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# CONVERGENCE OF LABOUR PRODUCTIVITY IN AGRICULTURE OF THE EUROPEAN UNION

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## Abstract

*Labour productivity is commonly considered as one of the most important parameters of development of economies, because it is conductive to reduction of costs, increase in supply of cheaper goods and services, higher dynamics of the market and higher purchasing power of societies, their wealth and competitive ability. But labour productivity is – at the backdrop of the EU countries – highly diversified, including in particular in agriculture where its level is much lower than in other sectors of the economy. The main objective of the presented paper is to examine and assess the changes in labour productivity in the EU agriculture in the context of the diversity of its level and dynamics of change underlying the identification of labour productivity convergence/divergence processes taking place in agriculture. The labour productivity convergence processes in the EU agriculture were analysed based on data from the period between 2005 and 2016, by testing two its basic types, namely* sigma *and* beta *convergence. The analysis applied statistical measures describing the degree of labour productivity differentiation in agriculture of the EU countries and cross-sectional regression function. The research showed that* sigma *and* beta *convergence exist in general in the EU-28 countries and in the group of the new Member States (UE-13). In the group of old Member States, however, no* sigma *convergence/divergence was identified, but statistically significant* beta *divergence was noted.*

**Keywords:** convergence, agriculture, EU, labour productivity.

**JEL codes**: Q13, O47, C2.

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## Introduction

In the aspect of integration processes taking place in the EU, a particular importance should be placed on the issue of labour productivity, conditioned by two basic factors. First of all, its low level in many of the EU countries is the main barrier to the transition to an intensive growth path. Secondly, changes in labour productivity will largely determine both the dynamics and costs of integration on the European and global scale, and the degree of levelling significant differences in the level of socio-economic development of the EU countries. It should also be emphasised that the level of labour productivity is widely recognised as one of the most important development parameters of economies because it leads to lower costs, increased supply of cheaper goods and services, it makes the market more dynamic and increases the purchasing power of societies, their wealth and competitive capacity. The above-comments refer to the entire economy, but especially to the agricultural sector, where the level of labour productivity in the EU countries is strongly differentiated and significantly lower than in other sectors of the economy. Therefore, the main goal of the presented article is to examine and assess the changes in labour productivity across the EU agricultural sector at the backdrop of diversification of its level and dynamics of change, forming the grounds for identifying the processes of convergence/divergence of labour productivity taking place in agriculture.

## Source materials and research methodology

The study uses the Economic Accounts for Agriculture (EAA), i.e. harmonised financial reports effective in the EU which enable analysis of the economic situation in agriculture according to uniform principles (Rozporządzenie..., 2004), published by the European Statistical Office (Economic..., 2018). On the basis of these sources of information, the real (in prices from 2010) level of labour productivity in agriculture in the individual EU countries, measured by the relation of gross value added (GVA) to the number of annual work units (AWU), was estimated for 2005-2016. The level of labour productivity estimated in the above manner was the basis for its multidimensional analyses in the aspect of dynamics of changes, spatial differentiation and convergence/divergence processes.

The article analyses two basic types of convergence, i.e. *sigma* ($\delta$) convergence and *beta* ($\beta$) absolute convergence. The former assesses the processes of convergence through the prism of changes in the degree of variation of the level of the studied phenomenon over time using different statistical measures of dispersion. The reduction in the variation of the studied phenomenon is generally the basis for a positive verification of the hypothesis about the occurrence of *sigma* ($\delta$) convergence. However, it requires verification of statistical significance. This type of approach to verification of the occurrence of economic convergence, including in relation to the agricultural sector, is adopted by many foreign and national researchers (see Andrade, Laurini, Madalozzo and Valls Pereira, 2004; Adamowicz and Szepulak, 2018, Baer-Nawrocka and Markiewicz, 2012; Baráth and Fertö, 2017; Brelik and Grzelak, 2011; Ciołek, 2005; Galanopoulos, 2011; Ghosh, 2006; Gutierrez, 2000;

Hamulczuk, 2015; Kumar, Lala and Chaudhary, 2014; Kusideł, 2013; Matkowski and Próchniak, 2005; Próchniak 2004, 2006; Próchniak and Witkowski, 2006; Rezitis, 2010; Sala-i-Martin, 1996 a,b; Sapa and Baer-Nawrocka, 2014; Suhariyanto and Thirtle, 2001; Quah, 1996).

In turn, the essence of *beta* ($\beta$) convergence is to examine the relationship between the initial level of the examined feature and its dynamics of changes. If this relationship is negative, $\beta$ convergence occurs, i.e. countries (regions) with a higher level of the analysed feature in the initial period develop more slowly than the countries where the level of this feature was lower. The relationship of this type is also verified in terms of statistical significance. This type of testing of economic convergence was formulated by Baumol (1986) and has been used in many empirical research of growth processes in agriculture and other sectors of the economy (see Barro and Sala-i-Martin, 1992; Baumol, 1986; Ciołek, 2005; Cuerva, 2012; De Long, 1988; Dowrick and Nguyen, 1989; Galanopoulos, 2011; Ghosh, 2006; Gutierrez, 2000; Hamulczuk, 2015; Kumar et al., 2014; Kusideł, 2013; McErlean and Wu, 2003; Levine and Renelt, 1992; Mankiw, Romer and Weil, 1992; Próchniak, 2004, 2006; Sala-i-Martin, 1996 a,b; Suhariyanto and Thirtle, 2001).

The analysis of $\delta$ convergence of labour productivity in the EU agriculture uses logarithmised standard deviation $sd(\ln WP)$ and the coefficient of variation ($v(\ln WP)$), calculated according to the following formulas:

$$sd(lnWP) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(lnWP_i(t) - \overline{WP}(t))^2} \qquad v(lnWP) = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(lnWP_i(t) - \overline{WP}(t))^2}}{ln\overline{WP}(t)}\ x\ 100$$

where:

$\overline{WP}(t) = \frac{1}{n}\sum_{i=1}^{n} lnWP_i(t)$ – average level of labour productivity in period $t$;

$WP_i(t)$ – labour productivity in the $i$-th country in the period $t$.

In addition, the $\delta$ convergence hypothesis was verified by estimating the equations of regression of standard deviation and the coefficient of variation of labour productivity ($WP$) in the form of:

$$sd(\ln WP) = \alpha_0 + \alpha_1\, t + \varepsilon \qquad \text{oraz} \qquad v(\ln WP) = \alpha_0 + \alpha_1\, t + \varepsilon$$

where:

$sd(\ln WP)$ – standard deviation of the natural logarithm of labour productivity in agriculture between the EU countries in year $t$;

$v(\ln WP)$ – the coefficient of variation of the natural logarithm of labour productivity in agriculture between the EU countries in year $t$;

$t$ – time variable ($t$ = 1…..12);

$\varepsilon$ – random disturbances.

In turn, one of the most commonly used models which explains the increase in the studied feature $i = 1,\ldots..,N$, between the period $t_0$ i $t_0 + T$ using the initial value of this feature was used to verify the *beta*-convergence hypothesis of labour productivity in the EU agriculture, using cross-sectional data (Ciołek, 2005; Kusideł, 2013; Próchniak, 2004, 2006):

$$ln\left(\frac{Y_{it_{0+T}}}{Y_{it_0}}\right) = \alpha_0 + \alpha_1\, ln(Y_{it_0}) + \varepsilon_{it_0,t_0} + T$$

A negative or positive and statistically significant value of the estimator means the occurrence of convergence or divergence. If this parameter is not significant, the convergence or divergence parameter does not occur. The estimator $\alpha_1$ of the above equation is also used to calculate the $\beta$ parameter called the convergence coefficient. It is calculated from the transformation of the equation $\alpha_1 = -(1 - e^{-\beta T})$ to the form $\beta = -ln(1+ \alpha_1)/T$, where $T$ is the time interval between extreme years of research (Kusideł, 2013). Signs of $\beta$ and $\alpha_1$ parameters inform about the occurrence of convergence or divergence. If $\beta < 0$, there is divergence (discrepancy) between the studied units, whereas in the case of $\beta > 0$, there is convergence. On the basis of the size of the $\beta$ convergence coefficient, it is possible to obtain information on what percentage of the distance from the so-called state of balance is covered in one period or how much in a given unit of time the difference between the actual value of the examined feature and its value in the stationary state of balance decreases (Kusideł, 2013; Malaga and Kliber, 2007). Generally, the higher the relative $\beta$ value, the faster the rate of convergence/divergence. In addition, the $\beta$ convergence coefficient is used to calculate the $HL_{1/2}$ (half-life), informing about the time needed to reduce current differences in the level of the studied phenomenon by half. In the case of the cross-sectional model presented above, this measure is calculated from the formula (Batóg, 2015; Ciołek, 2005; Kusideł, 2013): $HL_{1/2} = \frac{ln2}{\beta}$.

