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Land productivity in the EU in the context of financial support through direct subsidies

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Abstract: The main research objective of this study is to present the dynamics of land productivity changes in EU agriculture in the years 2012–2020 and evaluate the influence of direct subsidies received by farmers on land productivity. The source data for 2012–2020 are secondary and come from Eurostat. The research results were prepared for the entire European Union (EU-28), and divided into 'old' countries (EU-15) and 'new' countries (EU-13). The results were developed using the method of assessing convergence (in terms of differences in land productivity in individual countries) using the coefficient of variation and the relative index of changes in individual Member States in relation to the EU average over the period under study. Results showed that between 2012 and 2020, average land productivity in the EU increased by 7%. At the same time, differences in land productivity between EU countries decreased. The correlation analysis confirmed a statistically significant relationship between land productivity and the amount of direct payments per ha of agricultural land. Additionally, results of the correlation between productivity per 1 ha and the total area of agricultural land in EU countries confirmed the law of decreasing marginal productivity of land.

Keywords: agricultural payments; convergence; efficiency; financial resources

Agricultural land, as a factor of production, along with labour and capital (physical and financial), constitutes the basis of agricultural production. Its specific character lies in the fact that it is a natural resource offering its own production potential (Golębiewska and Stefańczyk 2016). Agricultural land, as an important part of natural resources, also affects the wealth of a country (Lazikova et al. 2015). The primary function of agricultural land is to produce food and ensure food security for the population. As Wilkin (2014) has written: 'the importance of land has been changing, primarily depending on the importance of agriculture in the national economy; when agriculture provided employment for the majority of people and agricultural production accounted for a dominant share of the national product, agricultural land was the most desirable economic asset and the most important factor of production'. As the economy has developed, its significance in creating global products and its contribution to employment has declined. Instead, the role of the land factor in ensuring food security, both in quantitative, qualitative and economic terms, has become increasingly important. The characteristics of land are its immovability, permanence and the fact that its resources cannot be expanded in any way. Its permanence over time means that if it is used properly, it does not lose

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its productive capacity, while technological progress allows achieving ever-increasing yields (Marks-Bielska 2010). It is crucial, both in the context of the successive designation of agricultural land to non-agricultural purposes and the growing demand for food on global markets. In turn, Wicki (2016) states that in the period 2001–2013, on a global scale, the 2.5% increase in agricultural production was also due to 70% of the implemented technological progress.

Productivity is the ability of production factors to create effects in the form of output. Thus, the term reflects the relationship between the volume of output and the amount of input. Total factor productivity (TFP) is used in assessing the efficiency of management (Čechura et al. 2015; Coelli et al. 2005). This assessment also refers to partial productivity indicators (e.g., labour productivity; Latruffe 2010). The productivity of agricultural production is evaluated from the perspective of three production factors: land, labour and capital (Wicki 2016). In particular, land productivity determines the condition of farm development to a greater extent than its acreage. In general, it is worth noting that productivity and efficiency can be used to measure competitiveness in the long-term perspective (European Commission 2009; Čechura et al. 2022).

