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Beta and Sigma Economic Convergence of Central and Eastern European Countries to the EU-12

Abstract

Theoretical background: The concept of the economic convergence process is one of the conclusions of neoclassical growth models, especially the Solow–Swan model. According to it, it is possible to catch up with countries with a lower level of economic development to the economic level of developed countries and to finally equalize the economies of countries. However, endogenous economic theories have indicated that economic convergence is not the only realistic scenario of economic development in the modern economy.
Purpose of the article: The aim of the research is to determine the degree of beta and sigma economic convergence of the countries of Central and Eastern Europe to the EU-12 in the years 2004–2021.

Research methods: Descriptive statistics and regression analysis were used in the research. The regression analysis was based on a beta and sigma convergence study. The first one was aimed at checking whether less developed countries are characterized by a faster rate of economic growth than more developed states, while sigma convergence made it possible to check whether dispersion in the level of socio-economic development in selected countries was levelled in the years 2004–2021.

Main findings: According to the results of the research, it is possible to confirm the existence of beta convergence of the CEE countries compared to the EU-12 in terms of economic prosperity, taking into account the average wealth of citizens (GDP per capita). The economic measure, which is key in the study of economic convergence, is the basis for stating that in the years 2004–2021, there was a process of convergence between the groups of the surveyed EU countries. On the other hand, no reduction in the economic differentiation of the countries studied was observed based on the sigma convergence study.

Introduction

Convergence in a broad sense is understood as the phenomenon of increasing similarity of objects. In economic sciences, it has been assumed that this term will mean the process of economic convergence of countries or regions (Wójcik, 2018).

The study of convergence is particularly important in the modern economy. Globalization has contributed to the increased integration and interconnection of state economies, as a result of which both the possibility of stimulating socio-economic development has occurred, but also the increase in economic divergence and the risk of transferring macroeconomic shocks (Pukin-Sowul, 2021a; Włodarczyk, 2014). Therefore, three objectives of economic convergence studies are distinguished (Próchniak, 2019):

– monitoring the progress of the convergence process both in the global economy and in smaller groups of countries,

– assessing the scale of reducing the income gap between countries,

– creating recommendations for macroeconomic policy.

This topic is particularly important from the point of view of the economic integration of countries characterized by economic diversification. In the modern economy, the World Bank classifies economies into four income groups: low, lower-middle, upper-middle, and high income. One of the EU's challenges is that the Member States included in the first two development groups form convergence clubs. Central and Eastern Europe (CEE) is one of the "clubs" of the EU. This group includes new member states that joined the EU in 2004, 2007 and 2013. These countries despite many differences are similar in many respects, both economically, geographically and politically (Kotliński & Warżała, 2020; Białowąs, 2016). The countries that created the euro area form the second EU convergence club (EU-12). The EU-12 is also characterized by a longer experience of international economic cooperation. These countries are often the starting point for research on the economic development of new member state (Borsi & Metiu, 2015). Other EU countries (Denmark, Sweden, Cyprus and Malta) were not included in the research due to the purpose of the article. The elimination of these countries is due to the fact that:

– Denmark and Sweden are not euro zone countries,

– Cyprus and Malta are island countries with a small area and economic importance, even though they are in the euro zone, and they could distort the results on the economic convergence of selected convergence clubs (EU-12 and CEE).

The elimination of these countries indicates a more precise context for examining the economic convergence of Central and Eastern Europe with the countries that created the euro area and usually constitute key trading partners of the CEE countries. Therefore, by focusing on the analysis of convergence between the CEE and the EU-12 countries, researchers can better understand the economic and social dynamics of the region and the potential benefits and challenges of monetary integration – both for the CEE countries that joined the euro area and countries with derogation.

The impact of economic integration on the increase in economic convergence has been repeatedly described in the source literature (Jena, 2018; Rapacki & Próchniak, 2014; Próchniak, 2019). According to the assumptions of the concept of economic convergence, the neoclassical school and Krugman's theory of foreign trade, economic cooperation is conducive to increasing efficiency, prosperity and improving the allocation of resources, resulting in the processes of homogenization and convergence of economies cooperating with each other (Jena, 2018; Toplu Yılmaz, 2022). On the other hand, economic integration may have a negative impact on economic convergence (Alcidi, 2019). According to the concept of conditional economic convergence, integration may lead to divergence tendencies and consolidation of socio-economic differences between the so-called convergence clubs, i.e. groups of countries that share a common development path (Rapacki & Próchniak, 2014; Próchniak, 2019). Economic convergence is particularly important in the context of monetary integration.