In the analysis of convergence processes, very often there is the problem of the so-called atypical values which can have a very large impact on the estimation of parameters of convergence models, and thus on the assessment of its nature. Atypical values may cause a significant change in the value of assessment of structural parameters after their removal, but at the same time they do not have to generate large regression residues (Batóg, 2015). *DfBeta* was used in the article to identify atypical values. The use of this measure, firstly, allows assessing the difference between the values of assessments obtained for regression at the full number of observations and for regression with the atypical value removed, and secondly, allows assessing the strength and direction of the impact of labour productivity transformations in each of the EU countries on the convergence process by analysing changes in the $\beta$ parameter. The size of this measure is calculated according to the formula (Belsley, Kuh and Welsch, 1980; Ciołek, 2005):

$$DfBeta = \frac{\hat{\beta}_j - \hat{\beta}_{j(i)}}{\sqrt{MSE_{(i)}(X^T X)^{-1}_{jj}}}$$

where:

$\hat{\beta}_j$ – means the *j*-th regression coefficient;

$\hat{\beta}_{j(i)}$ – the same coefficient but without the *i*-th observation;

$MSE_{(i)}$ – root mean square error.

It is assumed that a given observation is influential when for small and medium-sized samples $|DfBeta| > 1$, and for large samples if $|DfBeta| > \frac{2}{\sqrt{n}}$.

## Changes in labour productivity in the EU agricultural sector

Table 1 includes basic statistics presenting transformations in labour productivity in the EU agriculture in 2005-2016 in terms of its level and dynamics of changes and in the aspect of dynamics of changes in gross value added (GVA) and employment in agriculture (AWU). Their analysis indicates that total labour productivity in the EU in the analysed period increased on an annual average 2.13%, and this increase was the result of a much faster rate of decline in the number of people employed (-2.67%) than added value (-0.60%).

The above path of changes in labour productivity is essentially similar in the case of the EU-15 countries and the new Member States (EU-13). In the EU-15, transformations in labour productivity were also determined by a downward trend in value added (-0.65%) associated with a relatively faster rate of decline in the number of people employed (-1.61%), which resulted in an increase in labour productivity of 0.98% on annual average. In turn, in the EU-13, the favourable direction of labour productivity changes (3.45%) was mainly determined by a strong reduction in employment (-3.64%), and to a much smaller extent by changes in value added (-0.32%). However, the intensity of these changes as well as their direction strongly differentiates the EU countries.

Taking into account the leaders in the growth of labour productivity, attention should firstly be paid to dynamic changes in labour productivity in agriculture of Poland, Hungary, the Czech Republic, Bulgaria and Slovakia. In Poland, its level increased on annual average by as much as 4.82% and resulted from the increase in value added (1.88%) and reduction in employment (-2.81%). Similarly, these changes took place in Hungary where a relatively high labour productivity dynamics (4.75%) was associated with a strong increase in value added (3.01%) and a moderate reduction in the employment level (-1.66%). In turn, taking into consideration agriculture of the Czech Republic, it can be noted that the significant labour productivity dynamics (5.25%) was to a similar degree determined by both increase in value added (2.54%) and a decline in the number of people employed (-2.57%). A strong reduction in employment is also the factor which predominantly determined high dynamics

of increase in labour productivity in agriculture in Bulgaria (5.77%) and Slovakia (6.6%). In these countries, with different changes in value added (2.46% and -0.04%) in terms of scale and direction, the number of people employed in agriculture on annual average decreased by 7.79% and 6.23%, respectively.

Table 1

*Labour productivity in the EU agriculture in 2005-2016 (EUR thousand/AWU, real values in 2010 prices)*

| EU countries | Labour productivity (EUR thousand/AWU) | | | | ΔWP[a] | ΔGVA[b] | ΔAWU[c] |
|---|---|---|---|---|---|---|---|
| | 2005-2007 | 2008-2010 | 2011-2013 | 2014-2016 | % | | |
| Austria | 18.72 | 19.62 | 22.41 | 20.37 | 2.13 | 0.14 | -1.95 |
| Belgium | 38.51 | 35.24 | 39.37 | 36.42 | -0.03 | -1.81 | -1.77 |
| Bulgaria | 3.16 | 3.54 | 4.47 | 5.64 | 5.77 | -2.46 | -7.79 |
| Croatia | 6.57 | 7.20 | 5.87 | 4.87 | -0.74 | -3.14 | -2.42 |
| Cyprus | 12.52 | 12.02 | 12.48 | 13.65 | 1.18 | -1.71 | -2.86 |
| Czech Republic | 9.64 | 8.54 | 13.09 | 14.78 | 5.25 | 2.54 | -2.57 |
| Denmark | 44.89 | 38.16 | 58.00 | 44.32 | -1.19 | -2.56 | -1.38 |
| Estonia | 8.52 | 7.51 | 13.23 | 10.63 | -1.78 | -7.17 | -5.49 |
| Finland | 15.39 | 15.67 | 15.54 | 13.82 | -1.29 | -3.98 | -2.72 |
| France | 33.45 | 31.13 | 35.39 | 35.94 | -0.14 | -1.82 | -1.69 |
| Germany | 25.82 | 29.86 | 37.92 | 32.85 | 2.75 | 0.95 | -1.75 |
| Greece | 12.35 | 12.37 | 11.20 | 12.78 | -1.07 | -4.10 | -3.06 |
| Hungary | 4.87 | 4.83 | 6.32 | 7.31 | 4.75 | 3.01 | -1.66 |
| Ireland | 10.65 | 7.60 | 11.28 | 13.03 | 0.22 | 1.10 | 0.88 |
| Italy | 24.38 | 23.48 | 27.19 | 26.52 | 0.17 | -0.76 | -0.93 |
| Latvia | 2.98 | 2.57 | 2.96 | 3.88 | 3.17 | -2.26 | -5.26 |
| Lithuania | 4.53 | 4.51 | 6.70 | 6.28 | 2.91 | 1.48 | -1.39 |
| Luxembourg | 31.50 | 27.02 | 25.89 | 28.44 | -0.87 | -2.17 | -1.31 |
| Malta | 15.78 | 13.73 | 10.90 | 10.84 | -3.56 | -1.65 | 1.99 |
| Netherlands | 62.11 | 58.78 | 61.88 | 66.51 | 1.38 | 0.42 | -0.94 |
| Poland | 3.32 | 3.63 | 4.74 | 4.43 | 4.82 | 1.88 | -2.81 |
| Portugal | 8.18 | 7.97 | 7.89 | 9.54 | 1.32 | -2.22 | -3.49 |
| Romania | 3.14 | 3.59 | 4.50 | 4.25 | 1.02 | -3.37 | -4.35 |
| Slovakia | 6.64 | 5.73 | 9.89 | 10.91 | 6.60 | -0.04 | -6.23 |
| Slovenia | 5.69 | 4.95 | 5.18 | 5.85 | -0.41 | -1.48 | -1.07 |
| Spain | 25.00 | 22.88 | 24.74 | 29.61 | 1.53 | -0.12 | -1.63 |
| Sweden | 21.21 | 21.13 | 24.35 | 26.45 | 3.34 | 0.93 | -2.33 |
| United Kingdom | 21.42 | 27.68 | 33.12 | 31.65 | 2.84 | 2.44 | -0.39 |
| EU-28 | 13.26 | 13.65 | 16.38 | 16.80 | 2.13 | -0.60 | -2.67 |
| EU-15 | 24.38 | 24.09 | 27.53 | 28.04 | 0.98 | -0.65 | -1.61 |
| EU-13 | 3.77 | 4.03 | 5.18 | 5.16 | 3.45 | -0.32 | -3.64 |

[a] ΔWP – the annual average dynamics of changes in labour productivity, [b] ΔGVA – the annual average dynamics of changes in gross value added, [c] ΔAWU – the annual average dynamics of changes in employment in agriculture

Source: own study based on Eurostat.