Land productivity is a problem frequently studied by researchers, mainly in the context of comparisons across time and between the EU countries (Bezat-Jarzębowska and Rembisz 2016). The productivity of agricultural land in Poland has also been addressed by geographers, especially by Kulikowski (2013). The research carried out by Wicki showed that a significant increase in the productivity of production factors was observed in Polish agriculture in the period 1995–2015, primarily regarding land productivity (Wicki 2016). Similar studies covering agricultural land productivity of the EU countries also indicate upward trends in the years 2005–2012, and in particular, a large difference in the level of land productivity in the old and new EU member states. During this period, better production effects were achieved by the EU-15 farmers; however, more favourable dynamics of change occurred in the countries of the new accession. Land productivity increased in the entire European Union by almost 11%, including approx. 30% in the EU-12 and 7% in the EU-15. Lower growth of land productivity in the EU-15 countries suggests the operation of the law of diminishing marginal productivity (Tarnowska 2014). Modernisation transformations in agriculture of the new member states resulting both from the need to adapt to the requirements of the Common Agricultural Policy (CAP) and from financial support of the agricultural sector from the EU budget, contributed to the accelerated pace of this sector development and increased the dynamics of productivity growth. Studies on the analysis of productivity in the EU agriculture covering the period of 2002–2007 indicated an average production increase of 4.7% (however, the increase for the EU-15 was only 1.2% in the same period, whereas in the EU-12 it reached as much as 28.6%; Poczta et al. 2009). The average value of agricultural area (AA) productivity at that time was 2 003 EUR/1 ha AA, and varied widely in terms of the division between the 'old' and 'new' EU countries and within the individual member states. In the EU-15, land productivity amounted to 2 337 EUR/ha AA, while in the EU-12 it was more than half that value (1 132 Euro/ha AA). The lowest productivity of this factor was recorded in Romania (949 EUR/ha AA), and the highest in the Netherlands (12 000 EUR/ha AA). Land productivity in the new member states was lower, mainly due to a lower level of production intensity and a lower level of production organisation on farms. During the analysed period, compared to other countries, land productivity in Polish agriculture was low, which mainly resulted from the significant agricultural land resources, relatively low capital inputs and production level (Poczta et al. 2009).

The subsidies allocated to the agricultural sector support farmers' incomes (Žáková Kroupová et al. 2023). One type of subsidy takes the form of direct subsidies, which have been the primary instrument for supporting the income of agricultural producers in the European Union since the mid-1990s. The report Polska Wieś i Rolnictwo 2020 (Polish Rural Areas and Agriculture 2020) indicates what purposes Polish farmers allocated such funds for (KOWR 2020). The money was spent mainly on purchasing fuel, mineral fertilisers and plant protection products, i.e. on supplying farms with the means for carrying out current production. The research conducted in the Lower Silesia region showed that farm owners of up to 20 ha of AA allocated the received financial support mainly to the purchase of inputs, whereas larger farms used these funds for the purchase of land and for modernisation purposes (Kutkowska et al. 2015). On the other hand, research findings covering the Warmińsko-Mazurskie Voivodship confirm that farmers spent the obtained subsidies mainly on purchasing production inputs (Marks-Bielska and Babuchowska 2010). Therefore, the following question can be formulated:

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do the monetary amounts received from direct subsidies used to purchase inputs have a significant impact on increasing land productivity? Ściubeł (2021) studied factor productivity in the selected EU countries in the period 2004–2017, taking into account payments from the Common Agricultural Policy. As she also pointed out, citing the results of other authors (Rizov et al. 2013), determining the effects of financial support, especially from Pillar II of the CAP [which includes Rural Development Program (RDP) measures financed by the European Agricultural Fund for Rural Development], is difficult due to the variety of factors and their multi-sectoral effect.

MATERIAL AND METHODS

The purpose of the study was to present the dynamics of land productivity changes in agriculture of the EU countries in the years 2012–2020 and to attempt to determine whether there was a correlation (if so, how strong and in what direction) of direct subsidies received by farmers on the land productivity.

The paper used figures from the resources of official statistics provided by Eurostat (2022a, b) for the period 2012–2020. The adopted timespan of the conducted research was determined by the availability of data in terms of constant prices from 2010. Land productivity was calculated as the value of agricultural production expressed in thousands of EUR per ha of agricultural area. The value of agricultural production, according to the Farm Accountancy Data Network (FADN) methodology, is the sum of the value of crop and livestock production and the remaining production (Bocian et al. 2023). In this study, only crop and livestock production was taken into account in estimating the value of agricultural production.

The main research purpose was carried out by completing partial tasks, which included the analysis of land productivity changes in the following aspects:

i) The dynamics of change relative to 2012,

ii) Determining the relative index of changes in land productivity in the years 2012–2020, along with an assessment of its variability,

iii) Calculating Pearson's correlation coefficient in the following relationships:

– agricultural production per ha of AA and total agricultural area;

– total agricultural production and total direct subsidies;

– agricultural production per hectare of AA and direct subsidies per hectare of AA.

The above analyses were prepared for the entire European Union (EU-28), and divided into 'old' (EU-15) and 'new' (EU-13) countries.