The existing literature (Bayoumi & Eichengreen, 1992; Simionescu, 2015; Borowiec, 2017; Stanišić et al., 2018; Próchniak, 2019) on the subject has repeatedly discussed the economic convergence of the CEE and EU-12 countries in the context of European integration, including monetary cooperation. However, there is a lack of studies with extended time frames that take into account the initial but significant impact of COVID-19 on the European economy.

It is therefore important and necessary to update and deepen research on beta and sigma economic convergence of the CEE countries to the EU-12. The research gap constitutes a premise for the originality of the research of this work. The novelty of this work lies primarily in the extension of the research period, which takes into account the initial impact of COVID-19 on the European economy. The article's added value is own research, which allows to: monitor the progress of the convergence process in the European Union, assess the scale of reducing the income gap between EU-12 and CEE countries and create recommendations for macroeconomic policy.

The aim of the research is to determine the degree of beta and sigma economic convergence of the CEE countries to the EU-12 in the years 2004–2021.

Literature review

Economic convergence refers to theories explaining economic growth and economic differences between selected areas, most often countries. Economic growth is a key indicator of a country's well-being, which indicates an increase in the number of goods and services produced in the country over a given period of time.

Most of the models to which economic convergence refers indicate that technology is the primary driver of economic growth and differences in economic development in individual countries (Dosi et al., 2019). Therefore, technological progress may enable less developed countries to catch up to the economic level of more developed economies (Luo et al., 2020). In the source, the concepts of convergence refer to two different approaches to economic growth: exogenous and endogenous (Rahman et al., 2018).

The first theory refers to the exogenous approach, which is based on the neoclassical model of economic growth, according to which exogenous factors, including population change and technological changes affect long-term economic growth (Chirwa & Odhiambo, 2018; Haftu, 2019), while short-term economic growth depends on the combination and effective use of production factors (Acquah & Ibrahim, 2020). According to it, it is possible to catch up with countries with a lower level of economic development to the economic level of developed countries and to finally equalize the economies of countries. This is due to the law of diminishing returns on capital (Asanović, 2020; Desli & Ghoulghotshika, 2020). It indicates that countries with a lower level of socio-economic development obtain a higher marginal productivity of capital because they have a higher level of return on capital and investment opportunities because capital is relatively scarce (Barrios et al., 2019; Romero, 2019).

Moreover, the Solow model assumes that economic convergence is possible because there is a so-called the point of long-term equilibrium or steady-state, to which all countries strive. It is a mortgage assumption and is not precisely determined by economists (Bernadelli et al., 2017). According to one of the exogenous models, only capital affects long-term economic growth. At that time, the size of the workforce was not taken into account due to its constant growth. Income convergence will occur when the steady point is reached, because at that time capital will be fully used for depreciation, and income per capita will not increase at the same time. The model assumes that all countries will reach this state (Thach, 2021).

By the end of the 1990s, the concept of economic convergence was developed based on endogenous growth models. Firstly, the possibility of international economic divergence (a process opposed to economic convergence) was noticed due to the fact that less developed countries do not always develop faster than more developed countries. Secondly, the importance of external factors in economic development has been limited (Rangongo & Ngwakwe, 2019), as a result of which other factors have been appreciated in theories of economic growth (Donou-Adonsou, 2019). In addition, new concepts of endogenous growth indicate that economic convergence is possible when additional conditions are met (Stanišić, 2018).

Both types of convergence (beta and sigma) are important in the modern economy. They can be classified as real convergence understood as the process of increasing the similarity of real variables; primarily the volume of production, but also other issues of the real economy. Due to the fact that real convergence mainly concerns similarity in terms of the average level of income per capita, it is often called income convergence (Bernardelli et al., 2017). A large part of empirical research focuses on the convergence of high- and low-income countries in the context of international economic integration. One of the directions of research of European and American economists is to determine the impact of European integration on the economic convergence of Central European countries with the EU-12 (Stanišić et al., 2018; Próchniak, 2019; Bayoumi & Eichengreen, 1992; Simionescu, 2015).

