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FACTOR PRODUCTIVITY AND INFLUENCE ON THE DEGREE OF CONVERGENCE IN THE CEREAL SECTOR

ABSTRACT

The paper aims to analyse cereal chain productivity in Romania, EU-15 and NEU-13, highlighting the determining factors for increasing productivity and accelerating the process of productivity convergence to the European average. Together with agricultural performance indicators: utilized agricultural area, labour force in annual working units, value of agricultural production, average yield per hectare, value of agricultural production/ha, total output/annual work unit, total output/hectare, farm net value added/annual work unit, total output to total input ratio, this study also uses total factor productivity (TFP) using the Malmquist productivity index, as well as other indicators such as the pesticide use or the use of certified seeds in the cereal sector. For the comparative study of the cereal sector productivity in Romania and in EU-15 and NEU-13, we used the Pearson correlation coefficient and/or the Spearman's rank correlation coefficient. The results indicate that the cereal crop sector in Romania has the potential to increase agricultural productivity and can be one of the solutions by improving the efficiency of production methods.

Key words: productivity, areas, production, consumption, cereals, Romania.

JEL Classification: Q10, Q13.

1. INTRODUCTION

Any economic activity is based on the productivity criterion. Under free market conditions, the importance of continuous efficiency assessment becomes an absolutely mandatory goal. Furthermore, the effect of globalization calls for comparing the efficiency of an economic system in a broader, regional or global context.

Membership of various organizations and economic and/or political structures imposes a series of limitations (constraints), which becoming mandatory determine, in addition to adapting the economic phenomenon to the new requirements, the constant re-assessment of this process efficiency in the new context. In the absence of this ongoing assessment, in the European context, one of the objectives of the CAP, namely convergence, cannot be achieved. Although economic policies are generally left to the discretion of each state, increasing productivity and achieving economic convergence in the European Union are

important issues. Even after many years since the establishment of the European Union, convergence continues to be an objective that is far from being reached.

The great heterogeneity of the climate conditions, of farm size, of labour force involved in this economic sector, the credit conditions (very different from country to country) leading to different dynamics of endowment with equipment and technologies, regional specificity – in terms of ownership, specialization, different development level of commodity chains and even the different moments of accession of the EU member states, which are only some of the factors that directly determine productivity and convergence, lead to significant disparities resulting in different economic outcomes at country and even regional level in the European Union.

Agriculture is a specific sector which, due to its great importance, is often under monitoring by governments, and that is why it is desirable to measure the efficiency of this sector in particular.

2. STATE OF KNOWLEDGE

The TFP and PFP indicators contribute to a deeper understanding of the agricultural systems, necessary for policy and investment decisions, enabling comparisons over time, between countries and regions.

Increasing the efficiency of agricultural production – obtaining a larger amount of products from the same amount of resources – is essential for improving food security. To measure the efficiency of agricultural systems, total factor productivity (TFP) is used, which is a key measure of efficiency and therefore an important indicator for decision makers.

Because partial factor productivity (PFP) measures, i.e. land and labour productivity are easier to estimate, these are often used to measure the performance of agricultural production.

The dynamics of partial factor productivity is important to see the evolution of cereal sector, by various components, in the post-accession period, and how the CAP policy has reached its objective.

3. MATERIAL AND METHOD

The performance of the agricultural sector is based on the total factor productivity (TFP) approach, so that to define and delimit the fundamental objective of the study, as well as to describe the phenomena, a specialized bibliographic research will be performed, with the consultation of several data sources: reference books, scientific articles from national and international literature.

For the purpose of the above-mentioned approach, in the paper we shall use data extracted from the Farm Accountancy Data Network (FADN) database.

Together with agriculture performance indicators: utilized agricultural area, number of agricultural workers, value of agricultural production, GVA, value of agricultural production/ha, value of agricultural production/agricultural worker, GVA/ha, GVA/agricultural worker, utilized agricultural area/agricultural worker, we shall calculate the total factor productivity (TFP) using the Malmquist productivity index, as well as other indicators, such as: pesticide consumption or use of certified seeds, insofar as relevant data for the cereal sector will be found.

For the comparative study of cereal sector productivity in Romania and EU-15 and NEU-13 the Pearson correlation coefficient and/or the Spearman rank correlation coefficient will be used.