The assessment of convergence in terms of land productivity changes was carried out using the method described by Nowak (2022). The concept of convergence refers to the assessment of scale and reasons for interregional differences in the level of development. This phenomenon can also be considered in relation to agriculture (Nowak 2022). The most common types of convergence are sigma and beta types of convergence. The first of them (sigma type) evaluates convergence processes from the perspective of changes in the degree of variation over time in the level of the phenomenon under analysis (Nowak 2022), while beta type refers to the analysis of correlations between the initial level of the feature under study and its dynamics of change (Golas 2019; Nowak 2022). In this paper, convergence processes were analysed in relation to land productivity in agriculture of the EU countries. The assessment of convergence in terms of land productivity variation in individual countries was performed using the coefficient of variation (sigma convergence) and the relative change index in individual member states against the EU average over the studied period of time (beta convergence).

The coefficient of variation was calculated according to the formula (1):

$$V = \frac{s}{\overline{X}} \tag{1}$$

where: V – coefficient of variation; s – standard deviation, where the country's land productivity was adopted as the analysed value and the EU-28 land productivity as the average value; $\overline{X}$ – average land productivity for the EU-28.

The relative change index for land productivity index was calculated according to formula (2):

$$X = \frac{\frac{Z_{i-2020}}{Z_{i-2012}}}{\frac{Z_{p-2020}}{Z_p - 2012}} \times 100 - 100 \tag{2}$$

where: X – country's relative growth index against the EU-28 in the period 2012–2020; $Z_{i\,-\,2012}$ – value of the analysed variable in a given country in 2012; $Z_{i\,-\,2020}$ – value of the analysed variable in a given country in 2020; $Z_{p\,-\,2012}$ – value of the analysed variable in the EU in 2012; $Z_{p\,-\,2020}$ – value of the analysed variable in the EU in 2020.

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The value of agricultural output per hectare of agricultural area (AA) expressed at 2010 constant was used as the analysed variable.

RESULTS AND DISCUSSION

When analysing the dynamics of land productivity changes in 2013–2020 in relation to the level of such productivity in 2012, an upward trend was observed, both for the EU as a whole and for its 'new' and 'old' member states (Figure 1). In the analysed period, land productivity for all countries increased by 7%. The largest increase was recorded in Hungary (39%), Romania (30%), Ireland (30%), Spain (29%) and Slovenia (26%). On the other hand, the following countries recorded a decline in productivity: Italy –5.2%, Croatia –4.1%, Malta –4.0, France –0.2%. In 2012, the average land productivity at constant 2010 prices for the new member states was 907 EUR/ha, ranging from 576 EUR/ha in Latvia to 2 000 EUR/ha in Slovenia. The average value for this group of countries overstates significantly the productivity of Cyprus (5 600 EUR/ha) and Malta (9 800 EUR/ha). In the case of the EU-15, land productivity in the first year of analysis was over 2.5 times higher compared to the EU-13, and presented the average level of 2 400 EUR/ha, with value changes ranging from 1 300 to 1 700 EUR/ha in the UK, Ireland, Sweden, Finland, Spain and Portugal, to 5 600 EUR/ha in Denmark and 13 300 EUR/ha in the Netherlands (Table 1).

The analyses conducted for the purposes of this research paper identified significant variation in the value of agricultural production per ha across the EU member states, which was also previously identified by Smędzik-Ambroży et al. (2019). Figure 2 shows the values of the coefficient of variation for land productivity characterising sigma type convergence. During the period 2012–2020, a gradual diminishing of land productivity differences between member countries was recorded, as evidenced by the decreasing, although still high, values of the coefficient of variation calculated both for all member states and for the 'old' and 'new' EU countries separately. A significantly higher variability, primarily in the initial period of the study, was characteristic for the new EU countries (V = 1.2), while for the EU-15 the coefficient was V = 0.93. In 2020, the coefficient of variation decreased to the value of V = 0.89 for the EU-15 and the average variability for EU-28 was approximated at the level of V = 0.99. The weak convergence in land productivity was determined by the high values of this feature in the Netherlands and Malta. Eliminating these countries from the variability analysis reduced the value of the coefficient to V = 0.63 (Figure 3). The justification for omitting data from Malta was related to its low share of agricultural land on the EU scale and the data from the Netherlands were omit-

