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LABOUR PRODUCTIVITY CONVERGENCE OF CEE COUNTRIES WITH THE EURO AREA – EVIDENCE AT AGGREGATE AND SECTORAL LEVEL[2]

The paper aims to verify the existence of labour productivity convergence of Central and Eastern European (CEE) countries with the euro area over the period 2000-2020 at aggregate and sectoral levels. For this purpose, the study uses the beta and sigma convergence methods. The application of the ordinary least squares fixed effects panel regression proves the existence of beta convergence of the countries of Central and Eastern Europe with the euro area at both aggregate and sectoral levels. Stronger convergence is observed in the agriculture, forestry and fishing sector and in the industry sector (including construction) than at aggregate level. The weakest convergence is observed in the services sector. The results of the linear trend model of the coefficient of variation for the σ-coefficient confirm the hypothesis of sigma convergence between the average level of labour productivity of the countries of Central and Eastern Europe and the average of the euro area at aggregate and sectoral levels. At the same time, the differences in the degree of convergence between the three sectors resulting from the application of beta convergence are confirmed. The comparison according to the degree of sigma convergence with the euro area in the different countries of Central and Eastern Europe shows stronger convergence in the countries that have adopted the euro than in the countries outside the euro area, which is considered to be a consequence of the Europeanisation effect.
Keywords: Labour productivity convergence; Beta and Sigma convergence; countries from Central and Eastern Europe; Euro area; Panel regression model
JEL: *E24; F02; L16; O47*

1. Introduction

Labour productivity is an important indicator of the level of economic development achieved. It reflects both productivity through the use of labour and the contribution of other factors of production and technologies used. At the same time, labour productivity is a main characteristic of the labour market and is inextricably linked to income in society. According to neoclassical and endogenous growth theory, labour productivity plays a key role in achieving economic growth and improving living conditions in the long run. In this respect,

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the study of labour productivity convergence is an important part of the analysis of real convergence, together with the study of income convergence. In this context, positive labour productivity dynamics and convergence are identified as a factor for real convergence (e.g. Schadler et al., 2006;Grela et al., 2017;Adomnicai, 2018, etc.).

The analysis of the real convergence of the Central and Eastern European (CEE) countries to the euro area or to the old Member States has aroused academic interest over a long period of time. It is well understood in the literature that nominal convergence should be accompanied by real convergence of incomes and labour productivity in order to increase the effectiveness of the monetary policy. In this context, and in view of the adoption of the euro in Bulgaria and other CEE countries that are not yet part of the euro area, it is important to achieve convergence of labour productivity with the euro area, as this facilitates the convergence of real incomes and is an indicator of similarities in the technological principles used.

Different dynamics and magnitudes of labour productivity can be observed in the distinct sectors of the economy. This is due to their specific characteristics in terms of the combination and quantity of factors of production used, the technological principles applied, their share in the economy, etc. Changes in labour productivity at the sectoral level, as well as the presence of structural change, generally characterised by the transition of the economy from a dominant share of agriculture through a dominant share of industry to a dominant share of services, may influence the dynamics of labour productivity in the economy as a whole. In this respect, the identification of trends in individual sectors of the economy reveals what the drivers of labour productivity dynamics are at the aggregate level.

The study of labour productivity convergence between the CEE countries and the euro area at sectoral level addresses, on the one hand, the issue of real convergence and, on the other hand, partly the question of convergence of certain structural characteristics of the economy. Structural changes in the economies of the CEE countries are reported for the period 2000-2020, which are consistent with trends in the euro area. The share of value added and employment in the agriculture, forestry and fishing sector is declining and is higher in CEE countries on average than in the euro area throughout the period 2000-2020. In industry, the share of the sector in gross value added and employment is declining in the euro area and in the CEE countries on average. At the same time, the share of the sector is higher in the CEE countries on average than in the euro area during the period under investigation. Opposite trends can be observed in the services sector. On the one hand, the share of employment in this sector is growing in the CEE countries and in the euro area. On the other hand, the share is higher in the euro area than in the CEE countries.

Differences in labour productivity between countries determine variation in the competitiveness of economies and comparative advantages in international trade, which show peculiar differences in individual economic sectors. Labour productivity in the CEE countries has traditionally lagged behind that of the euro area. In 2020, the average in the CEE countries was only 37.9% of the value in the euro area. At the same time, there are differences in the individual sectors (agriculture, forestry and fishing sector – 46.3% of euro area labour productivity, industry (including construction) sector – 34.3% of euro area labour productivity, services sector – 40.5% of euro area labour productivity), but on average the

CEE countries do not reach 50% of euro area labour productivity in any of the sectors. However, some countries reach more than 50% of the euro area average in 2020 – Slovenia and Slovakia at the aggregate level, Slovakia, Estonia and Czechia in the agriculture, forestry and fishing sector, Slovenia in the industry sector and in the services sector. The lowest labour productivity as a percentage of the euro area is reported from countries outside the euro area, namely Bulgaria and Romania. These results indicate some differences between the countries of CEE in terms of labour productivity levels and convergence with the euro area, largely due to the distinct levels of development and integration into the European economy.

