

The evidence of agricultural total factor productivity convergence in the European Union countries

Peter Bielik, Natália Turčeková, Izabela Adamičková, Stefaniia Belinska, Miriam Buliková

Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Economics
Tr. Andreja Hlinku 2, 949 76 Nitra, Slovakia

Introduction

Ensuring food security of the impacts of climate change on agricultural production, nutrition and food systems is a global challenge, but it can only be tackled through agricultural production, the development of the bioeconomy and continuous improvement of agricultural productivity. The social, economic and environmental aspects of sustainability must also be considered in the agricultural sector. Technological growth, product diversification, improved plant varieties and animal breeds, better land and water management practices, and agricultural openness have a positive effect on agricultural productivity and the balance between conserving and using all resources. Increasing agricultural productivity is the driving force for both economic and social development.

Thus, agricultural transformation can affect the three pillars of sustainable development to varying degrees and is particularly important for reducing greenhouse gas emissions. Sustainable increases in agricultural productivity are essential to address the increased demand in a resource-limited world and climate uncertainty. These efforts to support the agricultural sector, in turn, will contribute to the achievement of the sustainable development goals of the 2030 Agenda for Sustainable Development. These goals are achieved mainly through the provision of subsidies to farmers in the main sectors, access to financing at preferential tariffs, the creation of the necessary infrastructure for electricity, water supply in remote areas and export support.

The main goal of our research was analysis of efficiency and productivity of production factors in agriculture in the European Union countries during 2007-2018 and reveal the essence of agricultural total factor productivity (TFP) as a source of national income growth and a factor in increasing the competitiveness of the national economy. We wanted to conduct a comparative analysis of the achieved level of TFP and explore the determinants of TFP growth gap between EU countries. We investigated the presence of convergence processes or vice versa divergence processes of TFP, in order to confirm the hypothesis that countries with low agricultural productivity are catching up with countries with high agricultural productivity.

Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input use (OECD, 2001). Agricultural productivity is generally considered to be an indicator of the efficiency of the production process. Agricultural policy tends to be more focused on increasing productivity through technological change rather than making better use of existing technologies. Productivity gains associated with innovation and technological change have been identified as the most important source of agricultural economic growth. Increasing production with higher productivity in EU agriculture generates additional income upstream and downstream of the value chain. Moreover, changing agricultural productivity is a key aspect of structural change and competitiveness.

In agricultural production, regional features are important, which act as a constant factor of efficiency, special ones are the provision of land and the intensity of production, which is characterized by costs and profitability per unit area of agricultural land, production volumes and the use of resources. The basis for sustainable development of agricultural production is intensification, the main factor of which is an increase in the use of labour potential and an increase in the productivity of agricultural labour. Growth in agricultural production can be achieved either by increasing the number of resources used, or by increasing the efficiency of their use.

The production efficiency of this sector needs to be measured in order to increase its productivity, competitiveness and profitability. Factor productivity analysis is especially important as it is a useful management tool at any economic level. In agriculture, the analysis of the level of resource use can provide objective information about the main reason for the increase or decrease in agricultural production and become the basis for the development of measures of state regulation of the agricultural sector.

Agricultural productivity can be calculated as partial productivity attributable to a single factor, or as total productivity (multi-factor). Multi-factor or total factor productivity growth (MFP or TFP) is the change in production because of changes in all or several of the factors of production. The most comprehensive measure of productivity is total factor productivity (TFP), which measures the efficiency with which manufacturers combine inputs to produce outputs. Total factor productivity (TFP) is a key indicator of agricultural economic performance. It shows how efficiently the agricultural sector uses available resources to convert inputs into outputs. TFP provides a more complete picture of performance and is more closely related to technical change and better economic performance. Improving TFP in agriculture is a prerequisite for sustainable economic growth.

Total factor productivity (TFP) measures the ratio total marketable outputs (crop and livestock products) to marketable inputs (land, labour, capital, and materials), but excludes inputs and outputs that have no economic value to the producer. TFP is calculated as the ratio between the growth rates of output and the sum of the growth rates of input, weighted by the corresponding elasticities. TFP growth, expressed in index form, can be defined as the ratio between the change in production volumes over a period and the corresponding change of inputs to produce them.

Research and development, as well as new technologies, are critical and cover a wide range of areas that underlie the development of new decision support tools for farmers related to biological processes, innovations in crop production, as well as the application of the digital economy and Industry 4.0 technologies, and Agriculture 5.0. Thus, the long-term effects of research results may also influence the development of TFP.