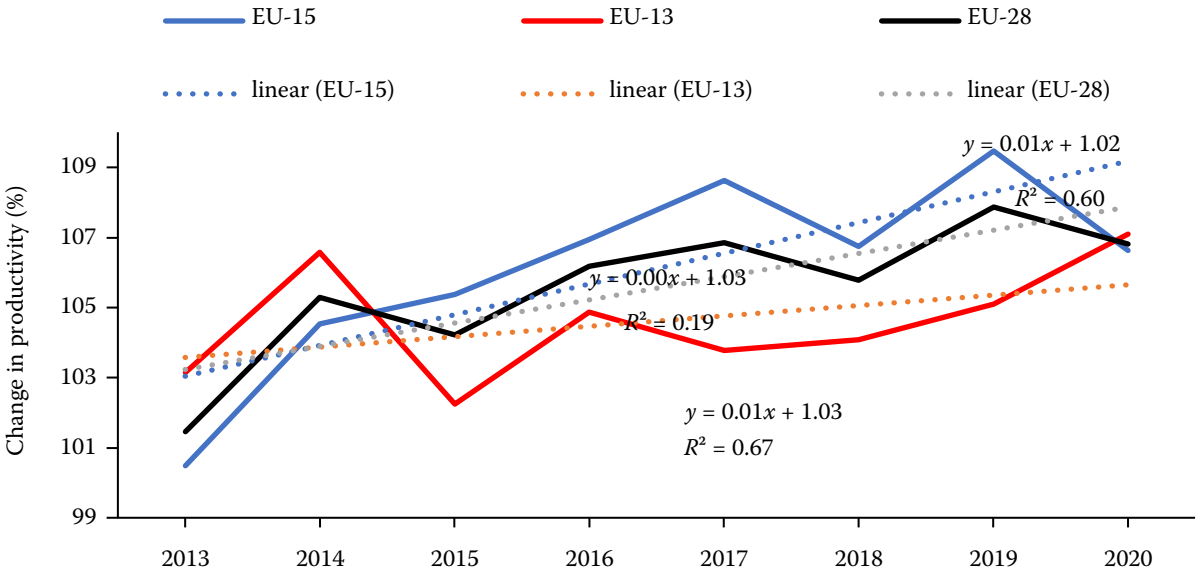

Figure 1. Dynamics of change in land productivity in the European Union in 2012–2020 [constant prices in 2010 (2012 = 100)]

Source: Authors' compilation based on Eurostat (2022a, b)

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Table 1. Land productivity in the EU countries (constant prices in 2010 in thousands EUR/ha)