Clearly less favourable processes of changes in labour productivity took place in agriculture of the majority of other new Member States, especially in Estonia, Croatia, Slovenia and Malta. In their case, there was a downward trend in the level of labour productivity, generally (except for Malta) as a result of a faster rate of decrease in value added than employment. Among these countries, a very strong regression was recorded in Malta where labour productivity dropped by as much as 3.56% on annual average, i.e. the fastest in the EU, following a downward trend in value added (-1.65%) and an upward trend in employment in agriculture (1.99%).

Taking into account the EU-15 countries, it can be noted that in half of them labour productivity decreased (Denmark -1.19%, Greece -1.07%, Luxembourg -0.87%, Finland -1.29%) or changed to a marginal extent (Belgium -0.03%, Ireland 0.22%, France -0.14%, Italy 0.17%), while in others it had an upward trend (Germany 2.75%, Spain 1.53%, the Netherlands 1.38%, Austria 2.13%, Portugal 1.32%, Sweden 3.34%, the United Kingdom 2.84%). In the EU-15 countries, where a marked decline in labour productivity was observed, unfavourable trends were determined by negative changes in value added which in the analysed period decreased on annual average in the range of 2.17-3.98%, with a decreasing, but more slowly, employment level (1.31-3.06%). On the other hand, the increase in labour productivity in the countries of this group resulted mainly from the increase in the value added associated with the decline in employment. Only Portugal and Spain stepped out of this path of labour productivity growth. In Portuguese agriculture, a quite strong downward trend in value added was recorded (-2.22%), however, weaker than the dynamics of decline in employment (-3.49%). The decline in the employment level (-1.63%) was also the factor that largely determined the increase in labour productivity in Spanish agriculture. However, unlike in Portugal, the impact of changes in the value added of agriculture on changes in labour productivity in Spain was small, gross value added decreased on annual average to a small extent (-0.12%).

The significantly higher growth rate of labour productivity observed in the analysed years in the EU-13 countries (3.45%) compared to the EU-15 (0.98%) did not translate into a significant reduction of differences in the level of labour productivity between these groups of countries. Despite the fact that both groups of countries are not uniform in terms of labour productivity, the differences between them are still very large. It can be noticed that on average in 2005-2007, labour productivity in the EU-15 (EUR 24.38 thousand/AWU) was nearly seven times (6.5) higher than on average in the EU-13 (EUR 3.77 thousand/AWU), and in 2014-2016, this relation decreased to about five (5.4). These relations indicate that despite a clear progress in labour productivity, its level in agriculture in the new Member States is still significantly lower. But then, the direction of changes in this relationship suggests that in the area of labour productivity, convergence processes take place in the EU agriculture. However, verification of this hypothesis requires application of appropriate analytical tools.

## Sigma ($\delta$) convergence/divergence of labour productivity in the EU agriculture

Table 2 and Figures 1-2 show changes in standard deviation (*sd*) and coefficient of variation (*v*) of labour productivity values, for which logarithms were found, in the EU agriculture (EU-28) and additionally broken down into groups of thr EU-15 and EU-13 countries. The above measures of dispersion were used to verify the occurrence of *sigma* ($\delta$) convergence/divergence.

The analysis of data included in Table 2 indicates that the convergence measures used have decreased in the analysed period which indicates a gradual levelling of differences in the level of labour productivity in agriculture between the EU-28 countries. Taking into account the coefficient of variation (EU-28), it can be noticed that in the analysed years its level was substantially decreasing, and this trend was subject to minor disturbances only in two years, i.e. in 2009 and 2012, in which – compared to previous years – there was a not very strong but noticeable increase in the level of this measure (33.4% and 29.1%). However, these deviations from the general trend did not disturb the main direction of changes. Its determinants are the levels of volatility index which in 2005-2007 (31.0-31.2%) were higher than in 2014-2016 (27.0-28.7%). The direction of changes in the size of this dispersion measure suggests the occurrence of processes of *sigma* ($\delta$) convergence of labour productivity.

Table 2

*Sigma (*δ*) convergence of labour productivity in the EU agriculture in 2005-2016 measured by standard deviation (*sd*) and coefficient of variation (*v*)*

| Measure | EU countries | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *v* (%) | EU-28 | 31.1 | 31.0 | 31.2 | 30.1 | 33.4 | 30.8 | 28.3 | 29.1 | 28.8 | 28.7 | 27.0 | 27.1 |
| | EU-13 | 29.8 | 28.8 | 29.0 | 26.5 | 31.8 | 25.6 | 23.9 | 24.3 | 24.8 | 23.9 | 22.2 | 23.3 |
| | EU-15 | 15.4 | 18.1 | 17.6 | 17.1 | 18.5 | 17.6 | 17.5 | 18.5 | 17.2 | 16.9 | 15.8 | 15.1 |
| *sd* | EU-28 | 0.88 | 0.87 | 0.90 | 0.85 | 0.90 | 0.88 | 0.83 | 0.87 | 0.85 | 0.85 | 0.79 | 0.79 |
| | EU-13 | 0.56 | 0.55 | 0.56 | 0.51 | 0.56 | 0.48 | 0.49 | 0.50 | 0.51 | 0.49 | 0.46 | 0.49 |
| | EU-15 | 0.50 | 0.59 | 0.58 | 0.55 | 0.58 | 0.58 | 0.58 | 0.63 | 0.58 | 0.57 | 0.53 | 0.50 |

Source: own study.

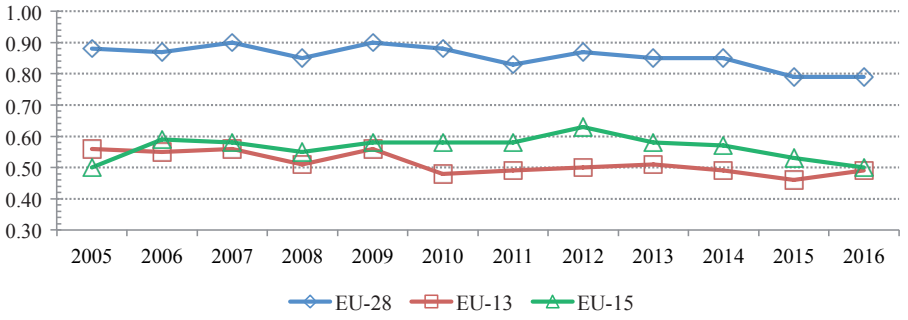


*Fig. 1. Sigma* (δ) convergence of labour productivity in agriculture in the European Union in 2005-2016 measured by standard deviation.

Source: own study.