Methodology

In this paper, we wanted to point out the current level of convergence between the EU-28 countries by examining total factor productivity in agriculture in the analysed period of 2007-2018 years. Data were taken from Agri-food data portal provided by the European Commission.

The concept of beta convergence was introduced by R. Barro and X. Sala-i-Martin (1992). Absolute beta-convergence refers to a process in which poor countries grow faster than rich ones and therefore catch up on them, which in the long term should lead to an equalization of levels of economic development. Formally, the absolute beta convergence model can be written as follows:

$$\ln\left(\frac{y_{i,t_1}}{y_{i,t_0}}\right) = \alpha + \beta \ln(y_{i,t_0}) + \varepsilon$$

where: ε – is a random error; $y_{i,t}$, $y_{i,t-1}$ – is the initial/final amount of welfare (TFP, income) in the country i at time t .

If the coefficient β is significant and negative, the hypothesis of absolute convergence is confirmed. With a positive coefficient β , divergence is observed.

Sigma convergence is defined as a decrease in the time of variation in the levels of economic development and productivity of countries. Sigma convergence (divergence) occurs when the value of the interregional variance of the examined indicator decreases (increases) over time for a group of countries. The most used indicator for testing the convergence hypothesis is the coefficient of variation:

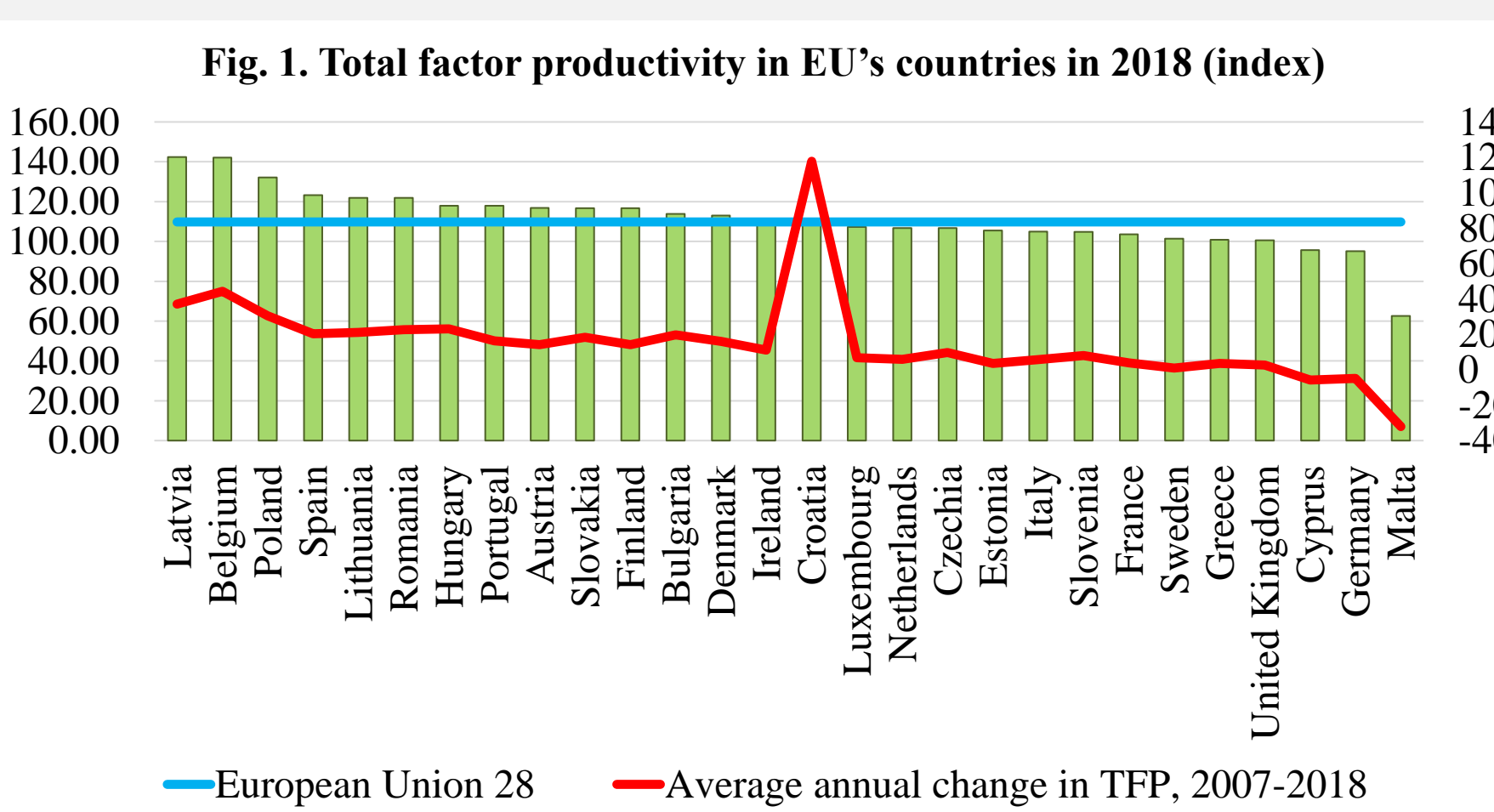
$$CV = \frac{\sigma}{\bar{y}} = \frac{\sqrt{\frac{1}{N} \sum_{i=1}^N (y_{i,t} - \bar{y}_t)^2}}{\bar{y}_t} \times 100\%$$