Economic convergence is particularly important in the context of monetary integration. According to the theory of the optimal currency area, economic convergence of countries is a factor conducive to the creation and effective functioning of monetary unions (Pukin-Sowul, 2021a). Monetary integration can be treated as an opportunity to eliminate economic differences and to catch up with the economic level of highly developed countries for countries with a lower economic level, as a result of which economic convergence is a desirable effect for countries. An increase in economic convergence is possible because the common currency leads to a reduction in transaction costs and political uncertainty, increasing foreign trade and investment, technology flow and GDP growth. Such a situation is conducive to economic convergence (Eichengreen, 2012). In addition, economic convergence is an important factor for the efficiently functioning of a monetary union. On the other hand, monetary integration can contribute to an increase in economic divergence (Šviklikova & Kroh, 2018).

The low level of economic convergence, and thus the inadequacy of the monetary policy, has a significant impact on the competitiveness of individual economies of the monetary union and the functioning of the entire community. In addition, the diversification of the levels of competitiveness of the member states, which usually increases after the exchange rate is fixed, contributes to many economic and financial problems, including balance of payments imbalances and macroeconomic imbalances, which may threaten the unity and solidarity of the monetary and economic union, leading to economic and political tensions (De Grauwe, 2010; Matkowski et al., 2013; Razzaghi et al., 2018).

Despite the importance of real convergence in the monetary union, another type of convergence – nominal convergence – is emphasized. It indicates the importance of the similarity of selected economic indicators (Dospinescu, 2021). Its importance was taken into account in the final creation of the institutional framework of the euro area. It was expressed in the convergence criteria. They are set out in the Treaty on the Functioning of the European Union. The Treaty states that these criteria should be met by euro area candidate countries (Ialomitianu & Boldeanu, 2017).

The literature on the subject indicates an ambivalent relationship between nominal and real convergence, especially in the context of monetary integration. Propo-

nents of the nominal convergence criteria point out that nominal convergence is an important condition for real convergence (Neculita & Micu, 2020). This assumption was based on the "new" OCA, according to which the common currency may contribute to economic convergence (Adamczyk-Łojewska, 2011). In addition, economic integration should enable an increase in nominal and thus real convergence in the long term (Twardowska, 2019). Nevertheless, it should be emphasized that TOCA does not indicate the importance of nominal convergence criteria in creating an optimal currency area (Nkwatoh, 2018).

After a long-term functioning of the monetary union, it can be concluded that nominal convergence has not occurred in the euro area, and therefore there is no condition for real convergence (Michalczyk, 2016). It can be assumed that the Maastricht criteria do not meet their basic goal, i.e. the convergence of the members of the monetary union, on the contrary – the implementation of the criteria contributes to increasing economic disproportions among the members of the union (Paleta, 2012).

Has the integration of CEE with the EU-12 had an impact on achieving economic convergence? According to the analysis of the literature on the subject, this should happen for several reasons. Firstly, in the 1990s, the CEE countries chose a similar direction of socio-economic policy and structural reforms, shaped by models from Western Europe, including the EU-12. Secondly, the prospect and actual membership in the EU were an additional element that made these countries similar in terms of the institutional environment, economic structure, and directions of trade and capital exchange. Moreover, it can be assumed that all current members of the enlarged EU strive for the same long-term equilibrium. The disappearance of differences in the level of development is additionally reinforced by the formulated objectives of EU policy, which are intended to ensure the reduction of income gaps between the EU-12 and CEE countries and regions (Rapacki & Próchniak, 2014, p. 91).

The accession of the CEE countries to the EU meant that they were obliged to join the euro area after achieving economic and political readiness, including meeting the nominal convergence criteria (inflation, budget deficit and public debt, long-term interest rates, stable exchange rate). Some of the CEE countries that joined the EU in 2004–2013 decided to adopt the euro as soon as possible. Slovenia achieved the goal in 2007, then Slovakia (2009), Estonia (2011), Latvia (2014) and Lithuania (2015) joined the euro zone (Kotliński & Warżała, 2020, p. 10). Croatia adopted the euro in 2023.

Research methods

The subjective scope covers 23 EU member states. Such a large group of countries was divided into two parts: the CEE countries and the EU-12 countries.

The first group includes such countries as Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia and Slovenia. These

countries are characterized by a similar economic history and geographical location (Kotliński & Warżała, 2020, p. 7). The accession of CEE countries contributed to the reduction of the homogenization of economies in the EU (Monfort et al., 2018). The study of economic convergence becomes even more important from the point of view of the monetary integration of CEE with other EU member states, with some CEE countries (Bulgaria, the Czech Republic, Poland, Romania, Hungary) still not joining the monetary union. Candidate countries to adopt the common currency are required to meet the so-called convergence criteria. They define the economic requirements that countries aspiring to join the euro area should meet for their economies to be considered coordinated with members of the monetary union (Pukin-Sowul, 2021b). Scientific debates should increase citizens' economic and political awareness of the positive and negative consequences of introducing the euro from the point of view of economic convergence (Pukin, 2019; Włodarczyk, 2016).