Specification	2012	2013	2014	2015	2016	2017	2018	2019	2020
Austria	2.1340	2.1065	2.3451	2.3104	2.4017	2.4350	2.4788	2.4823	2.5463
Belgium	5.6598	5.7689	6.0264	6.3386	6.1716	6.4222	6.3418	6.4634	6.4623
Bulgaria	0.6096	0.7151	0.7327	0.6739	0.6850	0.7294	0.7336	0.7241	0.6415
Croatia	1.8875	2.0347	1.9814	1.6488	1.7549	1.7165	1.8381	1.7929	1.8103
Cyprus	5.6554	5.8692	5.8586	5.4014	6.0148	5.8940	5.4827	5.9920	5.7615
Czech Republic	1.1563	1.2267	1.3539	1.2800	1.3718	1.2730	1.2588	1.2865	1.3501
Denmark	3.7512	3.5412	3.9642	3.9360	4.1247	4.2037	4.1061	4.4772	4.5070
Estonia	0.7528	0.7802	0.8243	0.8833	0.7338	0.8039	0.7460	0.9268	0.9237
Finland	1.5384	1.5738	1.6028	1.6632	1.6512	1.6313	1.5932	1.6870	1.6629
France	2.2961	2.2632	2.4262	2.3886	2.2424	2.3270	2.3634	2.3544	2.2904
Germany	2.9826	2.9660	3.1369	2.9864	3.0006	3.0138	2.7995	2.9534	3.0831
Greece	2.0235	1.9385	1.9027	1.9560	1.9212	2.0771	1.9814	2.0572	2.0298
Hungary	1.1178	1.2607	1.4081	1.3686	1.4990	1.4417	1.4841	1.4905	1.5489
Ireland	1.2999	1.3683	1.4221	1.5019	1.5373	1.5865	1.5980	1.6571	1.6860
Italy	3.4751	3.5474	3.3857	3.5273	3.4801	3.3125	3.4276	3.3186	3.2932
Latvia	0.5764	0.5714	0.5962	0.6803	0.6176	0.6175	0.5440	0.6768	0.6969
Lithuania	0.8483	0.8048	0.8553	0.9063	0.8834	0.9013	0.8098	0.8838	0.9966
Luxembourg	2.4472	2.5027	2.6822	2.4557	2.5930	2.5633	2.6620	2.5983	2.6317
Malta	9.7755	9.7297	9.8922	9.4508	9.2012	9.2159	9.1321	8.9102	9.3841
Netherlands	13.2819	13.4008	13.6116	13.6901	14.3555	14.5104	13.9729	14.2439	14.2102
Poland	1.3715	1.3867	1.4909	1.4484	1.5716	1.5787	1.5699	1.5549	1.6545
Portugal	1.6836	1.6855	1.7755	1.8842	1.8502	1.9906	1.9878	1.9251	1.9003
Romania	0.8614	1.0732	1.1116	1.0327	1.0904	1.2650	1.3556	1.2639	1.1174
Slovak Republic	0.9430	1.0106	1.0930	1.0591	1.2154	1.1411	1.0908	1.0467	1.0979
Slovenia	2.0647	2.0291	2.2380	2.4085	2.3264	2.0881	2.7035	2.4817	2.5953
Spain	1.6271	1.7441	1.8425	1.8203	1.9546	1.9175	2.0312	2.0394	2.0885
Sweden	1.7120	1.7140	1.8078	1.8504	1.8202	1.8776	1.6519	1.9761	1.9665
United Kingdom	1.3081	1.3304	1.4317	1.4516	1.3983	1.4288	1.4156	1.4611	–
Total	1.8537	1.8388	2.0569	2.0439	1.8973	1.9914	2.1772	2.2569	2.3144

Source: Authors' compilation based on Eurostat (2022a, b)

ted due to land concentration and high intensification of production compared to other EU countries.

Beta convergence was assessed by calculating the relative change index value of land productivity in the member states compared to the EU average. The data presented in Table 2 show that in most countries, the dynamics of changes in land productivity was lower compared to the EU-28 average. Similar trends were also noticeable in the arrangement of old and new member states. The exceptions were Spain, where land productivity growth was approx. 3% higher than the EU average, and Ireland (approx. 4%). In Romania, in the EU-28 system, land productivity increased by almost 4% compared to the EU average, whereas in relation to the EU-13 average, the change trend was negative. In the remaining member states, change dynamics in land productivity were lower than the EU average. The least favourable change index was observed in Italy (–24.10%), Croatia (–23.18%) and Malta (–23.12%). The results of the above analysis indicated weak dynamics of land productivity change in the period covered by the analysis.

The results of correlation analysis confirmed a statistically significant relationship between land productivity and the amount of subsidies per ha (Table 3). This relationship was significant for the new member states (r = 0.94), which translated into a strong relationship in terms of the EU-28 (r = 0.84). As a result of the funds obtained from direct subsidies, modernisation trans-