In the study of sectoral analysis for the cereal market, we analysed the total productivity factor (TFP) of Romania compared to the EU-15 and NEU-13 average. At the same time, we also calculated this index for the sample of EU-15 member states (France and Germany) and NEU-13 (Poland and Hungary) to highlight the particular situation of member states in each category.

Coelli (2005) defines several methods for productivity calculation:

1. Productivity calculation models based on the least squares method;
2. Tornquist/Fisher total factor productivity index;
3. Data envelopment analysis (DEA);
4. Stochastic frontier analysis method (SFA).

How these methods can be used differs depending on the data available, the purpose for which they are used (because some of them can be used to determine the total factor productivity, but cannot break down this index into its components: technical efficiency, allocative efficiency, technical changes or returns to scale). The Tornquist/Fischer method also requires information on input and output quantities and on their prices, but this requirement cannot always be met.

That is why it is important to choose the TFP calculation method depending on the data available and the desired granularity of the results.

To calculate TFP, we used the Malmquist index for determining the total factor productivity, with the breakdown by components:

1. technical efficiency;
2. allocative efficiency (in the case when information on input/output prices are also available);
3. technical and technological changes;
4. returns to scale – the proportionality by which the percentage increase of inputs determines the increase of outputs.

As prices for the cereal sector are rather dictated by the economic context and the volume of production, than by optimized prices in a highly competitive market (such as the banking sector), the DEA analysis is focused on output, namely output optimization considering constant inputs, as opposed with the focus on input,

which starts from the premise "how much can be inputs decreased to obtain the same output?".

At the same time, in the absence of input prices, the Malmquist method is indicated because, unlike the calculation of the total productivity index based on the Tornquist/Fisher method, this requires only the quantities of resources as input data, not the prices.

The Malmquist index is defined using distance functions, which express a production process with several inputs/outputs, without specifying its behaviour, in the sense of optimizing the process (reducing costs or maximizing profit) (Coelli *et al.*, 2005).

The Malquist TFP index measures the distance between two data points in different periods of time as ratio of the distance of each data point relative to an efficiency frontier.

It is calculated using the formula:

$$M_0(y^{t+1}, x^{t+1}, y^t, x^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{1/2}$$

m_0 represents productivity at the moment t+1 related to the moment t. A value of m_0 greater than one will indicate an increase in productivity, while a value less than one indicates a decline in productivity.

To highlight the dynamics of productivity in the components, changes in efficiency as a result of production process optimization, and the dynamics of efficiency due to technical and technological progress through the development of new technologies or the acquisition of high-performance technology, the equation above can be written under the form:

$$M_0(y^{t+1}, x^{t+1}, y^t, x^t) = \left(\frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)}\right)\left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)}\right]^{1/2}$$

For the sectoral analysis of the cereal market, we used FADN data as Eurostat provides only partial sectoral data, insufficient for the purpose of our study. As output data we considered total output (SE131) expressed in euros/farm, and as input data we used agricultural labour, utilized capital and agricultural area.

Labour force is expressed in AWU (annual work units), capital flow is an aggregate input variable comprising intermediate consumption (SE275), as sum of total specific costs (SE281 – seeds and plants, fertilizers, crop protection materials, fodder, etc.) and total agricultural expenditure (SE336 – energy, employment contract work, equipment and buildings, other direct expenses).

In order to calculate the influence of land used in the production process as share of TFP, we used the total agricultural area expressed in hectares.

This study also presents the dynamics of partial productivity factors.

For comparison, we calculated the TFP average for the EU-15 member states and also for the new entrants, NEU-13.

We also analysed TFP in the period 2008 – 2016 for two representative countries for each group, namely France and Germany for the group of EU-15 and Poland and Hungary for the NEU-13.

For the analysis of the partial factor productivity we used the ratio of inputs to total output.

4. RESULTS AND DISCUSSIONS

To create a complex picture of this dynamics, we set out to investigate the dynamics of a number of partial productivity factors, such as utilized agricultural area, number of agricultural workers, value of agricultural production, GVA, value of agricultural production/ha, value of agricultural production/agricultural worker, GVA/ha, GVA/agricultural worker, utilized agricultural area/agricultural worker, for Romania, as well as to establish the context of the Romanian cereal sector in relation to the main cereal producers in Europe.

Utilized agricultural area in the cereal sector. The utilized agricultural area does not vary much so that the partial productivity of this indicator is not significantly affected. In Romania, an increase of land areas under cereals can be noticed. Their distribution by economic farm size has significant variations, which is also reflected by the SO/ha. The largest farms, which have access to high performance planting, fertilization and crop protection technologies, agricultural equipment and implements, also have the highest SO/ha ratio.