where: σ – is a standard deviation; \bar{y} – is an arithmetic mean of the examined indicator; $y_{i,t}$ – is the level of the indicator in the region i at time t ; \bar{y}_t – is the average level of the indicator in the country (group of regions); N – is the number of regions.

The hypothesis of the existence of convergence processes is confirmed if the values of the coefficient of variation decrease. On the contrary, the higher the value of the coefficient of variation, the greater the differences between countries, and divergent processes prevail.

Results

Total factor productivity is one of the three impact indicators for the general CAP objective. TFP allows for a comprehensive measure of productivity change over time. Productivity in the EU has increased over time. TFP grew by 9.90% in 2018 compared to 2007, TFP growth has slowed down. We can see decreasing in TFP growth after financial crisis during 2009-2012, and in 2015-2017 years, when was the new programming period CAP 2014-2020. In 2012-2015 TFP growth is positively affected by the growth of overall agricultural output and increasing labour productivity.



The results in Figure 1 demonstrate that an increase in total productivity was noted in almost all member countries of EU. Total factor productivity in the EU countries is differ. Therefore, we are dealing with a significant increase in the diversification of agricultural productivity. Latvia (142.42), Belgium (142.05) and Poland (132.17) as the three countries with the highest total factor productivity and total factor productivity growth in 2007-2018. Belgium and Latvia show a 44.37% and 37.12% average growth in total factor productivity change. Total factor productivity increase in these countries was affected by technology and technical efficient changes. Such countries as Cyprus (95.7), Germany (95.13) and Malta (62.53) exhibit the lowest total factor productivity in agriculture sector and negative TFP growth.