The existence of common policies, institutions and regulations, as well as the functioning of the Single market and Monetary union in the European Union, provide an appropriate framework for analysing labour productivity convergence between countries. Despite the reported trends and differences in labour productivity between the CEE countries and the euro area over the period 2000-2020, there has been an improvement in the position of this group of countries. The growth rate of labour productivity in the CEE countries, on average, as a percentage of the euro area for this period is 50.4%, which is a significant improvement. Facilitating factors for convergence between CEE countries and the euro area could be the integration and functioning of the economies in the European single market with all the consequences that this entails, the pursuit of common objectives and priorities of the Union, the transfer of knowledge and technologies, the identical structural change in the economies, the impact of the EU structural and investment funds, etc. The economies of the countries that have adopted the euro are even more interdependent, which may, to some extent, lead to greater convergence with the euro area. According to Bower and Turrini (2010), the EU accession has accelerated the catching-up process and improved the institutions of the new Member States' laggards.The impact of EU and euro area membership on various aspects of Member States' development is known in the literature as the "Europeanisation effect" and can be seen as a factor facilitating convergence between countries, but not equally strong for all CEE countries.

The Europeanisation effect can influence convergence between the CEE countries and the euro area through various transmission mechanisms. If labour productivity improves in one sector in an EU country as a result of R&D and the new knowledge is transferred to the same sector in another country, this leads to sectoral convergence in labour productivity. At the same time, it is also possible that new knowledge in one sector is transferred to another sector, increasing productivity at the aggregate level. In this respect, the standardisation of technological principles can manifest itself as a convergence factor both in aggregate labour productivity and at the sectoral level. There is free movement of capital and labour within the EU and channels for the diffusion of technology and innovation. As trade between countries increases, relations between firms intensify. Firms from more backward countries are able to copy firms from more developed countries in terms of production processes and technology, management techniques, etc. In addition, the increasing trade in capital and intermediate goods leads to standardisation of production technologies in companies, and the increasing mobility of labour within the Single market facilitates the transfer of new ideas between countries. There are also some factors, such as institutions and national characteristics, that affect labour productivity, regardless of the economic sectors. The

psychology of the nation, cultural characteristics and traditions, etc., can be perceived as such.

The aim of the article is to investigate the existence and degree of convergence of labour productivity of the CEE countries with the euro area by applying the sigma and beta convergence methods. An important research question is whether the trends that characterise the productivity of the economy at the aggregate level can also be found in the individual sectors of the economy and what specific characteristics exist at the sectoral level. In this respect, this paper contributes to the literature by providing empirical evidence on the presence or absence of unconditional beta and sigma convergence of labour productivity at both aggregate and sectoral levels of CEE countries to the euro area over a 21-year period (2000-2020). The study presents an original beta convergence approach based on time series analysis and the use of the euro area as a benchmark (common steady-state). At the same time, it investigates the impact of the Europeanisation effect on the degree of convergence by highlighting the specificities of each CEE country.

The paper is structured as follows. The next section provides a brief review of relevant literature in the field. The third part describes the methodology adopted. The fourth part presents the main findings of the application of beta and sigma convergence, aiming to verify the hypothesis of the existence of labour productivity convergence of countries of Central and Eastern Europe with the euro area at aggregate and sectoral levels. The last part presents the main conclusions drawn from the analysis.

2. Literature Review

The empirical examination of labour productivity convergence at the aggregate and sectoral levels is a topic of academic interest, as it plays an important role in revealing trends in real convergence. This type of studies are often conducted in the context of the integration of countries within the European Union, as such processes are expected due to the Europeanisation effect and the strong interdependence of Member States' economies. The results of the studies on labour productivity convergence do not lead to unambiguous conclusions, which is mainly due to the different periods of investigation and the methodology chosen.

The study by Bernard and Jones (1996) is one of the founders in this field. It examines labour productivity convergence at an aggregate level and in six economic sectors (agriculture, mining, manufacturing, electricity/gas/water, construction and services) in 14 OECD countries for the period 1970-1987. By applying the beta and sigma convergence methods, aggregate labour productivity was found to converge across countries. The application of the beta convergence method shows that this trend masks growing differences in individual sectors. In manufacturing, the study finds evidence of divergence or a weak convergence process. Similar results are obtained for agriculture and mining. At the same time, labour productivity in the services sector shows strong convergence between the countries studied. Convergence also exists in the electricity/gas/water and construction sectors. According to Bernard and Jones (1996), the strong convergence in the services sector, together with the structural change characterised by the declining share of industry in all countries, is the main

factor for the existing convergence of labour productivity at an aggregate level. The authors explain the lack of convergence in certain sectors by specialisation based on comparative advantages. Such an analysis is particularly interesting in an economic integration project such as the European Union. Similar studies have been conducted by a number of authors (Doyle, O'Leary, 1999; Sondermann, 2012; Naveed, Ahmad, 2016, etc.). There are also studies that examine the convergence of a particular country with the EU, the EU-15 or the euro area (Doyle, 1997; Wojciechowski, 2016; Adomnicai, 2018; Micallef, 2020; Stefanova, 2021a; Stefanova, 2021b; Raleva et al., 2022, etc.).