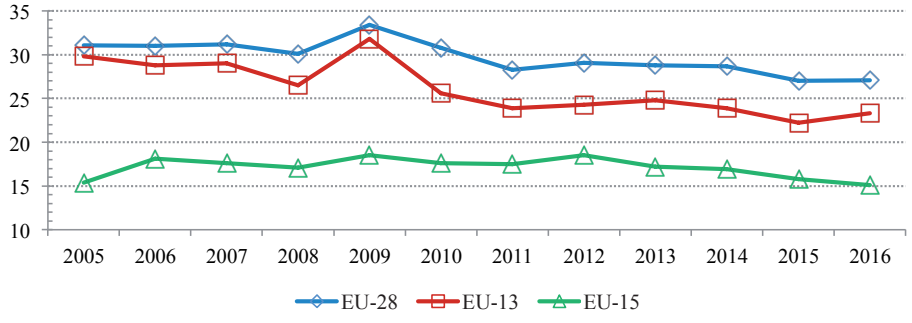


*Fig. 2. Sigma* (δ) convergence of labour productivity in agriculture in the European Union in 2005-2016 measured by the volatility index.

Source: own study.

Quite similar conclusions result from the assessment of convergence of labour productivity by means of standard deviation. In the analysed years, the size of this measure of polarisation decreased in the EU-28, and slight deviations from the trend are noticeable only in 2007, 2009 and 2012. However, also these deviations from the general trend did not disturb its direction of changes. In 2005-2007, the level of standard deviation (0.87-0.90) of labour productivity in the EU-28 was higher than in 2014-2016 (0.79-0.85).

The results of verification of δ convergence processes of labour productivity presented above also justify separate research for the new and the old Member States. The purposefulness of this type of analysis is justified not only by specific changes in labour productivity in the selected EU countries, but also significant differences in its level between the EU-15 and EU-13 countries as well as within the EU-15 and EU-13. In the light of data included in Table 2 and Figures 1-2, the changes in labour productivity polarisation in the EU-13 measured by the volatility index ran according to a fairly similar trajectory as in the EU-28, and a relatively stronger

disruption of the downward trend of changes in this measure of polarisation can be noted in this case only in 2009 when its size increased to 31.8%. This deviation from the general trend did not disturb the main direction of change in any way. Its determinants are the levels of volatility index which in 2005-2007 (28.8-29.8%) were clearly higher than in 2014-2016 (22.2-23.9%). This direction of changes in the applied dispersion measure quite strongly suggests the occurrence of *sigma* ($\delta$) convergence processes of labour productivity in the EU-13.

Similar conclusions follow from the assessment of convergence of labour productivity in the EU-13 by means of standard deviation. In the analysed years, the size of this measure was systematically decreasing, and slight deviations from the trend, not affecting its direction of changes, are also noticeable only in 2009. Between 2005 and 2007, the level of standard deviation (0.55-0.56) of labour productivity in the EU-13, similarly to the coefficient of variation, was higher than in 2014-2016 (0.46-0.49), and this also suggests the existence of *sigma* ($\delta$) convergence processes of labour productivity in the EU-13.

A significantly weaker intensity of changes in the diversity of labour productivity in agriculture was recorded in the EU-15. Even though also in this group of countries there is a gradual decrease in the level of applied dispersion measures, compared to the EU-13 countries, it is clearly weaker and does not have a clear trend. The comparison of volatility indices and standard deviation between extreme periods indicates relatively insignificant changes in the diversity of labour productivity (Table 2). In these periods, the levels of these dispersion measures are basically comparable and most likely related to the absence of *sigma* ($\delta$) convergence processes.

Trends in *sigma* ($\delta$) convergence of labour productivity presented above generally suggest the occurrence of convergence processes of labour productivity in agriculture of the EU-28 and EU-13 and the absence of this process in the EU-15. In order to verify this hypothesis, regression models were developed, whose parameters form the basis for the statistical assessment of the significance of the studied phenomenon, and thus a clear evaluation of its nature.

Table 3 presents parameters of the linear regression function of the trend of changes in applied dispersion measures for the EU-28, EU-13 and EU-15. On their basis, it can be concluded that the negative signs of time variables $\alpha_1$ and their high levels of significance ($p(\alpha_1) = 0.000$) indicate clearly, both in the case of the coefficient of variation ($\alpha_1 = -0.420$) and standard deviation ($\alpha_1 = -0.007$), the processes of *sigma* convergence of labour productivity in the EU-28. The parameters of this model are quite well aligned with empirical data. The time variable explains the variability of dispersion measures of labour productivity in the EU-28 in 63.6% and 52.8%.

Table 3

*Parameters of* sigma (δ) *convergence regression models of labour productivity in the EU agriculture (2005-2016)*

| Measure | EU countries | $\alpha_0$ | $\alpha_1$ | $t(\alpha_0)$ | $t(\alpha_1)$ | $p(\alpha_0)$ | $p(\alpha_1)$ | $R^2$ | δ convergence |
|---|---|---|---|---|---|---|---|---|---|
| *v* (%) | EU-28 | 32.45 | -0.420 | 47.29 | -6.20 | 0.000 | **0.000** | 0.636 | YES |
| | EU-13 | 30.67 | -0.695 | 34.32 | -8.39 | 0.000 | **0.000** | 0.689 | YES |
| | EU-15 | 17.74 | -0.099 | 19.41 | -0.82 | 0.000 | **0.410** | 0.099 | NO |
| *sd* | EU-28 | 0.889 | -0.007 | 56.94 | -3.52 | 0.000 | **0.000** | 0.528 | YES |
| | EU-13 | 0.914 | -0.013 | 41.44 | -5.48 | 0.000 | **0.000** | 0.715 | YES |
| | EU-15 | 0.552 | -0.001 | 19.15 | -0.24 | 0.000 | **0.813** | 0.009 | NO |

Source: own study.

The parameters of the regression model estimated for the EU-13 indicate a faster rate of convergence of agricultural labour productivity than in the EU-28. The negative signs of the time variable $\alpha_1$ here amount to: $\alpha_1$ = -0.695 (coefficient of variation) and $\alpha_1$ = -0.013 (standard deviation). In addition, in the case of both measures of dispersion, the significance of the time variable is high ($p(\alpha_1) = 0.000$) and, similarly to EU-28, it is related to the matching of the model to empirical data (68.9% and 71.5%).

In turn, a different assessment of the processes of labour productivity convergence in agriculture is justified by the parameters of the regression model estimated on the basis of the EU-15 countries. This assessment is largely consistent with the assessments made earlier on the basis of tabular and graphical analysis. In the light of data included in Table 3, although the parameter for the time variable α1 is negative here, both in the case of the variability index ($\alpha_1$ = -0.099) and standard deviation ($\alpha_1$ = -0.001), in relation to the parameters estimated for the EU-28 and EU-15, they are very low, and above all, highly statistically insignificant ($p(\alpha_1) = 0.410$ and 0.813). Therefore, the parameters of this model clearly indicate that in the EU-15 countries the processes of *sigma* (δ) convergence of agricultural labour productivity in the analysed years did not take place.

## *Beta* (β) convergence/divergence of labour productivity in the EU agriculture

*Beta* convergence is a condition necessary, but not sufficient for *sigma* convergence to occur. It is possible that regions with a low level of the studied phenomenon will develop faster than regions with higher level. However, this does not necessarily mean a reduction in the distance between them (Quah, 1996, Sala-i-Martin, 1996a). *Sigma* convergence is a sufficient but unnecessary condition for *beta* convergence to occur, and as a consequence the absence of *sigma* convergence does not allow concluding that regions with a lower initial level of the studied phenomenon do not develop faster than others.

As already pointed out, *beta* convergence occurs when regions with an initially lower value of the studied feature show a faster growth rate than the regions with initially higher value. A tool used to verify this type of relationship is usually their graphical presentation and econometric models where the dependent variable is assumed to be the periodic growth dynamics of the studied feature, and the explanatory variable – its value from the beginning of the analysed period.