A trend of land consolidation into large-sized farms can be noticed. Out of total 4.41 million farms in 2016, 88% have a physical size under 4.9 ha, cultivating 13% of the utilized agricultural area. These use 60% of total AWU, accounting for 14% of Standard Output.

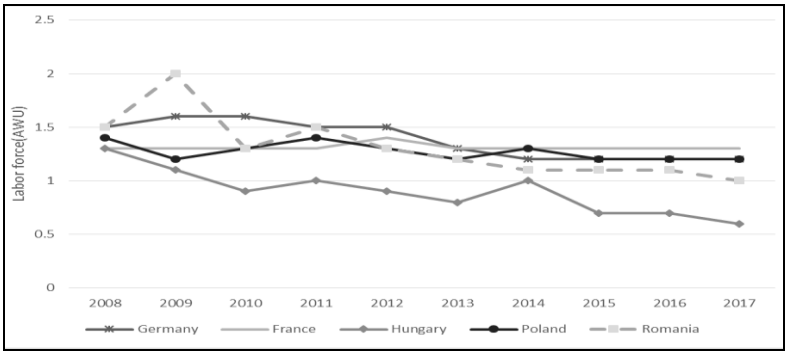
The farms with a physical size larger than 50 ha account for 2.1% of the total number of farms, using 77% of UAA and 21% of AWU. They contribute by 76% to total standard output, with the highest standard output/AWU, 10 times higher than the farms under 4.8 ha.

The share of leased in areas for growing cereals decreased from maximum 79.6% in the year 2010 to 64% in 2017.

Labour force in agriculture – the cereal sector. The increase of TFP is largely due to the decrease of inputs generated by the labour force used in agriculture, and mainly in the cereal sector, in favour of capital.

Recent studies have shown that labour force has a strong decreasing trend throughout the investigated period (1992–2015), while capital has a reverse trend, with an increase by about 20% at the end of the investigated period compared to the reference year (2005).

Figure 1 shows that in the investigated NEU-13 countries, there is a stronger decline of labour force, by 54% in Hungary, followed by Romania with 33%, while in Germany the labour force decreased by 30%. France maintains its level of 1.3 AWU throughout the investigated period.

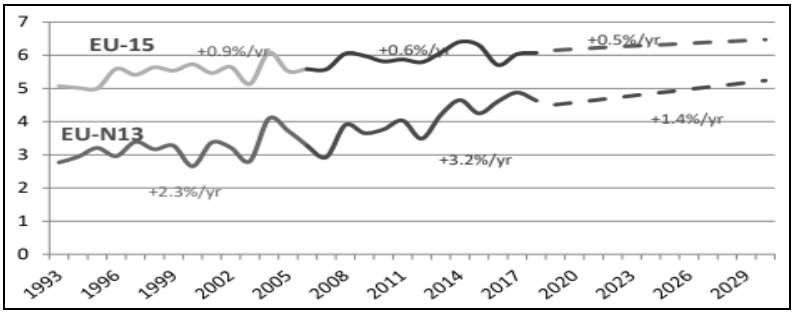


Source: author's own processing of FADN data

Figure 1. Labour force in AWU

Although, in Romania's case, the decreasing trend in AWU has been consistent over time, there are major discrepancies, in absolute figures, in terms of the absolute net value related to AWU. The strong decline in AWU, in Romania's case, is due both to demographic factors, through labour migration, mainly young labour, and to the ageing of the remaining labour force in the rural area, as well as to the fact that access to new technologies diminishes the need for labour in the activities that can be optimized with high-performance equipment. At the same time, the decline of unskilled labour implies replacing it, in terms of human resources, by medium and highly qualified staff, able to use the new technologies, equipment and implements to their full capacity.

Average yield/hectare. An analysis by the European Commission (DG-Agri, 2018) presents an outlook of the average cereal yields, which will increase by the year 2030, by about 1.4%/year in the NEU-13 member states and by about 0.5%/year in the EU-15 member states. The convergence process of the cereal sector in NEU-13 countries to the average yields in EU-15 will be maintained throughout the investigated period, although at the end of this period there will be still gaps between the countries from the two groups. The dynamics of cereal average yields in the period 1993 – 2018, with projections until 2030, is presented in Figure 2.