Doyle and O'Leary (1999) examine whether there is convergence in labour productivity between 11 EU countries over the period 1970-1990 at the aggregate level and across the three economic sectors (agriculture, including agriculture, forestry and fisheries; manufacturing, including manufacturing, mining and quarrying; and services, including electricity, construction, trade, transport, finance, community and government services). Despite the differences in the scope of the countries studied and the methodology used, the results of the study confirm the conclusions of Bernard and Jones (1996), who find greater convergence between countries in labour productivity at an aggregate level than in labour productivity at a sectoral level. Doyle and O'Leary (1999) confirm that these results may be due to the same structural changes across countries. At the same time, they find that labour productivity diverges in the industry and agriculture, forestry and fisheries sectors, while in the services sector, there is a convergence between the countries studied. According to the authors, structural change in two or more countries, associated with a reduction in the share of the less productive sectors in the economy, leads to higher labour productivity in the economy at an aggregate level and to a convergent trend in this area rather than at the sectoral level. It should be noted, however, that there is also empirical evidence for the opposite trend. This is the conclusion of a study by Sondermann (2012), which examined the convergence of labour productivity in twelve euro area countries over a much longer period of time (1970 to 2007) and at a more disaggregated level of economic activity. The analysis covers eleven sectors and 11 sub-sectors of industry according to the classification NACE Rev. 1.1. The study is based on the beta convergence method and the panel unit root test model and draws different conclusions than Bernard and Jones (1996) and Doyle and O'Leary (1999). The results show no convergence between the countries studied in terms of labour productivity at the aggregate level and show a low degree of convergence at the sectoral level. On the other hand, Sondermann (2012) also demonstrates divergence in manufacturing, but at a disaggregated level, it shows that the opposite trend is observed in some low-technology sub-industries. In the services sector, the empirical results show convergence in transport and communications, financial services and non-market services. Convergence is also observed in agriculture.

A more recent study by Naveed and Ahmad (2016) comes to different conclusions. The authors examine the convergence of labour productivity at an aggregate level and in six economic sectors between 19 European countries for the period 1991-2009. By applying the method of beta convergence, the study concludes that there is a convergence of labour productivity between countries at an aggregate level and in individual sectors.

Peshev and Pirimova (2020) examine the presence of beta and sigma convergence processes (measured by calculating coefficients of variance) in labour productivity between NUTS2

regions in all CEE member states during the period 2000-2016. The results demonstrate the presence of a beta convergence process and a decrease in differences in labour productivity in NUTS2 regions in all CEE member states during the period studied, indicating sigma convergence.

The factors behind the convergence process of labour productivity may be different. Structural change (as measured by changes in employment in different economic sectors) is considered one of these factors because of its impact on the dynamics of labour productivity (e.g. Ark, 1995; Naveed, Ahmad, 2016). According to Ark (1995), the movement of workers from less productive sectors to higher productive sectors can lead to an overall increase in labour productivity in the economy. In this context, it is pointed out that structural change is seen as a factor that has a stronger impact on labour productivity at an aggregate level than on sectoral labour productivity. If there is a similar structural change in two or more countries, it is possible that this will lead to a convergence of labour productivity at an aggregate level.

The importance of the diffusion of technology between countries for the convergence of labour productivity between them has been recognised by a number of authors (e.g. Wacziarg, 2004; Barro, Sala-i-Martin, 1997). Technology transfer can lead to a reduction in labour productivity differences between CEE countries and the euro area. In this respect, the degree of convergence depends on the extent to which technologies are transferred and absorbed within the EU. This is what most theories of economic growth predict – the openness of economies and the spillover effects of R&D investment will contribute to convergence between countries. The question of interest is whether this dependence exists and accordingly affects the convergence process of labour productivity between CEE countries and the euro area, and whether it also exists at the sectoral level. Bernard and Jones (1996) point out that in sectors where comparative advantages lead to a specialisation of the countries, labour productivity convergence between them is not to be expected.

Sondermann (2012) distinguishes between the factors of labour productivity convergence in the industrial sector and in the services sector in the context of European integration. According to him, the process of European integration reduces barriers to capital, labour and knowledge, which stimulates labour productivity convergence in the industrial sector, where technology transfers between EU countries are facilitated. As regards the services sector, progress in the development of information and communication technologies and the reduction of regulations in some areas have had a positive impact on productivity growth and convergence between countries.

A review of some of the existing empirical studies on labour productivity convergence has shown that differences are found at an aggregate level and in individual sectors of the economy. This paper offers a different approach to examine the convergence of CEE countries by assessing their convergence with the euro area as a benchmark.

3. Methodology

The paper examines the existence of convergence/divergence of labour productivity of CEE countries to the euro area as a benchmark at both aggregate and sectoral levels over the period 2000-2020. For this purpose, real labour productivity is calculated for each economic sector and for the economy at an aggregate level. The three main economic sectors are defined according to the classification NACE Rev.2 (revision 2008): agriculture, forestry and fishing sector – activity A, industry (including construction) by activities C to F and services by activities G to U. Real labour productivity is calculated as a ratio between gross value added (GVA) at constant prices (chain-linked volumes 2010) and employment for each CEE country and the euro area (19) on average for each year of the period under review. Employment is expressed in thousands of hours worked, as this indicator is more precise than employment, measured as thousand people. The data source is Eurostat. The sigma and beta convergence approaches, first introduced by Barro and Sala-I-Martin (1991) in the study of income convergence, are used to study the convergence of CEE countries to the euro area. Because the process of convergence to the euro area as a common steady state is taken into consideration, the research tests for unconditional (absolute) beta convergence rather than conditional beta convergence. Conditional convergence is not examined, because it implies that each country has its own steady state to which to converge.