The economies of CEE countries will be compared to the countries that created the euro area in 1999 and 2001, i.e. Austria, Belgium, Finland, France, Greece, Spain, the Netherlands, Ireland, Luxembourg, Germany, Portugal and Italy (i.e. EU-12).

The time range of the research covers the years 2004–2021. Such a period was dictated by both the availability and completeness of statistical data. Moreover, 8 out of 11 CEE countries joined the euro area in 2007–2015, which contributed to some CEE countries achieving a higher level of advancement of economic integration with the EU-12. The remaining three countries (Poland, the Czech Republic, Hungary) are countries with a derogation, which means that they are obliged to join the euro area after achieving economic and political goals, including meeting the nominal convergence criteria. Two main types of economic convergence were considered:

1) beta economic convergence – it occurs when less developed countries are characterized by a faster rate of economic growth than more developed countries (Ram, 2021). The main assumption of this convergence is the existence of a specific state of long-term equilibrium for all selected countries (Próchniak, 2019). To determine the degree of economic beta convergence, the following formula was used:

$$\frac{1}{T}(\ln Y_{iT} - ln Y_{i0}) = \alpha_0 + \alpha_1 \ln Y_{i0+} \varepsilon$$

where:

Y_{iT} and Y_{i0} – GDP per capita in the final and initial years

T – the number of years between the final and initial years ($T = 18$ for the period 2004–2021)

ε – random component. β convergence occurs when the assessment of parameter $\alpha 1$ is negative and statistically significant. In such a situation, the rate of convergence factor β can be calculated from the formula:

$$\beta = -\frac{1}{t}\ln(1 + \propto_1 t).$$

2) sigma economic convergence – makes it possible to determine the situation when the dispersion in the level of socio-economic development in selected countries is leveled (Borowiec, 2017; Maulana et al., 2020).

$$s.d.(lnY_t) = \propto_0 + \propto_1 t + \varepsilon$$

where:
$s.d.(lnY_t)$ is the standard deviation of the natural logarithms of GDP per capita in year t, the variable t on the right side of the equation is a time variable (a linear trend is assumed).

Results

The economic convergence analysis begins with the presentation of the level of GDP and GDP per capita of selected EU countries. These data should enable the determination of both the diversification of basic macroeconomic measures and trends related to the economic convergence of the CEE countries to the EU-12 countries. EU member states are characterized by significant differences in terms of national wealth (Table 1).

Table 1. Nominal GDP per capita of CEE and EU-12 in 2004–2021

Group of countires	Country	2004 (in thousands USD)	2021 (in thousands USD)	Change (%)
EU-12	Austria	36.89	53.64	45.40
	Belgium	35.43	51.25	44.65
	Finland	37.77	53.65	42.05
	France	33.80	43.66	29.18
	Germany	34.11	51.20	50.13
	Greece	22.00	20.19	-8.20
	Ireland	47.75	100.17	109.77
	Italy	31.32	35.66	13.86
	Luxembourg	76.54	133.59	74.53
	Netherlands	40.44	57.77	42.86
	Portugal	18.06	24.57	36.00
	Spain	24.91	30.10	20.86
CEE	Bulgaria	3.39	12.22	260.55
	Croatia	9.76	17.69	81.20
	Czechia	11.75	26.82	128.27
	Estonia	8.91	27.94	213.48
	Hungary	10.30	18.73	81.80
	Latvia	6.38	21.15	231.55
	Lithuania	6.70	23.72	254.06
	Poland	6.68	18.00	169.40
	Romania	3.49	14.86	325.13
	Slovak Republic	10.69	21.39	100.08
	Slovenia	17.23	29.29	69.97

Source: Authors' own study based on World Bank data.

In 2004, the average nominal value of GDP per capita in the CEE was USD 14.66 thousand. The most developed countries in 2004 were: Slovenia, the Czech Republic and Slovakia (approx. USD 10 thousand), while in 2021 the highest GDP per capita was recorded in Slovenia, Estonia and the Czech Republic (USD 26–30 thousand GDP). In the years 2004–2021, there was a much greater increase in GDP per capita in CEE countries than in the EU-12. Most CEE countries (except Croatia, Slovenia and Hungary) recorded an increase in GDP per capita by over 100%, with the highest growth recorded in Lithuania and Romania, as well as Bulgaria and Estonia.