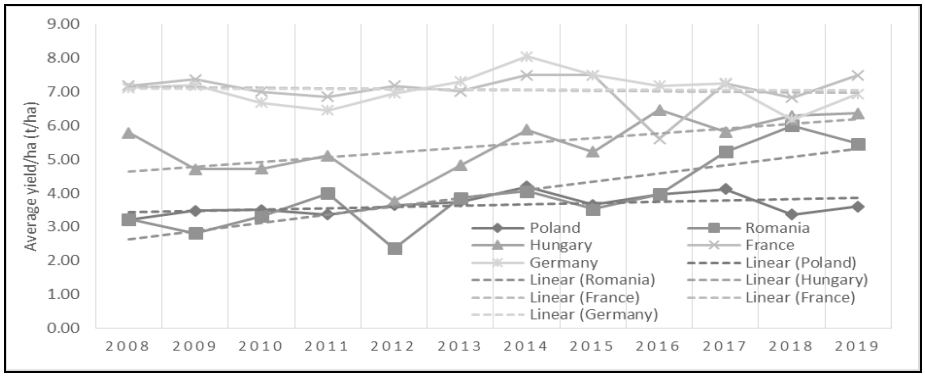


Source: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/production-yields-productivity_en.pdf

Figure 2. Average cereal yield outlook (t/ha)

It can be noticed that in the pre-accession period (2004, 2007), the average yields per hectare, in the NEU-13 member states were lower by 50% than in the EU-15 member states; after the accession the convergence process has accelerated, with access to new technologies, equipment, finance and more favourable trade conditions. Therefore, if the 1.4% growth outlook is determined considering the 1993 data, it is possible to be corrected in the sense of growth for the NEU-13 countries, based on data since 2004 and 2007, respectively (for Romania and Bulgaria).

For the EU-15 member states, the growth outlook is 0.5%, the technology and production methods bringing the average yields/ha close to theoretical results, which cannot be overlooked, and also by promoting specific CAP policies, such as limiting the amount of fertilizers, specific policies on genetically modified organisms, or banning the use of neonicotinoid pesticides. In the cereal group, the higher increase is noticed in maize (3.7%/year), while in wheat the increase amounts to 2.1%/year.



Source: author's own processing of FADN data

Figure 3. Average yields/ha and trends

In the particular case of Poland and Hungary, an increasing trend of average yields/ha can be also noticed, in line with the trend for the entire group of NEU-13 member states.

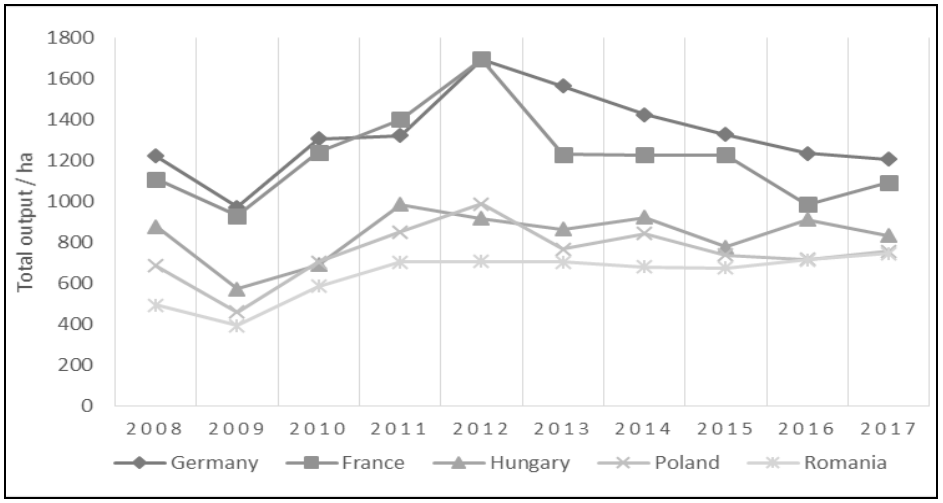
Although in Romania, the value of average cereal yield in the year 2019 is lower than that of the EU-15, by correlating it with the large area under these crops, compared to other countries, the value of cereal production is high, Romania being a major exporter of cereals on the global market. Self-sufficiency in cereals was reached in the year 2008 and increased throughout the investigated period.

Total output/ha. An important indicator in assessing productivity is the total output per hectare.