The application of the beta convergence approach in this article differs from the classical methodology in similar studies, as it examines the convergence of the CEE countries with the euro area (19) as a benchmark using a time series approach and an ordinary least squares (OLS) fixed effects panel regression. Three similar approaches exist in the literature, but they are used to study structural convergence or convergence in certain economic sectors (e.g. Gugler, Pfaffermayr, 2004; Höhenberger, Schmiedeberg, 2008; Stefanova,Peshev, 2021, Raleva et al., 2022). The adequacy of the fixed effects models is confirmed by conducting a Hausman test.

Through the following formal representation of a fixed effects model, four separate models are applied at an aggregate level and for the three economic sectors:

$$Y_{it} = \alpha_i + \beta X_{it-1} + u_{it} \quad (1)$$

where:

$Y_{it}$is the dependent variable for country "i" at year "t";

α_i– country "I" specific, time-invariant individual factors containing constant and fixed effects;

β – kx1 Matrix of parameters representing the relationship between the explanatory variable (X_{it-n}) and the dependent variable (Y_{it});

X_{it-1}– the explanatory variable for country "i" at year "t-1";

u_{it}– the error term.

For the application of the beta convergence approach, the following equation is used:

$$\frac{LP_{sit}/LP_{sit-1}}{LP_{EAst}/LP_{EAst-1}} = \alpha_i + \beta \frac{LP_{sit-1}}{LP_{EAst-1}} + u_{it} \quad (2)$$

where:

LP_{sit}/ LP_{sit-1} is the quotient (annual change) of labour productivity in country "i" in sector "s" at year "t" and labour productivity in country "i" in sector "s" at year "t-1";

LP_{EAst}/LP_{EAt-1} – the quotient (annual change) of labour productivity in euro area in sector "s" at year "t" and labour productivity in the euro area in sector "s" at year "t-1";

LP_{sit-1}– labour productivity in country "i" in sector "s" at year "t-1";

LP_{EAt-1}– labour productivity in the euro area in sector "s" at year "t-1";

α_i– country "i" specific, time-invariant individual factors containing constant and fixed effects;

β –the kx1 matrix of parameters, representing the association between $\frac{LP_{sit-1}}{LP_{EAst-1}}$ and the $\frac{LP_{sit}/LP_{sit-1}}{LP_{EAst}/LP_{EAst-1}}$;

u_{it}–the error term.

The presence of beta convergence generally means that the change in an indicator is negatively affected by its initial value. Thus, a larger earlier value leads to a smaller change. When examining the convergence of labour productivity of the CEE countries with the euro area as a benchmark at aggregate and sectoral levels in this paper, the logic described is maintained. In this sense, the ratio between the annual change in labour productivity in the CEE countries and the annual change in labour productivity in the euro area should be negatively related to the ratio between the value of labour productivity in the previous year in the CEE countries on average and labour productivity in the euro area in the previous year. The ratio, which is the explanatory variable, provides information on the extent of the differences between the CEE countries and the euro area. This approach to measuring the gap is adopted because it avoids negative values of the independent variable.

The application of the beta convergence approach using equation (2) aims to find out whether countries with a higher (lower) labour productivity in year t-1 show a stronger decline (increase) compared to the euro area in year t. In particular, beta convergence occurs if the ratio between labour productivity in the CEE countries and labour productivity in the euro area in year t-1 has a significant and negative impact on the ratio between the annual changes in labour productivity in the CEE countries and the annual change in labour productivity in the euro area.

Applying the sigma convergence approach, this study examines whether labour productivity gaps between CEE countries and euro area have narrowed over the period 2000-2020. To measure the extent of the differences, coefficients of variation (as the ratio between the standard deviation and the mean in percents) are calculated between the values reported in each of the CEE countries and the euro area at aggregate and sectoral levels over the

researched period. In addition, a coefficient of variation between the average for the CEE countries and the euro area is calculated for each year of the period under consideration. The use of coefficients of variation is a standard approach to detect the presence of sigma convergence in income and other economic indicators.

The sigma convergence approach is applied by evaluating the trend line of the coefficient of variation of labour productivity by estimating the following linear trend model:

$$CV_{it} = \alpha_i + \sigma_t + u_{it} \quad (3)$$

where:

CV is coefficient of variation between the country "i" and the euro area at year "t". It is the dependent variable for country "i" at year "t";

α_i – constant;

σ – parameter, representing the association between the explanatory variable (t) and the dependent variable (CV_{it});

t – a time period variable, which is the explanatory variable;

u_{it} – the error term.

For sigma convergence to occur, there must be an inverse relationship between the independent and explanatory variables. Accordingly, the coefficient of variation must be negatively related to the time period and the trend line of CV must have a negative slope. The lower the value of the parameter σ (correspondingly higher its absolute value), the stronger the reported sigma convergence, indicating a larger decrease in the differences between the respective country and the euro area. Forty-four separate equations are estimated – for the CEE countries on average and separately for each of the ten countries at aggregate level and in the three economic sectors. The analysis of sigma convergence is complemented by the derivation of the dynamics of the coefficients of variation over the period 2000-2020.