Most of the EU-12 countries are more developed than the CEE countries. The average value of GDP per capita in the EU-12 countries in 2004 amounted to USD 31.47 thousand, and in 2021 USD 43.44 thousand. The country with the highest level of GDP per capita is Luxembourg, the lowest values were recorded in the peripheral countries (southern countries), and the highest in the core countries (highly developed countries). In the years 2004–2021, there was an increase in GDP per capita of all EU-12 countries, with the largest increase recorded in Ireland (109.77%).

Table 2. The ratio between average GDP per capita of CEE countries and EU-12 in 2004 and 2021

Country	2004	2021
Bulgaria	9.27	22.38
Croatia	26.68	32.38
Czechia	32.12	49.11
Estonia	24.37	51.16
Lithuania	28.16	34.29
Latvia	17.44	38.72
Poland	18.32	43.43
Romania	18.27	32.95
Slovak Republic	9.55	27.20
Slovenia	29.23	39.17
Hungary	47.11	53.63

Source: Authors' own study based on World Bank data.

From 2004 to 2021, the GDP of the CEE countries increased in comparison to the EU-12 average. The average value of the indicator was 23.68% in 2004 and 38.58% in 2021. However, these values are still very low. The highest were recorded in Hungary and the Czech Republic (over 30% in 2004, in 2021, in the Czech Republic, Estonia and Hungary (around 50% of the average GDP per capita of the EU-12 countries). The lowest values were recorded in Bulgaria and the Slovak Republic. In 2004, the GDP per capita ratio of these CEE countries to the average was approximately 9%, and in 2021, it increased to 22.38% and 27.20%. The regression analysis made it possible to determine the degree of beta and sigma economic convergence of CEE countries to the EU-12 (Table 3 and Table 4).

Table 3. Results of the estimation of the parameters of the regression equation of the GDP per capita growth rate about beta convergence between CEE and EU-12 in 2004–2021

Parameter	Value
α1	-0.0261352
std. error	0.0461303
t-ratio	-5.666
p-value	0.0002***
α0	0.288387
std. error	0.0420375
t-ratio	6.860
p-value	4.40e-05***
Adjusted *R*-squared	0.738705
Convergence *β*	Yes
β coefficient	0.020828944

Source: Authors' own study based on World Bank data.

Taking into account the assessment of the parameters of the regression equation, the existence of beta convergence of countries in relation to the value of GDP per capita can be confirmed. This is evidenced by the results of the regression analysis, including negative and statistically significant alpha coefficient, *p*-value (0.002) and three asterisks, as well as the coefficient of determination *R*-square (0.738705). A beta of 0.020828944 indicates a rate of economic convergence of around 2% per year. Thus, in the years 2004–2021, the CEE countries were characterized by a higher GDP per capita to the EU-12.

During the analyzed period, convergence was accompanied by the second type of convergence – sigma convergence (Table 4). This implies that the income gap between the CEE countries and the EU-12 is narrowing over time.

Table 4. Results of the estimation of the parameters of the regression equation of the GDP per capita growth rate in relation to sigma convergence between CEE and EU-12 in 2004–2021

Parameter	Value
α1	19.8301
std. error	30.8783
t-ratio	-0.6422
p-value	0.5298
α0	0.419947
std. error	334.238
t-ratio	28.14
p-value	4.68E-015***
Adjusted *R*-squared	-0.035801
Convergence σ	No

Source: Authors' own study based on World Bank data.

The research results indicate that in the years 2004–2021 there was no sigma convergence process in relation to GDP per capita. This is evidenced by the values and evaluations of the parameters of the regression equation. First, $\alpha 1$ is positive (19.8301). This value is not statistically significant (*p*-value is 0.5298). Moreover, the model is not a good fit (adjusted *R*-squared is -0.035801). This means that in the years 2004–2021 there was no process of decreasing the diversification of the surveyed CEE countries to the EU-12 in terms of GDP per capita.

Discussions

The study of the economic convergence of CEE countries in relation to the EU-12 group began in 2004, i.e. when 8 out of 11 of these countries joined the EU. According to most studies, economic integration has contributed to an increase in economic convergence, increasing economic similarity between the economies of CEE and the EU-12 countries (Stanišić et al., 2018).

For example, in the study by Próchniak (2019), the existence of beta and sigma economic convergence of post-socialist countries in relation to Western European countries was confirmed, with a faster rate of convergence recorded in the surveyed countries that joined the EU. Nevertheless, in periods of economic crises, an opposite phenomenon was observed, i.e. income divergence.