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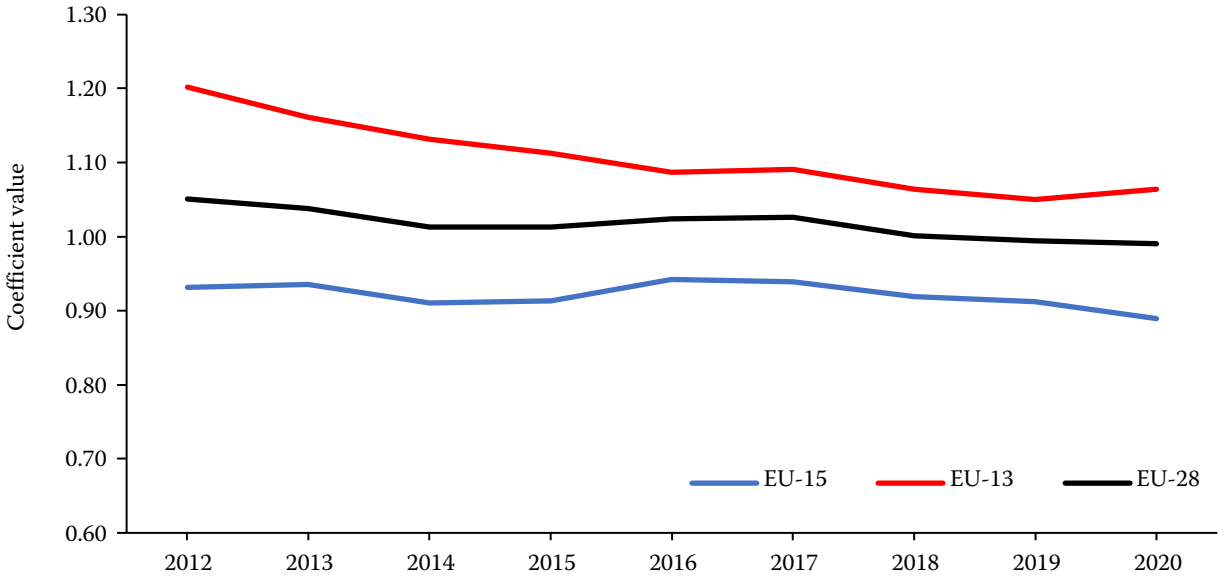

Figure 2. Coefficients of variation of land productivity in the EU agriculture

Source: Authors' compilation based on Eurostat data (2022a, b)

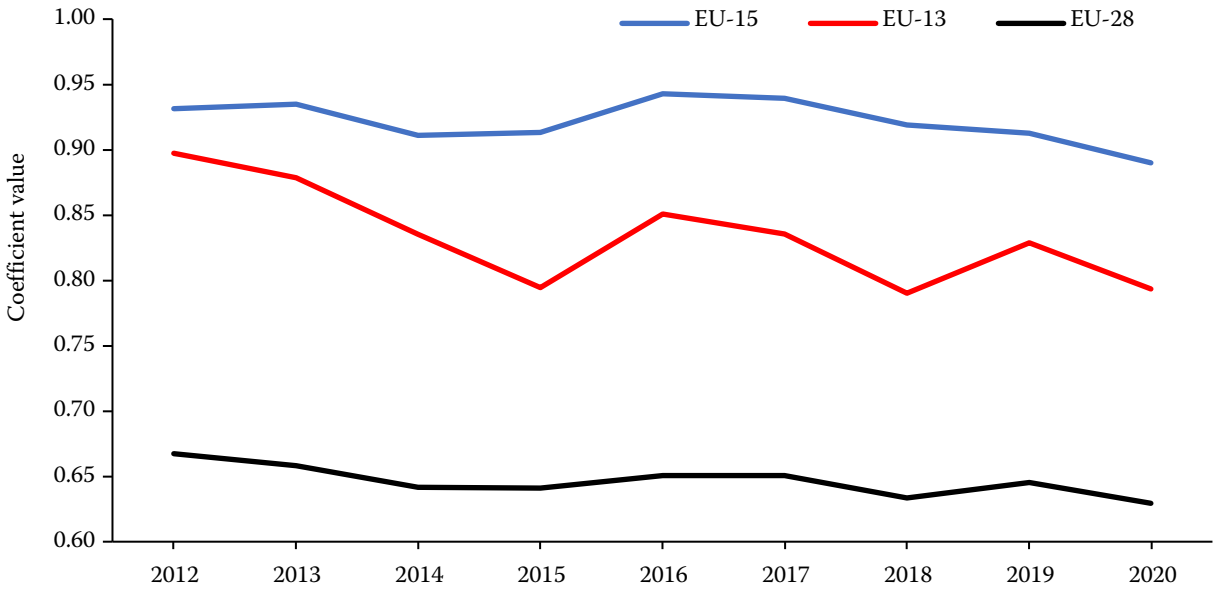

Figure 3. Coefficients of variation of land productivity in the EU agriculture excluding Malta and the Netherlands