4. Results and Discussion

The existence of similarities between countries in terms of institutions and their national characteristics can be seen as supporting labour productivity convergence between countries. In this respect, the analysis of labour productivity convergence of CEE countries to the euro area at the aggregate and sectoral levels should take into account the impact of the initial conditions in the countries – qualitative and quantitative characteristics of the factors of production, technology and competitiveness of the economies, etc. The countries examined in this article are characterised by similar conditions at the beginning of the period, with much smaller differences between them than between individual countries or CEE countries on average and the euro area (Figure 1).

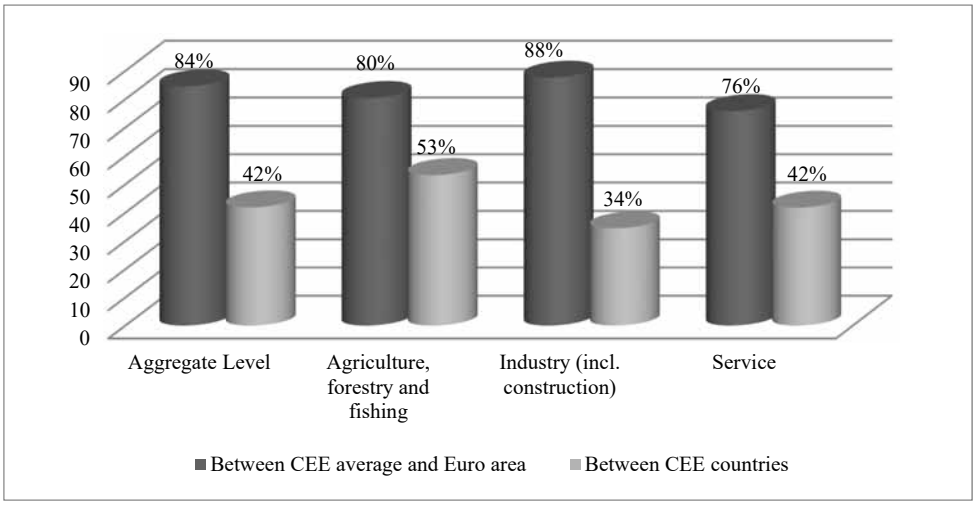
In the European Union, there has traditionally been a gap between the Member States in terms of labour productivity, with the CEE countries showing the least favourable trends in the EU.

The value of the indicator is below the EU average in all CEE countries throughout the 2000-2020 period. In contrast, labour productivity in the old Member States (EU-14) is above the EU average with a few exceptions (some Mediterranean countries).

In 2020, Bulgaria had the lowest value of labour productivity both at an aggregate level and in the three sectors of the economy. At the end of the period, the highest labour productivity is reported by the countries that are members of the euro area and Czechia. For some countries, such as Croatia, the position among the other CEE countries deteriorates in 2020 compared to 2000 (Table 1).

Figure 1

Differences (Coefficient of variation) in labour productivity in 2020 (in %)



Source: Author's calculations based on Eurostat data.

Table 1

Labour productivity in the countries from Central and Eastern Europe and the euro area

Country	Aggregate Level		Agriculture, forestry and fishing sector		Industry (including construction) sector		Services sector	
	2000	2020	2000	2020	2000	2020	2000	2020
Bulgaria	3.9	6.8	1.8	2.0	3.97	6.6	5.0	8.3
Czechia	11.2	18.5	5.6	10.2	9.42	17.7	13.4	19.4
Estonia	7.9	15.9	4.0	13.0	6.71	15.6	9.2	16.2
Croatia	10.1	13.2	4.0	6.9	9.00	11.7	12.4	14.6
Latvia	5.5	12.7	2.1	7.4	6.17	12.3	6.5	13.5
Lithuania	6.3	14.3	1.8	7.0	6.02	16.5	8.0	14.2
Hungary	8.6	14.1	2.6	7.9	8.61	13.9	10.3	14.8
Poland	7.2	13.2	1.5	3.1	7.19	13.3	9.3	14.8
Romania	3.7	9.9	0.8	2.8	4.88	10.4	7.5	12.3
Slovenia	15.3	23.2	2.6	5.6	13.61	24.3	20.9	25.2
Slovakia	10.2	19.6	2.1	13.3	7.90	20.9	13.0	19.2
CEE average	8.2	14.7	2.6	7.2	7.59	14.8	10.5	15.7
EU-27	26.7	33.3	5.4	10.8	26.17	34.8	30.5	34.6
Euro area (19)	32.4	38.7	9.5	15.5	32.26	43.3	34.7	38.8