Figure 3 and Table 4 include basic information which is the basis for assessing the nature of $\beta$ convergence/divergence processes related to labour productivity in agriculture in the EU-28. Taking into account all the EU countries, it can be noted (Figure 3) that the slope of the line reflecting the relation between the annual average labour productivity growth rate and its initial level is negative, which suggests the occurrence of *beta* convergence. In addition, the vast majority of countries are located along and close to the regression line, and greater deviations in this respect are noticeable in relation to the countries forming two aggregations. The first one is made up of Germany, the United Kingdom and Sweden, while the second of Malta, Ireland, Greece and Finland. In case of the first group of countries, their rather remote location over the regression line denies the hypothesis of *beta* convergence. The level of labour productivity in agriculture in Germany, United Kingdom and Sweden was relatively high in the initial period compared to the average level in the EU-28, and in the analysed period it was increasing also with a relatively high dynamics. Thus, the path of transformations of labour productivity in agriculture in these countries inhibits *beta* convergence processes. Taking into account the second group of countries, it is not hard to see that Malta, Ireland, Greece and Finland are located quite far below the regression line, in a place indicating the level of labour productivity generally similar to the average in the EU-28 but related to the negative direction of its changes. This type of relations between the initial level of labour productivity and its dynamics of changes is conductive to $\beta$ convergence.

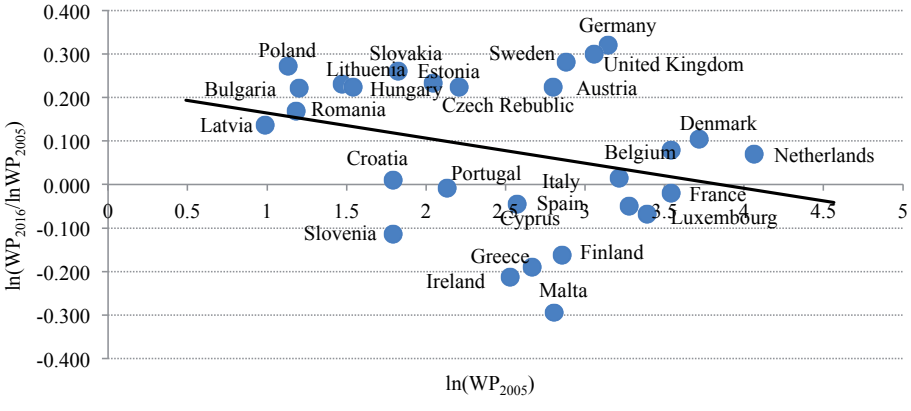


*Fig. 3. Beta* ($\beta$) convergence of labour productivity in agriculture – EU-28.

Source: own study.

Table 4

*Regression model of absolute type β convergence of labour productivity in agriculture for the EU-28*

| Regression parameters | | | | | | | β convergence | β (%) | $HL_{1/2}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha_0$ | $\alpha_1$ | $t(\alpha_0)$ | $t(\alpha_1)$ | $p(\alpha_0)$ | $p(\alpha_1)$ | $R^2$ | | | |
| 0.2218 | **-0.0576** | 5.9010 | -4.2910 | 0.0000 | **0.0000** | 0.0407 | **YES** | +0.49 | 140 |

Marking of model parameters: $\alpha_0$ – constant of equation, $\alpha_1$ – value of the parameter with explanatory variable ($ln(Y_{it_0})$), $t$ – Student's $t$-statistics, $p$ – significance levels, $R^2$ – coefficient of determination, $\beta$ – annual convergence rate (%), $HL_{1/2}$ (half-life) – time to reduce half of the productivity gap (in years).

Source: own study.

Table 5

*The impact of the individual EU-28 countries on the value of labour productivity convergence parameters ($\alpha_1$, β, $HL_{1/2}$) measured by* DfBeta

| EU-28 countries | *DfBeta* | Direction of impact +/- | $\alpha_1$ parameter | β (%) | $HL_{1/2}$(years) |
|---|---|---|---|---|---|
| Total | | | **-0.058** | **0.49** | **140** |
| Poland | **-0.473** | + | **-0.049** | **0.42** | **165** |
| Malta | **-0.353** | + | **-0.052** | **0.44** | **156** |
| Lithuania | -0.289 | + | -0.053 | 0.45 | 154 |
| Slovakia | -0.287 | + | -0.053 | 0.45 | 153 |
| Bulgaria | -0.273 | + | -0.053 | 0.45 | 153 |
| Luxembourg | -0.261 | + | -0.053 | 0.46 | 152 |
| Hungary | -0.257 | + | -0.053 | 0.46 | 152 |
| Finland | -0.252 | + | -0.054 | 0.46 | 151 |
| Spain | -0.200 | + | -0.054 | 0.47 | 149 |
| Estonia | -0.172 | + | -0.055 | 0.47 | 148 |
| Greece | -0.149 | + | -0.055 | 0.47 | 147 |
| France | -0.119 | + | -0.056 | 0.48 | 145 |
| Czech Republic | -0.105 | + | -0.056 | 0.48 | 145 |
| Romania | -0.056 | + | -0.057 | 0.49 | 143 |
| Ireland | -0.048 | + | -0.057 | 0.49 | 142 |
| Italy | -0.046 | + | -0.057 | 0.49 | 142 |
| Cyprus | -0.034 | + | -0.057 | 0.49 | 142 |
| Portugal | 0.113 | - | -0.060 | 0.51 | 136 |
| Latvia | 0.130 | - | -0.060 | 0.52 | 134 |
| Austria | 0.159 | - | -0.060 | 0.52 | 134 |
| Belgium | 0.199 | - | -0.061 | 0.53 | 132 |
| Croatia | 0.228 | - | -0.062 | 0.53 | 131 |
| Sweden | 0.275 | - | -0.062 | 0.54 | 130 |
| Denmark | 0.365 | - | -0.064 | 0.55 | 126 |
| Netherlands | **0.405** | - | **-0.065** | **0.56** | **123** |
| United Kingdom | **0.448** | - | **-0.065** | **0.56** | **123** |
| Slovenia | **0.486** | - | **-0.066** | **0.57** | **122** |
| Germany | **0.567** | - | **-0.067** | **0.58** | **120** |

Source: own study.

In order to verify the hypothesis of $\beta$ convergence of labour productivity in the EU-28, a cross-section growth regression was estimated in which explanatory variables are growth rates of labour productivity in agriculture, in accordance with the formula described in the methodical part of the article. In addition, the strength of the influence of individual countries on the value of the $\beta$ convergence parameter was estimated using *DfBeta*. The assessment of $\alpha_1$ parameter for the EU-28 presented in Table 4 is negative ($\alpha_1$ = -0.0576), which means that the processes of labour productivity convergence were taking place in the EU in the analysed period. In addition, the convergence parameter is statistically significant ($p(\alpha_1) = 0.000$) but explains the grow rate of labour productivity only in 3.8-4.1%. Thus, the estimated parameters of the model, on the one hand, indicate the process of convergence of labour productivity in the EU agriculture and, on the other, also inform about its very weak dynamics. Between 2005 and 2016, the annual rate of $\beta$ convergence of labour productivity was only 0.49%, which means that the time of reduction of half of the labour productivity gap is as much as around 140 years. This assessment also does not change fundamentally by omitting Germany, the United Kingdom and Sweden in the modelling. Even though, in the light of data in Table 5, the negative impact of the nature of changes in labour productivity in agriculture in these countries on the process of convergence in the EU is relatively high (*DfBeta* = 0.448-0.567), their omission has a limited impact on both the acceleration of the convergence rate ($\beta$ = 0.56-0.58) and the time of reduction of half of the labour productivity gap ($HL_{1/2}$ = 120-123 years). It is also worth emphasising that changes in the convergence of labour productivity in Poland had the strongest and positive influence on it in the EU-28 (*DfBeta* = -0.473). Although the omission of Poland in the construction of the productivity growth model does not translate into a significant slowdown in the convergence rate ($\beta$ = 0.42), it results in a fairly marked extension of the time of reduction of the productivity gap to 165 years.