In Romania, an increasing trend of this indicator can be noticed, yet it remains at a low level, in absolute value, compared to the EU-15 member states.

After the economic crisis of 2009, the total output/ha increased for three years in all investigated countries. Since 2013, with a sharp increase of inputs, this indicator has decreased.

Although in the year 2017 the total output/ha (749 euros/ha) was by 51% higher than in 2008 in Romania, which was practically the higher increase in the 5 investigated countries, this continues to be low compared to France (1056 euros/ha) or Germany (1209 euros/ha).



Source: author's own processing of FADN data

Figure 4. Total output/ha (euros/ha)

In Romania, we can notice a certain homogenization of standard output across regions for the farms with a physical size of more than 100 ha.

Total output/annual work unit. The standard output to annual work units ratio increases with the classification of farms in higher physical classes and with the advancement of a farm within the same class of physical size, from a lower economic size to a higher economic size. There is a positive correlation between the standard output/AWU and the physical and economic size of farms (Table 1).

The annual work units decrease with the increase in farm size due to the increase in the efficiency of the production process. From Table 1 it results that there are great differences of the standard output/AWU ratio within the same class and mainly between the classes with different farm sizes. Analysing the data series since the year 2007, an increasing trend of the standard output/AWU can be noticed, like in the case of other indicators, as a result of the cohesion policies, of implementing new production methods and increasing efficiency, in the conditions in which the number of AWU decreased.

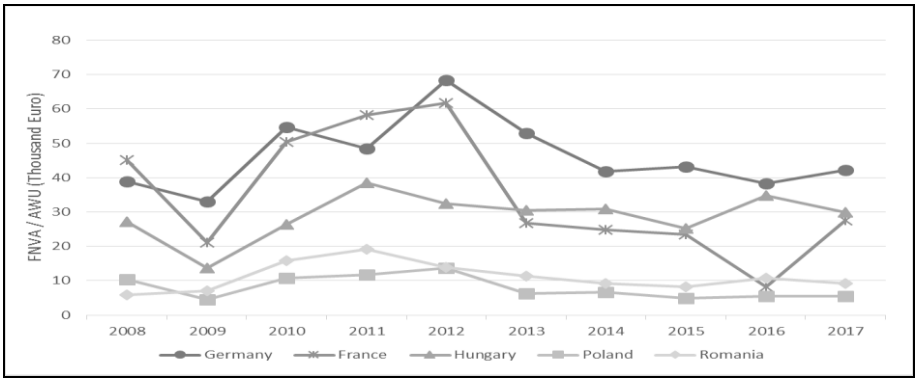
Table 1

Distribution of standard output per AWU by farm physical and economic size, 2016

Physical size	**under 2 ha**	**2 – 4.9 ha**	**5 – 9.9 ha**	**10 – 19.9 ha**	**20 – 29.9 ha**	**30 – 49.9 ha**	**50 – 99.9 ha**	**100 ha and over**
Total	2822.18	4978.32	7601.02	11601.74	16367.05	20311.05	27852.08	55210.63
>2000 euros	2822.18	4612.19	4382.68	2925.67				
2000 – 3999 euros		5260.12	7123.43	5873.5				
4 000 – 7999 euros		6376.5	7934.13	10855.57	11914		2033.5	
8000 – 14999 euros			7727.4	12117.78	16410.53	21791.67	5294	2912
15000 – 24999 euros				14058.4	16568.3	19406.97	17003.5	11741
25000 – 49999 euros						21466.01	27512.7	14654.5
50000 – 99999 euros							29460.94	36942.59
100000 – 249999 euros								45726.68
250000 – 499999 euros								**55357.86**
500000 euros and over								**65230.91**