In the case of economic convergence studies at the regional level (Borowiec, 2017), beta convergence was noticed in some regions of Central and Eastern Europe to the EU-12, but its effects were very diverse. Moreover, beta convergence was not generally accompanied by sigma convergence. Additionally, economic growth was conducive to beta convergence and sigma divergence, while the economic and financial crisis favoured beta divergence and sigma convergence. There is a close relationship between the initial level of national GDP per capita and regional convergence processes at the European level.

Many studies (Bayoumi & Eichengreen, 1992; Simionescu, 2015) show that there are still a few economic convergence clubs in the EU. The countries of Central and Eastern Europe have different development trends compared to the EU-12. Moreover, the gap in the level of economic development between CEE countries and the highly developed countries of the EU is still very large. By the concepts of economic convergence, in order to reduce socio-economic disparities in the European Union, measures aimed at increasing innovation and competitiveness are necessary (Mańkiewicz, 2016).

This article also provides similar conclusions. According to the research results, it is possible to confirm the existence of beta convergence of CEE countries compared to the EU-12 in terms of economic prosperity, taking into account the average wealth of citizens (GDP per capita). The economic measure, which is key in the study of economic convergence, is the basis for stating that in the years 2004–2021 there was

a process of convergence between the groups of the surveyed EU countries. On the other hand, based on the sigma convergence study, no reduction in the economic differentiation of the countries studied was observed.

The increase in economic (income) convergence of CEE and EU-12 countries is a positive observation confirmed empirically. The accession of several CEE countries to the EU has played a significant role in fostering convergence. The integration process involves adopting EU norms, standards, and policies, which has contributed to aligning economic structures and promoting economic development. A high level of economic convergence provides arguments for further economic integration, including monetary integration. It can be assumed that the deepening economic convergence of CEE and EU-12 will enable the achievement of stable development and increased effectiveness of joint initiatives in the future. It is important to note that convergence is a dynamic process, and challenges may still exist. While progress has been made, continued efforts in areas such as economic and institutional reforms, innovation, and addressing regional disparities are essential for sustained convergence between CEE and EU-12 countries.

Nevertheless, the process of convergence of CEE and EU-12 seems to be slow, there is no process of narrowing differences in GDP per capita, and economic forecasts indicate that the process of beta convergence may be reversed due to macroeconomic conditions and the pandemic crisis. The COVID-19 pandemic has had significant implications for economic convergence within the EU. The impact has been complex, affecting member states differently based on their economic structures, policy responses, and resilience. Initially, the pandemic exacerbated existing economic disparities between EU member states. Countries heavily reliant on sectors like tourism and hospitality, suffered more severe economic downturns compared to others. This widened the economic gap between the more prosperous EU-12 countries and CEE.

In such a situation, actions at the national and international level are necessary to reduce socio-economic inequalities and support the convergence process of CEE and EU-12 countries, including stimulating economic growth in less developed countries.

Conclusions

Economic convergence plays an important role in the modern economy. Economic convergence is a very frequently discussed topic in the context of economic integration. It points to the challenges faced by the member states of the EU. In addition, the literature on the subject emphasizes that economic integration has an ambivalent impact on economic convergence. Nevertheless, it can be assumed that the accession of CEE countries to the EU made it possible to accelerate the socio-economic development of their economies.

According to research results, between 2004 and 2021, there was an increase in beta convergence between CEE countries and the EU-12. On the other hand, based

on the sigma convergence study, no reduction in the economic differentiation of the countries studied was observed. This implies that during the analyzed period, a negative relationship existed between the average growth rate of per capita income and the initial level of this income. This indicates that low-income countries (CEE group) exhibited a higher rate of economic growth (GDP per capita) compared to the EU-12 countries. However, it cannot be conclusively stated that there has been a reduction in the differences in income per capita between regions or countries in the years 2004–2021. Therefore, it is crucial to continue efforts aimed at reducing the socio-economic disparities between the EU-12 and CEE.

Nevertheless, in order to more precisely determine the relationship between economic convergence and economic integration, further research should be conducted on the real convergence of CEE and EU-12 countries. This is particularly important given the fact that all CEE countries under consideration are expected to join the euro zone. Examining the extent of economic convergence of CEE countries with the EU-12 will facilitate an analysis of the feasibility of joining the euro area and provide insights into potential difficulties and challenges associated with the adoption of a single currency in an economically diverse region.

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