Source: Authors' compilation based on Eurostat data (2022a, b)

formations were taking place at the farms of the Central and Eastern Europe (CEE) countries, which had an impact on increasing farming efficiency in the agriculture of the EU-13 countries. The old EU countries carried out modernisation processes much earlier. The correlation between productivity per ha and total agricultural area (AA) in the country confirmed the operation of the law of diminishing marginal productivity

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Table 2. Relative change index in land productivity of the EU countries in 2012–2020

Specification	EU-15	EU-13	EU-28
Austria	–3.49	–	–4.44
Belgium	–7.65	–	–8.55
Bulgaria	–	–26.21	–15.72
Croatia	–	–32.74	–23.18
Cyprus	–	–28.56	–18.41
Czech Republic	–	–18.12	–6.48
Denmark	–2.82	–	–3.77
Estonia	–	–13.95	–1.73
Finland	–12.57	–	–13.43
France	–19.32	–	–20.11
Germany	–16.39	–	–17.21
Greece	–18.86	–	–19.66
Hungary	–	–2.83	10.98
Ireland	4.91	–	3.88
Italy	–23.35	–	–24.10
Latvia	–	–15.22	–3.17
Lithuania	–	–17.61	–5.91
Luxembourg	–13.02	–	–13.87
Malta	–	–32.68	–23.12
Netherlands	–13.46	–	–14.31
Poland	–	–15.40	–3.38
Portugal	–8.71	–	–9.60
Romania	–	–9.04	3.89
Slovak Republic	–	–18.35	–6.75
Slovenia	–	–11.85	0.67
Spain	3.83	–	2.81
Sweden	–7.09	–	–8.00
United Kingdom	–100.00	–	–100.00

Source: Authors' compilation based on Eurostat (2022a, b)

Table 3. Pearson's correlation coefficients of land productivity and direct subsidies in 2012–2020

Specification	EU-15	EU-13	EU-28
Production thousands EUR/ subsidies thousands EUR	–0.91*	0.94*	0.29
Production thousands EUR / subsidies thousands EUR per ha	–0.32	0.95*	0.34
Productivity thousands EUR per ha / subsidies thousands EUR per ha	0.43	0.94*	0.84*
Productivity thousands EUR per ha / ha agricultural area	–0.92*	–0.13	–0.82*

*statistically significant correlation at the level of $P = 0.05$
Source: Authors' compilation

of land, especially in the EU-15 ($r = -0.92$) and in the EU-28 system ($r = -0.82$). In the countries that joined the EU in 2004 and later, the typical dependence of this law could be seen; however, it was not statistically significant.

In the context of the general discussion, it should be noted that a key economic question is whether poor countries or regions tend to grow faster than rich ones. The question also arises whether there are automatic forces that lead to convergence over time in levels of income or product *per capita*. Barro and Sai-i-Martin (1992) used a neoclassical growth model and data on personal income and gross domestic product from the 48 US states and obtained results that clearly support convergence. They noted, however, that the results for gross domestic product *per capita* from a broad sample of countries are similar, provided that a set of variables is held constant. These variables also have to be proxies for differences in steady-state characteristics (Barro and Sala-i-Martin 1992). From the point of view of the problems of the article, it is worth mentioning the regression model that integrates the convergence assessment based on the relative rate of change in land productivity and the coefficient of variation (convergence). This approach can be useful for those who want to deepen this type of research and obtain results that facilitate more detailed analysis and discussion (Sala-i-Martin 1996).