Source: author's own processing of Eurostat [ef_m_farmleg] data

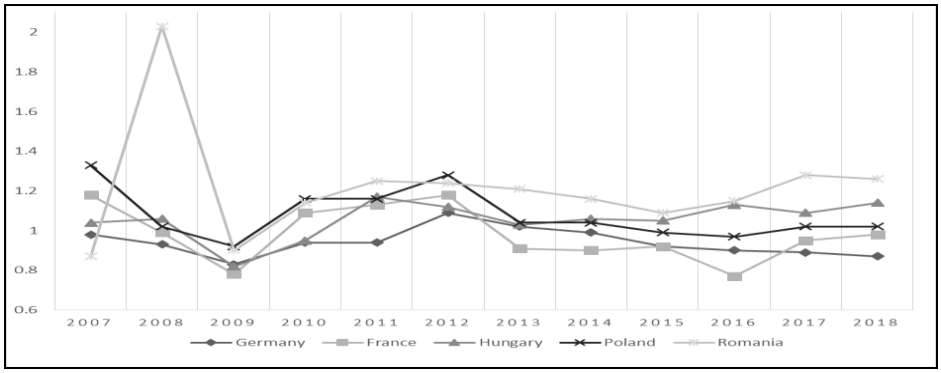
Farm net value added / annual work unit (AWU). The farm net value added (Figure 5) per annual work unit increased almost 7 times in Romania in the period 2007–2018. Although this is a significant increase, the value of 30794 euros/AWU in 2018 is lower by 7.7% than in Hungary, by 8.6% than in France and by 37% than in Germany. Poland and France had a decreasing trend of this indicator, while in Hungary and Romania FNVA/AWU increased.



Source: author's own processing of FADN data

Figure 5. Farm net value added / annual work unit (euros)

The economic crisis of 2009 was also a major disruptive factor in the case of this indicator. Romania had the highest coefficient of variation of growth indices, i.e. 99%, and France came next, with 57%.

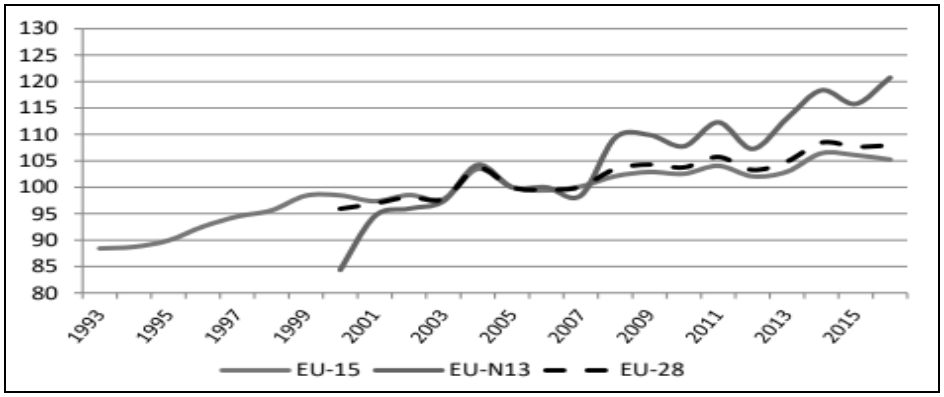


Source: author's processing of FADN data

Figure 6. Total output to total input ratio

After the economic crisis of 2009, the total output to total input ratio was greater than one in Romania and Hungary over the entire period until 2018, while in France and Germany, after 3 years of growth, steady decrease of this ratio followed, starting with the year 2013 for France and 2014 for Germany (Figure 6). The value of this ratio, for Romania, at the end of the period, reveals a sustained productivity growth.

Total factor productivity. Although in absolute values, the partial productivity factors in NEU-13 countries are lower than those in EU-15 countries (on average), the TFP growth rate is higher than in the case of EU-15 countries (Figure 7), which reveals that there is a real convergence process despite the existing gaps that currently exist between the countries in the two groups.



Source: DG-agri - https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/farming/documents/production-yields-productivity_en.pdf

Figure 7. TFP growth rate in EU-15 and NEU-13 (2005=100)

Considering the total labor force expressed in AWU, the total utilized agricultural area expressed in hectares and the intermediate consumption expressed in euros as input data, we aggregated the data as EU-15 and NEU-13 average, and total output expressed in euros as output variable. The input data were processed with DEAP (Data Envelopment Analysis Program – computer) version 2.1 and are presented in Table 2.

Table 2

Averages of total factor productivity index, of change in technical efficiency and change in operational efficiency – Malmquist indices

	Operational efficiency	Technical efficiency	TFP
EU-15	1	1.001	1.001
NEU-13	1.002	0.992	0.994
Romania	1.026	1.025	1.051
Geometric mean	1.009	1.006	1.015

Source: author's own processing based on FADN data

All the averages presented are geometric means. It can be noticed that throughout the investigated period, 2008–2018, in the cereal sector, Romania had the highest TFP index, i.e. 5.1% while in the EU-15 member states TFP increased by 1%, while in the NEU-13 member states, TFP decreased by 0.6%. By the breakdown of TFP into its components, it can be noticed that the cereal sector in Romania had approximately equal increases both in terms of operational efficiency by optimizing inputs and production processes and in terms of technical efficiency as a result of adopting more advanced technologies and equipment.