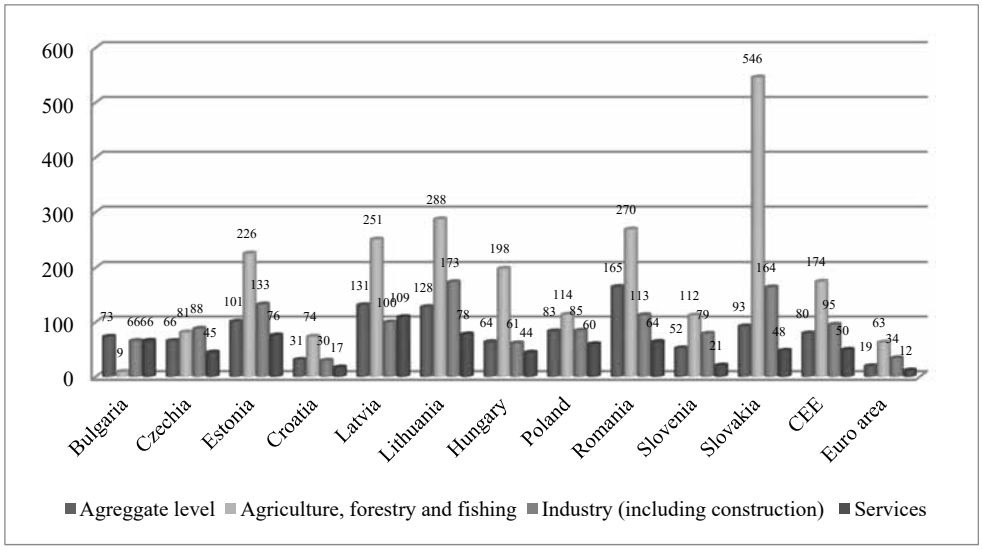
Source: Author's calculations based on Eurostat data.

Labour productivity in the three sectors of the economy shows certain differences due to the specific characteristics of the factors of production used, the technological principles applied and the organisation of the production process. In all the countries of Central and Eastern Europe and in the euro area, labour productivity is traditionally lowest in the agriculture, forestry and fishing sector (Table 1). However, this tendency, combined with the limited share of the sector in the economy in all countries, may have a positive impact on the dynamics of labour productivity at an aggregate level.

Despite relatively lower labour productivity, the agriculture, forestry and fishing sector is significantly modernised between 2000 and 2020, with a higher labour productivity growth rate in 2020 (compared to 2000) than in industry and services both in the euro area and CEE countries on average. This trend is also observed in most of the countries considered, with the exception of Bulgaria and Czechia (Figure 2). At the same time, in the countries of Central and Eastern Europe, there is a sharp decline in employment in this sector, which is more pronounced than in the industry sector. This confirms the thesis of Wacziarg (2004) that the relationship between changes in the share of employment in the sector and changes in labour productivity is negative and that when labour productivity increases in a given sector, employment in that sector tends to decrease.

Figure 2

Labour productivity growth rate in 2020 (compared to 2000) (in %)



Source: Author's calculations based on Eurostat data.

With the exception of two euro area Member States, Lithuania and Slovakia, labour productivity in 2020 is higher in services than in industry in CEE countries, whereas the opposite trend is observed in the euro area after 2010 (Table 1).

In all CEE countries, the growth rate of labour productivity at the aggregate level is higher than in the euro area, indicating convergence with the euro area. This trend is repeated in the

three sectors of the economy, with few exceptions. In Bulgaria, the growth rate of labour productivity in the agriculture, forestry and fishing sector and in Croatia, the value of the indicator in the industry sector are lower than in the euro area (Figure 2). These are the two countries that joined ERM II in 2020.

The application of fixed effects panel ordinary least squares panel regression proves the existence of beta convergence between the countries of Central and Eastern Europe and the euro area over the period 2000-2020, both at aggregate and sectoral levels. This is evidenced by the coefficients before the explanatory variable (significant at a 1% significance level), which have a negative sign (Table 2). The results show that there is a statistically significant and negative impact on the ratio between labour productivity at time "t-1" in the CEE countries and the same indicator in the euro area on the ratio between the annual change in labour productivity in the CEE countries at time "t" and the similar indicator in the euro area. Therefore, the existence of greater differences with the euro area in labour productivity leads to more significant growth of the indicator in the CEE countries compared to the euro area.

Table 2

Fixed-effects panel ordinary least squares regression results for b-convergence

Aggregate Level				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.139050	0.014273	79.80676	0.0000
X (expl.var.)	**-0.358073**	0.043681	-8.197463	0.0000
CorrelatedRandomEffects – HausmanTest				
Testcross-sectionrandomeffects				
TestSummary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.	
Cross-sectionrandom	36.101101	1	0.0000	
Agriculture, forestry and fishing sector				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.245666	0.033605	37.06736	0.0000
X (expl.var.)	**-0.547456**	0.084115	-6.508401	0.0000
CorrelatedRandomEffects – HausmanTest				
Testcross-sectionrandomeffects				
TestSummary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.	
Cross-sectionrandom	39.374888	1	0.0000	
Industry (including construction) sector				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.171908	0.021688	54.03550	0.0000
X (expl.var.)	**-0.498349**	0.070501	-7.068720	0.0000
CorrelatedRandomEffects – HausmanTest				
Testcross-sectionrandomeffects				
TestSummary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.	
Cross-sectionrandom	39.897350	1	0.0000	
Services sector				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.141491	0.025975	43.94654	0.0000
X (expl.var.)	**-0.349770**	0.072790	-4.805182	0.0000
CorrelatedRandomEffects – HausmanTest				
Testcross-sectionrandomeffects				
TestSummary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.	
Cross-sectionrandom	15.501108	1	0.0001	

Source: Application of the models in E-views based on Eurostat data.

