2008, no. 28.
Staňisić N., *The Effects of the Economic Crisis on Income Convergence in the European Union,* "Acta Oeconomica", 2012, no. 62.
Swan T., *Economic Growth and Capital Accumulation,* "Economic Record", 1956, no. 32(2).
Tatomir C.F., Alexe I., *Laggards or Performers? CEE vs. PIIGS Countries' Catch-up with the Euro Area in the Last Ten Years,* "Theoretical and Applied Economics", 2012, no. 9(574).
Vamvakidis A., *Convergence in Emerging Europe: Sustainability and Vulnerabilities,* "Eastern European Economics", 2009, no. 47.
Viner J., *The Custom Union Issue,* Carnegie Endowment for International Peace, New York 1950.
Vojinović B., Oplotnik Z., Próchniak M., *EU Enlargement and Real Economic Convergence,* "Post-Communist Economies", 2010, no. 22.
Walczak E., *Czynniki wzrostu gospodarczego w krajach Unii Europejskiej,* „Wiadomości Statystyczne", 2012, no. 4.
Wolszczak-Derlacz J., *Does Migration Lead to Economic Convergence in an Enlarged European Market?* "Bank i Kredyt", 2009, no. 40.