In the NEU-13 member states, an improvement of production processes can be noticed, yet the negative changes in technical efficiency result in the decrease of TFP. Productivity increase is mainly due to the decrease in the share of utilized labour force, as component part of TFP.

For the assessment of the cereal sector performance in Romania, a comparison with the main agricultural producers in Europe is absolutely necessary. For this purpose, France and Germany were selected from the group of EU-15 countries, and Poland and Hungary from the group of NEU-13 countries. Calculating TFP for the 5 countries, it can be seen that Romania has the highest increase in TFP among the analysed countries, i.e. 5% in the entire investigated period; both the increase of the operational efficiency by 3.1% and the increase of technical efficiency by 1.9% contributed to TFP increase. On a cumulated basis, in France and Germany total factor productivity increased by 0.25%, in Germany by the improvement of technical efficiency by 0.7%, while in France TFP decreased by 1.1%. (Table 3)

In Hungary, the decrease of technical efficiency is compensated by the increase of operational efficiency.

Analysing the TFP components for Romania, it can be noticed that total intermediate consumption strongly correlates with total output, the Pearson coefficient being 98%. Total intermediate consumption increase positively correlates with the utilised agricultural area (Pearson coefficient 96%).

Labour inputs have a correlation coefficient with total output of 48%.

Table 3

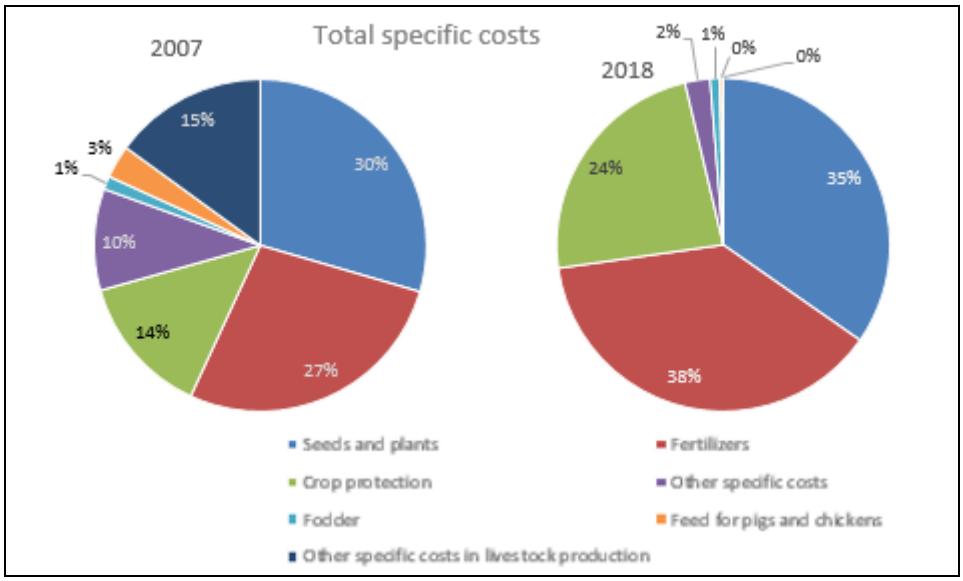
Total productivity of production factors – results on selected sample (2008–2018) – Malmquist indices

Country	Operational efficiency	Technical efficiency	TFP
Germany	1	1.007	1.007
France	0.998	0.99	0.989
Hungary	1.013	0.988	1
Poland	0.988	0.987	0.976
Romania	1.031	1.019	1.05
Geometric mean	1.006	0.998	1.004

Source: author's processing based on FADN data

The share of the two groups of expenditures in the composition of total intermediate consumption, i.e. total specific expenditures and general agricultural expenditures has changed since Romania's accession to the EU, in the year 2007, with specific expenditures having an increasing trend. The economic crisis of 2009 meant a significant decrease in total intermediate consumption by about 23%, followed by an upward trend until 2015 (15.42% compared to 2007), in 2018 this being by 10.5%. higher than in the reference year.

Intermediate consumption. If we look at the structure of intermediate consumption in the analyzed period, we can see that intermediate consumption was more heterogeneous at the beginning of the period, while at present it focuses on three important groups of expenditures totaling 97% of total (seeds and plants – 35 %, fertilizers – 38% and crop protection – 24%). The proportion of these costs increased by 49%, 76% and 117% respectively compared to the reference year.