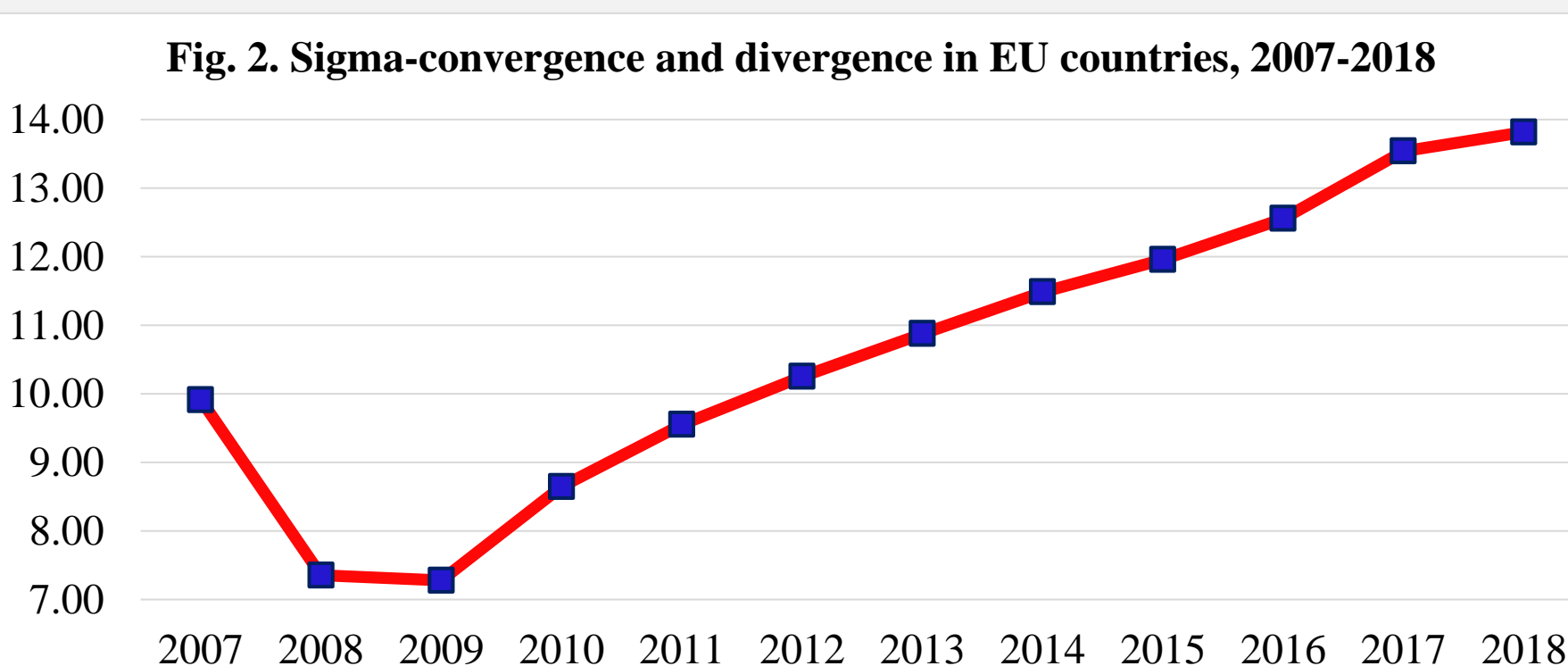
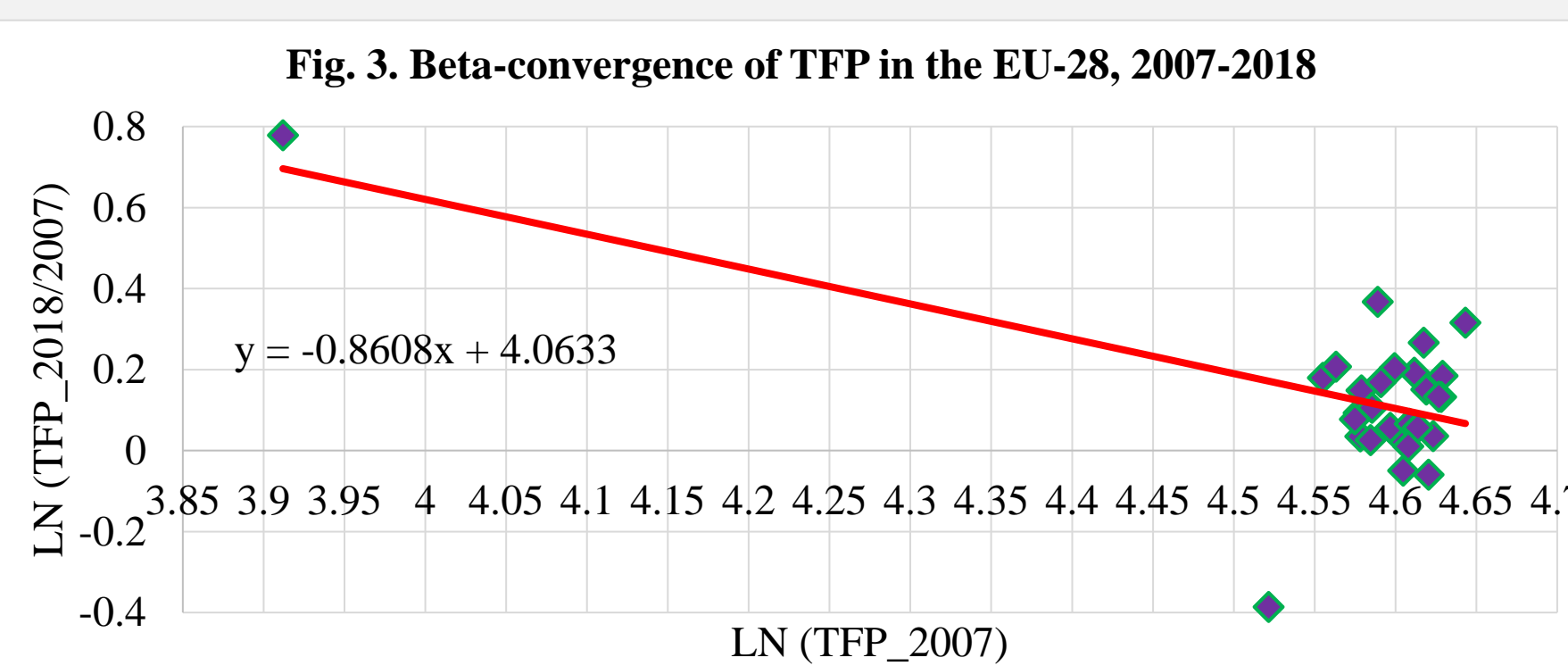