Figure 4 shows the relationship between the initial level of labour productivity in agriculture and the annual average rate of changes in this level for the EU-15 countries. The relations shown on it result in a positive slope of the regression line and suggest the occurrence of the divergence process. While analysing the location of points representing individual EU-15 countries, one can notice that some of them are clearly remote from the regression line. Detailed analysis of these points indicates that these are practically the same countries which have already been indicated in the analysis of convergence in the EU-28. Points representing Germany, the United Kingdom, Sweden and additionally Austria are located above the regression line, while Ireland, Greece and Finland are located the lowest under this line. However, such location of these EU-15 countries suggests conclusions different than in the case of the EU-28. The nature of changes in labour productivity in some of the EU-15 countries, determined by the relationship between its initial level and the dynamics of changes in this level in the case of Germany, the United Kingdom, Sweden and Austria, is consistent with the $\beta$ convergence hypothesis, while in the case of Ireland, Greece and Finland negates this hypothesis. In the first group of countries, a relatively strong increase in labour productivity

was recorded, with productivity level in the initial period close to the average in the EU-15. But then, in the second group, the productivity level which was in the initial period clearly lower than on average in the EU-15 slightly increased (Ireland) or showed a downward trend (Greece and Finland). What is more, the positive slope of the regression line justifies the statement that the strength of influence of these countries on convergence processes is large enough to determine the occurrence of $\beta$ divergences in the EU-15.

Table 6 presents the results of statistical verification of the studied processes on the basis of estimated parameters of regression of labour productivity growth. Their analysis indicates that the assessment of $\alpha_1$ parameter for the EU-15 is positive ($\alpha_1 = 0.069$), which means that there were no processes of convergence but of divergence of labour productivity in the EU-15 in the analysed period. Moreover, $\alpha 1$ parameter is statistically significant ($p(\alpha_1) = 0.0138$), but explains the growth rate of labour productivity to a very small extent (2.36%). Therefore, parameters of this model indicate the occurrence of the process of divergence of labour productivity in agriculture of the EU-15, but also inform about its not very strong dynamics. In 2005-2016, the annual rate of $\beta$ divergence of labour productivity was 0.56%. However, the assessment of productivity changes in the EU-15 is quite substantially changed by the omission of Ireland, Greece and Finland in the modelling of its growth. In the light of data from Table 7, the negative impact of the nature of changes in labour productivity in agriculture of these countries on the convergence process in the EU-15 is high enough (*DfBeta* = 0.419-1.100) that their omission fundamentally changes the parameters of the regression model. These parameters, estimated on the basis of the remaining 12 countries, indicate the convergence process ($\alpha_1 = -0{,}0553$) and its annual rate at 0.47%, which translates into the time of reduction of half of the productivity gap of 146 years. Therefore, the levels of these convergence characteristics are very close to the levels estimated for the EU-28 and indicate very weak dynamics of the studied phenomenon.

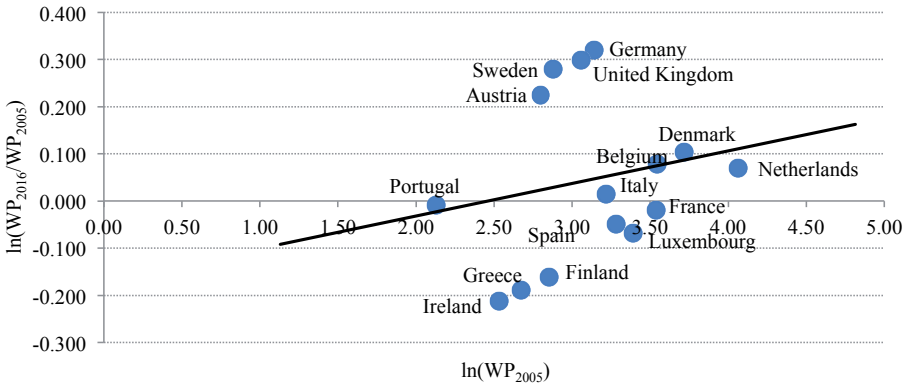


*Fig. 4. Beta* ($\beta$) convergence of labour productivity in agriculture – EU-15.

Source: own study.

Table 6

*Regression model of absolute β convergence of labour productivity in agriculture for the EU-15*

| Regression parameters | | | | | | | $\beta$ convergence | $\beta$ (%) | $HL_{1/2}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha_0$ | $\alpha_1$ | $t(\alpha_0)$ | $t(\alpha_1)$ | $p(\alpha_0)$ | $p(\alpha_1)$ | $R^2$ | | | |
| 0.4541 | **0.0690** | -1.8040 | 2.4620 | 0.0713 | **0.0138** | 0.0236 | **NO divergence** | -0.56 | - |

Marking of model parameters: $\alpha_0$ – constant of equation, $\alpha_1$ – value of the parameter with explanatory variable ($ln(Y_{i_0})$), $t$ – Student's $t$-statistics, $p$ – significance levels, $R^2$ – coefficient of determination, $\beta$ – annual convergence rate (%), $HL_{1/2}$ (half-life) – time to reduce half of the productivity gap (in years).

Source: own study.

Table 7

*The impact of the individual EU-15 countries on the value of labour productivity convergence parameters ($\alpha_1$, β, $HL_{1/2}$) measured by* DfBeta

| EU-15 countries | *DfBeta* | Direction of impact +/- | $\alpha_1$ parameter | $\beta$ (%) | $HL_{1/2}$ (years) |
|---|---|---|---|---|---|
| **Total** | | | **0.069** | **-0.56** | **-** |
| Austria | **-0.541** | + | **0.090** | **-0.72** | **-** |
| Sweden | **-0.505** | + | **0.088** | **-0.70** | **-** |
| France | -0.326 | + | 0.082 | -0.65 | **-** |
| Netherlands | -0.321 | + | 0.085 | -0.68 | **-** |
| Luxembourg | -0.299 | + | 0.080 | -0.64 | **-** |
| Spain | -0.139 | + | 0.074 | -0.60 | **-** |
| United Kingdom | -0.133 | + | 0.074 | -0.59 | **-** |
| Portugal | -0.127 | + | 0.076 | -0.61 | **-** |
| Italy | -0.029 | + | 0.070 | -0.56 | **-** |
| Belgium | 0.014 | - | 0.069 | -0.55 | **-** |
| Germany | 0.050 | - | 0.067 | -0.54 | **-** |
| Denmark | 0.086 | - | 0.066 | -0.53 | **-** |
| Finland | **0.419** | - | **0.053** | **-0.43** | **-** |
| Greece | **0.773** | - | **0.039** | **-0.32** | **-** |
| Ireland | **1.100** | - | **0.025** | **-0.20** | **-** |

Source: own study.

Figure 5 shows the relation between the initial level of labour productivity in agriculture and the annual average rate of changes in this level in the group of the new Member States (EU-13). These relations generate a clear and negative slope of the regression line and suggest the occurrence of *beta* divergence. The hypothesis of this type of convergence is confirmed by the parameters of labour productivity regression model (Table 8). The assessment of α1 parameter for the EU-13 is negative

($\alpha_1$ = -0.194), which means that the process of labour productivity convergence was taking place in agriculture of the EU-13 in the analysed period. The convergence parameter is statistically significant ($p(\alpha_1)$ = 0.000) and explains the grow rate of labour productivity in 14.4-15.0%. Therefore, the estimated parameters positively verify the *beta* convergence hypothesis, however, contrary to the model parameters forthe EU-28, they inform about its much greater dynamics. In 2005-2016, the annual rate of $\beta$ convergence of labour productivity was 1.8% (Table 8), which means that the time to reduce half of the labour productivity gap in the EU-13 group is around 39 years.