According to the results of the study, the strongest beta convergence is reported in the agriculture, forestry and fishing sector, followed by the industry sector (including construction). This is reflected in the higher absolute values of the coefficient before the independent variable. Interestingly, beta convergence at the aggregate level is weaker than in these two sectors. The weakest convergence is observed in the services sector.

The reasons for the greater convergence in the agriculture, forestry and fishing sector between CEE countries and the euro area can be attributed to the impact of the EU's Common Agricultural Policy and the significant modernisation of the sector in CEE countries due to EU funding. This could be seen as an aspect of the Europeanisation effect. The higher convergence of labour productivity in the industry compared to services could be due to the stronger and more successful transfer of innovations and production technologies to the CEE countries in this sector, as well as the lower share of services in trade within the EU. At the same time, the starting position of labour productivity is important, as the value in the industry sector in the CEE countries is lower than in the services sector. The data in Figure 2 also show that labour productivity in the CEE countries increased more in the industry sector than in the services sector during the period, reflecting, to some extent, the modernisation of the sector.

For the convergence of labour productivity at an aggregate level, the structural change in the economies (measured by the shares of hours worked in one of the sectors in the total number of hours worked) of the countries of Central and Eastern Europe and the euro area is important. It consists in the increase in the share of the services sector and the decrease in the share of the agriculture, forestry and fishing and industry sectors over the period 2000 – 2020.

The presence of β-convergence is a necessary but not a sufficient condition for the differences between the CEE countries and the euro area to narrow. For this reason, the existence of sigma convergence between the CEE countries and the euro area is assessed by estimating the linear trend model of the coefficient of variation.

The results of the study support the hypothesis of the existence of labour productivity sigma convergence between CEE countries and the euro area at aggregate and sectoral levels. Furthermore, the differences in the degree of convergence between the three sectors derived by applying beta convergence are confirmed. The results of the sigma convergence analysis also show the strongest convergence in the agriculture, forestry and fishing sector, followed by the industry sector, and the weakest convergence in the services sector. The degree of convergence at an aggregate level is lower than that reported in the agriculture, forestry and fishing sector (Table 3).

It is important to investigate the degree of sigma convergence with the euro area in the different countries of Central and Eastern Europe. Table 4 summarises the estimates for the parameter σ, which represents the relationship between the explanatory variable (t) and the dependent variable in equation (3). All coefficients are significant at a 1% level of significance. Applying the sigma convergence approach at the aggregate level shows that there is a sigma convergence trend in labour productivity between each CEE country and the euro area.

Table 3

Linear trend model of coefficient of variation results for σ-convergencebetween CEE countries on average and euro area

Aggregate Level				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	81.97960	0.810563	101.1391	0.0000
time (expl.var.)	**-0.920867**	0.064553	-14.26528	0.0000
Agriculture, forestryandfishingsector				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	75.01507	1.513816	49.55362	0.0000
time (expl.var.)	**-1.152924**	0.120560	-9.563073	0.0000
Industry (includingconstruction) sector				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	84.04173	1.105894	75.99436	0.0000
time (expl.var.)	**-0.808514**	0.088073	-9.180029	0.0000
Services sector				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	74.37517	0.594794	125.0436	0.0000
time (expl.var.)	**-0.674543**	0.047369	-14.24010	0.0000

Source: Application of the models in E-views based on Eurostat data.

The comparison between the countries that are in the euro area and those that are not, in terms of the degree of sigma convergence, is in favour of the first group. Of course, there are some exceptions, but the general trend is clear. Estonia, Latvia, Lithuania and Slovakia show the strongest sigma convergence with the euro area, while in Croatia, Czechia, Bulgaria and Hungary, the narrowing of the gap with the euro area is relatively weaker. These trends largely continue at the sectoral level. At the same time, it is important to note that some countries show a sigma divergence at the sectoral level. Again, these are countries outside the euro area – Bulgaria and Czechia in the agriculture, forestry and fishing sector and Croatia in the industry sector. This reflects a lower Europeanisation effect in these Member States.

Table 4

Linear trend model of coefficient of variation results for σ-coefficient

Country	Aggregate Level	Agriculture, forestry and fishing sector	Industry (including construction) sector	Services sector
Bulgaria	-0.587587	0.889301	-0.341288	-0.715771
Czechia	-0.786253	0.631245	-0.802544	-0.598397
Estonia	-1.138585	-2.162314	-1.259166	-0.909300
Croatia	-0.260843	-0.012876	0.227024	-0.169517
Latvia	-1.371851	-1.987163	-0.681712	-1.345740
Lithuania	-1.288426	-1.773775	-1.440285	-0.899182
Hungary	-0.521380	-1.247223	-0.207274	-0.383063
Poland	-1.014648	-0.299082	-0.894701	-0.761492
Romania	-1.380844	-0.851738	-0.890131	-1.068765
Slovenia	-0.651037	-0.530573	-0.663868	-0.215114
Slovakia	-1.238846	-3.886534	-1.733631	-0.696349