Observing agricultural land prices, one can notice their rapid increases, which is related to their attractiveness as safe instruments for allocating investments and savings. The price increase varies between regions due to the different levels of expected return on investment and potential land use possibilities in different regions. Research conducted in Italy covering the period 1990–2019 provided evidence of the convergence of the Italian agricultural land market. The obtained results confirmed the increasing territorial disparities in Italian agricultural land markets in the analysed period. Based on the research, it can be concluded that the divergence patterns reflect the well-established North-South dualism and disparities in socio-economic characteristics in Italy (Bruno et al. 2023).

Markets of agricultural land are often regulated and have specific legal provisions. One of the most important reasons for this legal status is the assumption that the activities of foreign and non-agricultural investors increase prices in domestic land markets. Unfortu-

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nately, empirical knowledge about the dynamics of agricultural land prices in different countries is not very widespread and accessible. In Germany, studies were conducted on the impact of the former internal German border on the dynamics of agricultural land prices in East and West Germany. The results show that even 25 years after German reunification, significant differences in land prices persist. In addition, it was determined that time, language barriers, differences in the institutional and legal framework and information asymmetry between domestic and foreign market participants were among the factors influencing the spread of agricultural land prices (Grau et al. 2020).

In Japan, studies were conducted on the impact of direct payments in less-favoured areas (LFA) on land use and the number of farms. Direct payments in Japan are directed to rural communities with agricultural land with a large slope and defined as 'less favourable'. The conclusions of these studies indicated that although direct payments encouraged continued use of agricultural land and reduced abandonment of agricultural land, these effects should be described as modest (Takayama et al. 2020).

Tomal and Gumieniak (2020) proposed to study the efficiency of the agricultural land market by applying the concept of spatial market integration and the current value (PV) model. The research aimed to check the convergence of agricultural land prices in Polish regions. An additional goal was to check the law of one price (LOP) according to the sale of agricultural land divided into good, medium and poor quality. Based on the results, it was found that agricultural land prices tend to converge in relative terms (voivodeships have a common long-term growth path). The research supported by traditional convergence tests confirms the growing integration in the agricultural land market in Poland. However, no evidence was found that the absolute version of the long-term LOP is valid. The research also identified that almost the same convergence factors apply to the prices of good, medium and poor-quality land. Among the conclusions were also statements that the only differences concerned the strength of the impact of independent variables on the prices of agricultural land of different types and that the prices of poor-quality land were significantly influenced by the density of livestock (Tomal and Gumieniak 2020).

CONCLUSION

Land is the primary factor of production in agriculture which is classified as a natural resource. The quantity and quality of soils determine the production potential of agriculture and help build the wealth of a country. The main function of agricultural land is related to food production and ensuring an adequate level of food security for society. Agricultural land has unique characteristics, such as immovability and permanence. The latter feature causes that, with proper use, production possibilities are not lost, while at the same time, by implementing the elements of technological progress, it is possible to achieve increasing productivity from a given unit of agricultural land. The problems related to the productivity of agricultural land are particularly important in the context of using agricultural land for non-agricultural purposes and the global population growth along with the resulting higher demand for food, which relates it to the quantitative, qualitative and economic approach to food security. In general, productivity is defined as the capacity of resources to produce effects in the form of output, which shows correlations between the value of output and the value of inputs incurred. In the case of agriculture, productivity is generally analysed in relation to three groups of resources: land, labour and capital. Land productivity is particularly important from the perspective of farm development, and even more than the sheer size of the acreage of these farms.

The paper presents the research results addressing the dynamics of land productivity changes in the European Union member states, and attempts to determine the impact of financial aid received by farmers, in the form of direct subsidies, on agricultural land productivity. In the period 2013–2020, average land productivity in the EU increased by 7% as compared to the base year 2012. At the same time, it was observed that the differences in land productivity among the EU countries decreased between 2012 and 2020, as confirmed by the declining values of the coefficient of variation. In addition, the conducted correlation analysis confirmed the statistically significant relationship between land productivity and the amount of direct subsidies per ha of agricultural land. Furthermore, based on the calculations of the correlation between productivity per ha and total agricultural area in the EU countries, the law of diminishing marginal productivity of land was confirmed.

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