Additional information on the conditions of the convergence process is provided by the analysis of the impact of the individual EU-13 countries on this process (Table 9). In their light, in the analysed years *beta* convergence of labour productivity was very strongly determined by its transformations in Malta (*DfBeta* = -1.537). Their nature is determined by the highest level of labour productivity in the EU-13 in the initial period and a strong decline in this level over the analysed years. Relations of this type are conductive to convergence processes. The strength of the impact of transformations of labour productivity in Malta on the overall assessment of convergence in the EU-13 is also demonstrated by the size of parameters of the productivity growth model estimated on the basis of other 12 countries. In this case, the omission of Malta translates into a significant reduction in the size of $\alpha_1$ parameter to -0.1015, and thus a significant reduction in the rate of $\beta$ convergence to 0.89% and the extension of the time of reduction of the productivity gap by half to nearly 78 years.

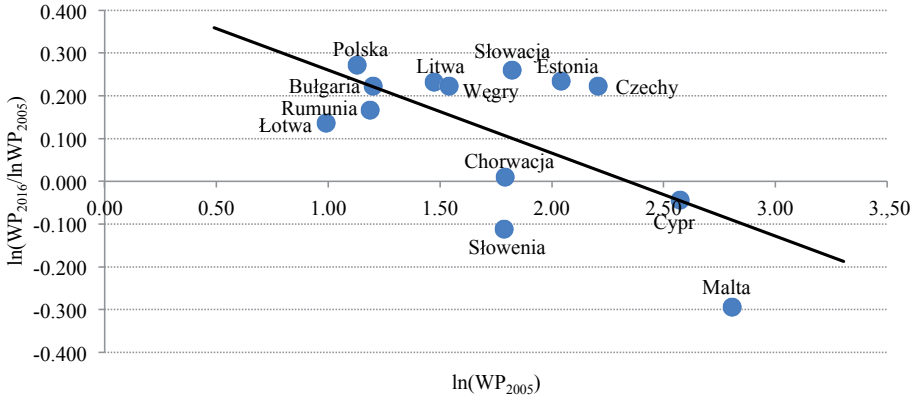


*Fig. 5. Beta* ($\beta$) convergence of labour productivity in agriculture – the EU-13.
Source: own study.

Table 8

*Regression model of absolute β convergence of labour productivity in agriculture for the EU-13*

| Regression parameters | | | | | | | $\beta$ convergence | $\beta$ (%) | $HL_{1/2}$ |
|---|---|---|---|---|---|---|---|---|---|
| $\alpha_0$ | $\alpha_1$ | $t(\alpha_0)$ | $t(\alpha_1)$ | $p(\alpha_0)$ | $p(\alpha_1)$ | $R^2$ | | | |
| -0.1699 | **-0.1940** | 7.4730 | -5.579 | 0.0000 | **0.0000** | 0.1504 | **YES** | +1.8 | 38.6 |

Marking of model parameters: $\alpha_0$ – constant of equation, $\alpha_1$ – value of the parameter with explanatory variable ($ln(Y_{i_0})$), $t$ – Student's $t$-statistics, p – significance levels, $R^2$ – coefficient of determination, $\beta$ – annual convergence rate (%), $HL_{1/2}$ (half-life) – time to reduce half of the productivity gap (in years).

Source: own study.

Table 9

*The impact of the individual EU-13 countries on the value of labour productivity convergence parameters ($\alpha_1$, β, $HL_{1/2}$) measured by* DfBeta

| EU-13 countries | *DfBeta* | Direction of impact +/- | $\alpha_1$ parameter | $\beta$ (%) | $HL_{1/2}$ (years) |
|---|---|---|---|---|---|
| **Total for the EU-13** | | | **-0.194** | **1.80** | **39** |
| Malta | -1.537 | + | -0.102 | 0.89 | 78 |
| Poland | -0.152 | + | -0.187 | 1.73 | 40 |
| Lithuania | -0.113 | + | -0.189 | 1.75 | 40 |
| Hungary | -0.090 | + | -0.190 | 1.76 | 39 |
| Slovenia | -0.081 | + | -0.191 | 1.76 | 39 |
| Croatia | -0.037 | + | -0.193 | 1.78 | 39 |
| Bulgaria | -0.005 | + | -0.194 | 1.80 | 39 |
| Cyprus | 0.008 | - | -0.194 | 1.80 | 39 |
| Slovakia | 0.099 | - | -0.198 | 1.84 | 38 |
| Romania | 0.214 | - | -0.204 | 1.90 | 37 |
| Estonia | 0.375 | - | -0.210 | 1.96 | 35 |
| Czech Republic | **0.646** | - | -0.223 | 2.10 | 33 |
| Latvia | **0.650** | - | -0.226 | 2.13 | 33 |

Source: own study.

On the other hand, its transformations in the Czech Republic (*DfBeta* = 0.646) and Latvia (*DfBeta* = 0.650) had a relatively strong and negative impact on labour productivity convergence in the EU-13. In the case of the Czech Republic, this impact results from a strong increase in labour productivity obtained at its high level in the initial period. Relations of this type are not conducive to convergence and impede this process. In contrast, in Latvia in the initial period labour productivity was the lowest in all of the new Member States, but increased at a rate close to the average in the EU-13. However, despite the upward trend, labour productivity in agriculture in this country was still at the lowest level in the EU-13 in subsequent

years, and thus had a negative impact on the convergence processes. The strength of the negative impact of transformations in labour productivity in agriculture in the Czech Republic and Latvia on convergence in the EU-13 can be seen by estimating the parameters of the growth model without taking these countries into account. In this case, the convergence parameter is, as to the absolute value, at a clearly higher level ($\alpha_1$ = -0.2556) and thus indicates a much faster rate of convergence ($\beta$ = 2.46%) and significantly shorter half-life of reduction in differences in labour productivity ($HL_{1/2}$ = 28 years).

## Summary

The conducted analyses confirmed the occurrence of *sigma* and *beta* convergence processes of labour productivity in agriculture of the European Union. However, these processes have very weak dynamics as evidenced by both the low rate of decrease in the level of labour productivity dispersion measures and the low rate of its convergence in the EU-28 of only 0.49% per year, which translates into a remote half time of reduction of the labour productivity gap amounting to 140 years. In addition, there are major differences between the EU-15 and EU-13 countries in the intensity of convergence processes. There was no *sigma* convergence/divergence in the old Member States, however, *beta* divergence of agricultural labour productivity was noted. Moreover, in the group of the new Member States, the favourable direction of labour productivity changes translated into the occurrence of *sigma* and *beta* convergence processes in the analysed period. However, also in their case it is hard to talk about their high dynamics. The rate of *beta* convergence was estimated for this group of countries at the level of 1.8% per year, which means that the time to reduce the labour productivity gap by half in them is 39 years.

To sum up, one of the most important general objectives of the European integration, which is to reduce the differences in the level of development between countries and regions, is implemented in the case of agricultural labour productivity to a small extent. The dispersion of the labour productivity level is still very high, and the rate of its levelling very slow. It should be assumed that without significant acceleration of broadly understood structural changes in agriculture, labour productivity convergence processes will not accelerate, and the lack of clear progress in this respect will determine the marginal scale of changes in the level of agricultural development between the EU countries in the long term.

**References**

Adamowicz, M., Szepeluk, A. (2018). Regional convergence of labour productivity in rural sectors in the context of funds obtained for agriculture from the European Union. *Problems of Agricultural Economics, No. 3*(356), pp. 3-31.

Andrade, E., Laurini, M., Madalozzo, R., Valls Pereira, P.L. (2004). Convergence clubs among Brazilian municipalities. *Economics Letters*, No. 83, pp. 179-184.

Baer-Nawrocka, A., Markiewicz, N. (2012). Procesy konwergencji/dywergencji w zakresie wydajności pracy w rolnictwie Unii Europejskiej – analiza regionalna. *Journal of Agribusiness and Rural Development, No. 3*(25), pp. 13-23.