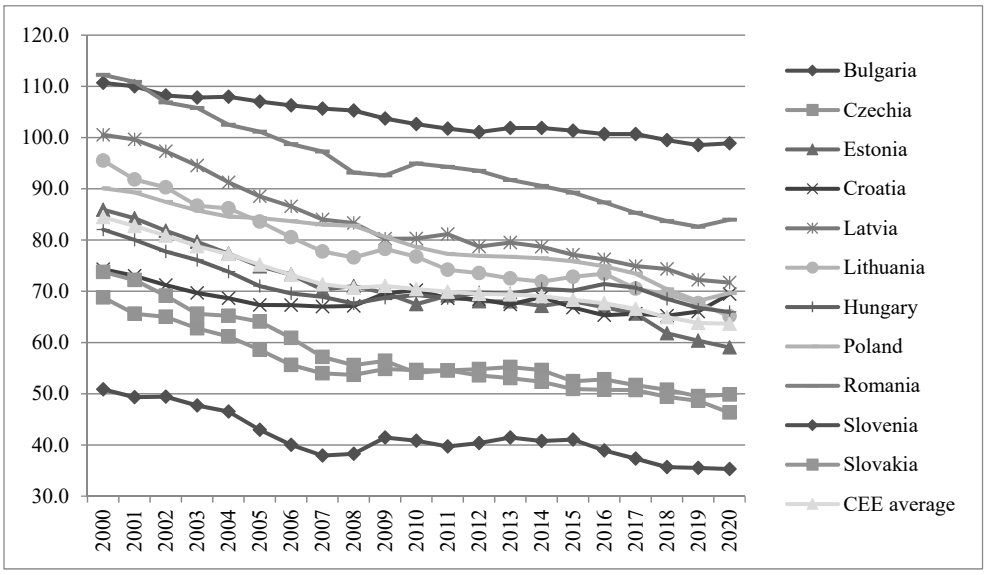
Source: Application of the models in E-views based on Eurostat data.

There are other differences between euro area and non-euro area CEE countries. For example, in the countries of CEE on average and in almost all CEE countries that have adopted the euro (with the exception of Latvia), convergence is stronger in the industry sector than in the services sector. In the other CEE countries outside the euro area (with the exception of Czechia), the trend is reversed.

Throughout the period under review, the differences with the euro area in terms of labour productivity at the aggregate level are largest in Bulgaria and Romania and smallest in Slovenia, Slovakia and Czechia (Figure 3).

Figure 3

Coefficients of variation between CEE countries and euro area at an aggregate level (in %)



Source: Author's calculations based on Eurostat data.

The coefficients of variation in 2020 in the countries outside the euro area, with the exception of Czechia, are above the average for the countries of Central and Eastern Europe and have higher values than that in the countries that have adopted the euro (excluding Lithuania) (Figure 3). This reaffirms the differences between these two groups of CEE countries.

The global economic crisis slows down the sigma convergence between the countries of CEE and the euro area, as a greater reduction in differences, as measured by the coefficient of variation, is observed in most countries until the crisis is reflected, after which the process slows down (Figure 3). The influence of the economic crisis on convergent averages in the CEE countries is also confirmed in studies on real and structural convergence (e.g. Matkowski, Próchniak, Rapacki, 2016; Coutinho, Turrini, 2020; Velichkov, Damyanov, 2021; Raleva, 2021).

Despite the reported convergence in the CEE countries on average at the end of the period, the differences with the euro area in terms of labour productivity remain significant, with

coefficients of variation above 50% at aggregate and sectoral levels, being most significant in the industry sector, followed by agriculture, forestry and fishing sector, and least significant in the services sector. This shows that although there is convergence, it is not yet very far advanced and the process must be continued and accelerated in the coming years.

5. Conclusion

The findings of the study support the hypothesis of the existence of beta and sigma convergence of labour productivity in the countries of Central and Eastern Europe with the euro area in the period 2000-2020, both at the aggregate and sectoral levels. The analysis reveals certain differences in the degree of convergence between economic sectors, reflecting their specific characteristics and providing insight into the drivers of labour productivity dynamics and convergence at the aggregate level. The results of the application of fixed effects panel regression show that the strongest convergence is in the agriculture, forestry and fishing sector, followed by the industry sector (including construction). Moreover, convergence in these two sectors is stronger than at the aggregate level. The weakest convergence is registered in the services sector. The ranking of sectors according to the degree of convergence between the average level of labour productivity in the CEE countries and the euro area on average is also confirmed by the results obtained by applying the linear trend model of the coefficient of variation.

The convergence of labour productivity between the countries of Central and Eastern Europe and the euro area in the period 2000-2020 is an indicator and facilitating factor for the real convergence of incomes. The Europeanisation effect supports this process through the transfer of knowledge and technology, the existence of common policies, institutions and regulations within the European Union, the functioning of the Single Market and the Monetary Union, the identical structural changes in the economies, the impact of EU structural and investment funds, etc. The strength of the Europeanisation effect may vary from one Member State to another. The results of the analysis allow such a conclusion. The comparison according to the degree of sigma convergence with the euro area in the different countries of Central and Eastern Europe shows a stronger convergence in the countries that have adopted the euro than in the countries outside the euro area. The reported trend manifests itself largely at the sectoral level, as even some of the non-euro area countries show a divergence trend – Bulgaria and Czechia in the agriculture, forestry and fishing sector and Croatia in the industry sector.

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