Figure 2 shows the dynamics of the coefficient of variation, characterised by constant growth during 2009-2018. The reducing of coefficient of variation before financial crisis in 2007-2009 present that differences between countries are narrowing. This means that disparities in the EU are decreasing, mainly due to sigma-convergence of countries. But after financial crisis, the rise in the values of coefficient of variation shows a significant increase in the difference between countries in TFP during the period 2009-2018. This is an indicator of the process of divergence and persistence of differences in agricultural sector productivity between countries over the years. The reasons are different natural conditions, different structure transformation in the agricultural sector, external and internal market factors, diversification processes and technological changes in agricultural sectors. We reject the hypothesis of the presence of sigma-convergence, and we can state sigma-divergence, which confirms the increase in the values of the coefficient of variation in countries from the initial 9.91% in 2007 and 7.28% in 2009 to 13.81% in 2018. This means that the difference in TFP in agriculture is widening between the EU-28 countries. The negative coefficients of the estimated regression models occur in case of the entire European Union. Using a regression model, we confirmed the process of beta-convergence in the EU countries.



The value of beta coefficient (-86.08%) is negative and statistically significant, which confirms the absolute beta convergence. The coefficient of determination is equal to 36.55%. We can confirm catching up with the better developed countries by the less developed countries.

The rate of absolute beta convergence is not constant over time, and the estimated rate of convergence is relatively higher at 17.93%. But the speed of convergence is higher in the poorer regions of the EU. In EU countries, there is a process of beta convergence between EU regions, and the general trend of reducing disparities in TFP persists. As regards the time to cover half the distance to the convergence of regional development levels based of TFP, we see that $\tau = 4.2$, e.g., relatively short period of time separates the economies of the regions from sustainable development.

As can be seen in figure 3, the change in the level of TFP in the years 2007-2018 allows to group countries. The first group, which includes countries with a high level of development (France, Germany, Belgium, the Netherlands, the United Kingdom). They did not significantly change the level of development but remained at the upper stages of development. These countries lie under the regression line. The second group includes countries with a relatively lower level of development in comparison with the EU average (Latvia, Lithuania, Estonia, Poland, Hungary, Slovakia, Bulgaria), which developed at an accelerated pace. These countries are above the regression line. Thus, it can be assumed that these countries are using the catch-up development strategy within the framework of the convergence policy applied in the European Union.

Main conclusions

Bioeconomy is capable solving global problems and harmonizing the socio-economic development. Therefore, increasing agricultural productivity will contribute to the development of bioeconomy, as agriculture is a major producer of biomass for food, feed and energy production. In turn development of bioeconomy brings new biotechnologies, which could support higher productivity, efficiency and resilience of agriculture.

The empirical assessment of economic convergence and growth carried out points to uneven economic convergence in the EU countries. This concerns the significant differences in the growth model of countries. Analysis of the dynamics of development of the coefficient of variation shows the existence of long-run divergent processes of TFP in agriculture among the EU countries. Despite a significant disparity in TFP levels and growth rates among countries, agricultural productivity in the EU-28 countries has grown. In addition to technological progress, changing labour factors also contribute to inter-country disparities in TFP levels and growth.

The absolute beta convergence takes place among the EU-28 countries which may result from the strong restructuring processes and the application of similar political instruments to support agriculture and rural areas. This means that divergence in the EU will continue as a major long-term economic trend. The current priority of EU policy is the development of economic development tools that will allow for high rates of TFP, ensuring long-term growth in agricultural productivity. Greater support for agriculture should lead to an improvement in its performance, that is, overall agricultural production. The increase will be accompanied by progressive structural changes that will ensure the country's diversification and competitiveness. This will bring the level of economic development of lagging countries closer to more developed countries.