Baráth, L., Fertö, L. (2017). Productivity and convergence in European agriculture. *Journal of Agricultural Economics, No. 68*(1), pp. 228-248.

Barro, R.J., Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy*, No. 100, pp. 223-251.

Batóg, J. (2015). Identyfikacja i znaczenie obserwacji nietypowych w modelach konwergencji dochodowej. *Zeszyty Naukowe Uniwersytet Ekonomiczny w Krakowie, No. 5*(941), pp. 5-15.

Baumol, W.J. (1986). Productivity Growth, Convergence and Welfare: What the Long-Run Data Show. *American Economic Review*, No. 76, pp. 1072-1085.

Belsley, D.A., Kuh, E., Welsch, R.E. (1980). *Regression diagnostics: Identifying influential data and sources of collinearity*. New York: Wiley.

Brelik, A., Grzelak, A. (2011). Ocena tendencji w kształtowaniu się dochodów gospodarstw rolnych w Polsce w regionach FADN po integracji z UE. *Journal of Agribusiness and Rural Development, No. 2*(20), pp. 5-11.

Ciołek, D. (2005). *Konwergencja krajów w okresie transformacji do krajów UE*. Uniwersytet Gdański, rozprawa doktorska, https://www.researchgate.net/publication/311653877.

Cuerva, M.C. (2012). Determinants of labour productivity convergence in the European agricultural sector. *Agrociencia, No. 46*(6), pp. 621-635.

De Long, J.B. (1988). Productivity Growth, Convergence, and Welfare: Comment. *American Economic Review, No. 78*, pp. 1138-1153.

Dowrick, S., Nguyen, D.T. (1989). OECD Comparative economic growth 1950-85: Catch-Up and Convergence. *The American Economic Review, No. 79*, pp. 1009-1030.

*Economic accounts for agriculture – values at real prices* (2018). http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=aact_eaa04&lang=en.

Galanopoulos, K. (2011). Agricultural productivity growth in the Euro-Med region: is there evidence of convergence?. *Outlook on agriculture, No. 40*(1), pp. 29-37.

Ghosh, M. (2006). Regional Convergence in Indian Agriculture. *Indian Journal of Agricultural Economics, No. 61*(4), pp. 610-629.

Gutierrez, L. (2000). Convergence in US and EU Agriculture. *European Review of Agricultural Economics, No. 27*(2), pp. 187-206.

Hamulczuk, M. (2015). Total factor productivity convergence in the EU agriculture. *Competitiveness of Agro-Food and Environmental Economy*. Bucharest University of Economic Studies, pp. 34-43.

Kumar, S., Lala, K.A., Chaudhary, K.R. (2014). Agricultural Growth and Economic Convergence in Indian Agriculture. *Indian Journal of Agricultural Economics, No. 69*(2), pp. 211-228.

Kusideł, E. (2013). *Konwergencja gospodarcza w Polsce i jej znaczenie w osiąganiu celów polityki spójności*. Wydawnictwo Uniwersytetu Łódzkiego.

Levine, R., Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *American Economic Review, No. 82*(4), pp. 942-963.

Malaga, K., Kliber, P. (2007). *Konwergencja i nierówności regionalne w Polsce w świetle neoklasycznych modeli wzrostu*. Poznań: Wydawnictwo Akademii Ekonomicznej.

Mankiw, N.G., Romer, D., Weil, D.N. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, No. 107, pp. 407-437.

Matkowski, Z., Próchniak, M. (2005). Zbieżność rozwoju gospodarczego w krajach Europy Środkowo-Wschodniej w stosunku do Unii Europejskiej. *Ekonomista*, No. 3, pp. 293-320.

McErlean, S., Wu, Z. (2003). Regional agricultural labour productivity convergence in China. *Food Policy, No. 28*(3), pp. 237-252.

Próchniak, M. (2004). Analiza zbieżności wzrostu gospodarczego województw w latach 1995--2000. *Gospodarka Narodowa*, No. 3, pp. 27-44.

Próchniak, M. (2006). Realna konwergencja typu beta (b) i sigma (s) w świetle badań empirycznych. *Zeszyty Naukowe, Szkoła Główna Handlowa, Kolegium Gospodarki Światowej*, No. 20, pp. 74-91.

Próchniak, M., Witkowski, B. (2006). Modelowanie realnej konwergencji w skali międzynarodowej. *Gospodarka Narodowa, No. 10*(82), pp. 1-31.

Quah, D.T. (1996). Empirics for Economic Growth and Convergence. *European Economic Review,* No. 40, pp. 1353-1375.

Rezitis, A.N. (2010). Agricultural Productivity and convergence. Europe and the United States. *Applied Economics, No. 42*(8), pp. 1029-1044.

Rozporządzenie (WE) nr 138/2004 Parlamentu Europejskiego i Rady z dnia 5 grudnia 2003 roku dotyczące rachunków gospodarczych dla rolnictwa we Wspólnocie (Dz.U. nr 33 z 05.02.2004). Retrieved from z: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX:32004R0138.

Sala-i-Martin, X. (1996a). Regional Cohesion: Evidence and Theories of Regional Growth and Convergence. *European Economic Review*, No. 40, pp. 1325-1352.

Sala-i-Martin, X. (1996b). The Classical Approach to Convergence Analysis. *The Economic Journal*, No. 106, pp. 1019-1036.

Sapa, A., Baer-Nawrocka, A. (2014). Konwergencja wydajności pracy w rolnictwie a intensywność handlu rolno-żywnościowego w amerykańskich ugrupowaniach handlowych. *Gospodarka Narodowa*, No. 3, pp. 111-131.

Suhariyanto, K., Thirtle, C. (2001). Asian Agricultural Productivity and Convergence. *Journal of Agricultural Economics, No. 52*(3), pp. 96-110.

Will, M., Devashish, M. (2001). Productivity Growth and Convergence in Agriculture versus Manufacturing. *Economic Development & Cultural Change, No. 49*(2), pp. 403-422.

# KONWERGENCJA WYDAJNOŚCI PRACY W ROLNICTWIE UNII EUROPEJSKIEJ


## Abstrakt

*Wydajność pracy jest powszechnie uznawana za jeden z najważniejszych parametrów rozwojowych gospodarek, ponieważ prowadzi do obniżenia kosztów, zwiększenia podaży tańszych dóbr i usług, dynamizuje rynek oraz zwiększa siłę nabywczą społeczeństw, ich zamożność i zdolności konkurencyjne. Jednak wydajność pracy jest w układzie krajów UE silnie zróżnicowana, w tym szczególnie w rolnictwie, gdzie jej poziom jest znacząco niższy aniżeli w innych działach gospodarki. Głównym celem prezentowanego artykułu jest zbadanie i ocena przemian wydajności pracy w rolnictwie krajów UE w kontekście zróżnicowania jej poziomu i dynamiki zmian będących podstawą do identyfikacji zachodzących w rolnictwie procesów konwergencji/dywergencji wydajności pracy. Procesy konwergencji wydajności pracy w rolnictwie UE analizowano na podstawie danych z lat 2005-2016, testując dwa jej podstawowe typy, tj. konwergencję* sigma *i* beta. *W analizie wykorzystano miary statystyczne opisujące stopień zróżnicowania wydajności pracy w rolnictwie krajów UE oraz przekrojową funkcję regresji. Badania wykazały wystąpienie procesu konwergencji typu* sigma *i* beta *ogółem w UE-28 i w grupie nowych krajów członkowskich (UE-13). Z kolei w grupie starych krajów członkowskich (UE-15) nie stwierdzono zbieżności/rozbieżności typu* sigma, *ale odnotowano statystycznie istotną dywergencję typu* beta.


**Słowa kluczowe**: konwergencja, wydajność pracy, rolnictwo, UE.

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