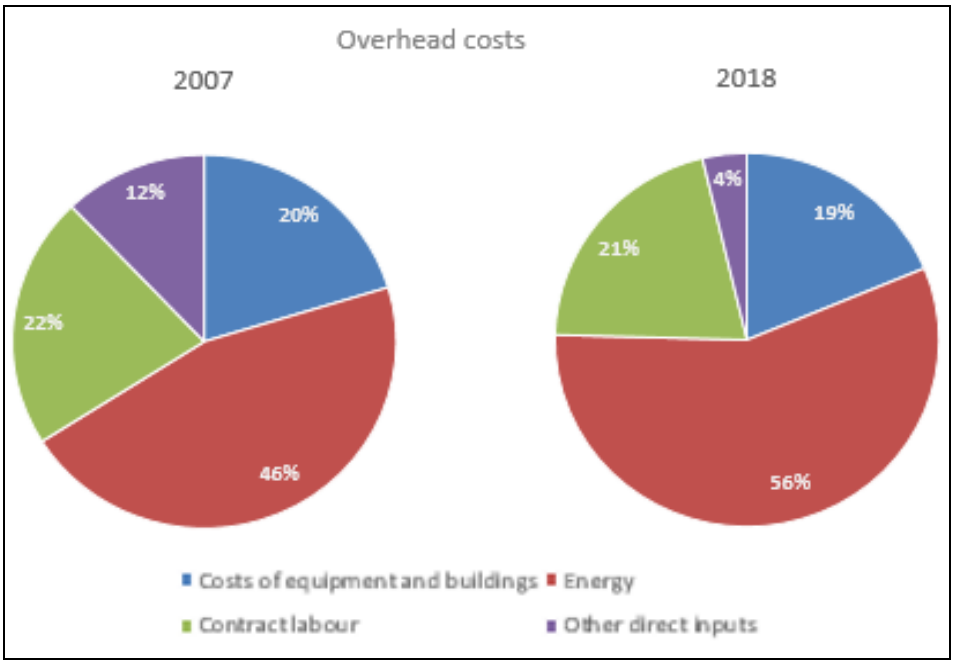


Source: author's own processing based on FDN data

Figure 8. Total specific costs – comparative situation 2007 – 2018

Compared to the year 2007, where other specific costs in livestock production accounted for 15%, especially by the share of veterinary expenses, in the year 2018 a specialization of farms almost exclusively in cereal production can be noticed, by the very high share of costs exclusively devoted to the production of cereals.

The overhead costs had a decreasing trend, from 45% in 2017, to 37% in 2018.



Source: author's own processing based on FDN data

Figure 9. Overhead costs – comparative situation 2007 – 2018

In the case of overhead costs (Figure 9), changes in the cost structure can be also noticed, yet not as significant as in the case of total specific costs. A significant increase can be noticed in energy costs, from 46% to 56% in total overheads/hectare. The main cause of this increase is the liberalization of energy prices, in the conditions in which the costs of equipment and buildings have remained at a constant level.

5. CONCLUSIONS

From the analysis of partial factor productivity and total factor productivity it can be noticed that the convergence policies have reached their

target. In the EU-15 member states, total factor productivity decreased in the last 12 years, while in the NEU-13 member states the values of this indicator increased.

However, the initial gaps between the economies of these countries, before the accession, and the EU-15 countries make this convergence process be a long-lasting process.

While simulations on TFP evolution in the EU-15 member states show a relatively small increase, with compensatory payments playing an important role in the output of agricultural holdings, there is a more favourable growth forecast (a steeper growth curve) for the NEU-13 member states, also due to the fact that the initial gap with the EU-15 countries was significant.

In Romania's case, although there is a greater convergence process than the NEU-13 average, there are certain challenges, such as labour migration, population ageing, insufficient endowment with irrigation infrastructure (seasonality playing an important role in the dynamics of economic results), increase in energy prices, in seeds and fertilizers and crop protection products.

How these challenges will be overcome will determine the speed of the convergence process. There are situations, such as the case of Poland, when starting from a better economic situation than that of Romania, TFP decreased, the factor productivity being lower than in Romania at the moment.

By decomposing the Malmquist index, we concluded that the growth rate was mainly due to the increase in operational efficiency (3.1%) and in technical efficiency (1.9%).

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