Journal of Central European Agriculture, 2013, 14(2), p.707-720 DOI: 10.5513/JCEA01/14.2.1251

Do field crop farms and mixed farms of eu members improve productivity at the same rate?

Czy gospodarstwa specjalizujące się w uprawach polowych i produkcji wielokierunkowej poprawiają produktywność w tym samym stopniu?

Lucyna BŁAŻEJCZYK-MAJKA[1]*, Radosław KALA[2] AND Krzysztof MACIEJEWSKI[3]

[1]Adam Mickiewicz University in Poznań, Chair of Economic History, Poznań, Poland; [2]Poznań University of Life Sciences, Departament of Mathematical and Statistical Methods, Poznań, Poland; [3]Poznań University of Economics, Department of Product Ecology, Poznań, Poland;

e-mail: majkal@amu.edu.pl,* ul.: Św. Marcin 78, 61-809 Poznań, Poland, + tel./fax +48 61 829 47 25

Abstract

In this paper we attempted to address the question presented in the title based on the data contained in the Farm Accounting Data Network (FADN). Analyses covered the first six years following the extension of the European Union in 2004. Estimation of the Malmquist total factor productivity (TFP) and its components was conducted using data envelopment analysis, separately for crop and mixed farms of EU (2004-2009) taking into consideration their economic size.
The analysis showed, in general, that for farms from the "old" regions the total factor productivity increased with an increase in the economic size of farms, while for farms from the "new" regions, just the opposite, the increase in the size of farms caused a decrease of productivity. As to differences in types of farming, the biggest improvement was observed in the technical and technological aspects. Finally, the estimated Malmquist total factor productivity index, although close to one, nevertheless indicates a slight progress for farms from "old" regions and, just the opposite, a slight regress for those from "new" regions.

Keywords: data envelopment analysis, Malmquist index, scale efficiency change, technical efficiency change, agriculture, EU.

Streszczenie

W pracy przedstawiono wyniki estymacji indeksu Malmquista, mierzącego ogólną produktywność czynników produkcji oraz komponenty tego współczynnika. Wszystkie

obliczenia przeprowadzono w oparciu o metodę DEA (data envelopment analysis) wykonaną zarówno w odniesieniu do gospodarstw specjalizujących się w uprawach polowych jak i gospodarstw wielokierunkowych, prowadzących swoją działalność w latach 2004-2009. W obliczeniach wzięto pod uwagę także wielkość ekonomiczną tych gospodarstw.
W wyniku przeprowadzonych badań ustalono, że w jednostkach reprezentujących regiony wcześniej uczestniczące we wspólnej polityce rolnej ogólna produktywność czynników produkcji wzrastała wraz ze wzrostem wielkości ekonomicznej gospodarstw rolnych. Natomiast w gospodarstwach reprezentujących „nowe" regiony UE, wzrost wielkości gospodarstw powodował obniżenie wydajności. W odniesieniu do różnic w poziomie specjalizacji, największą poprawę odnotowano w obszarze zmian technicznych i technologicznych. W podsumowaniu dokonano porównania Indeksów Malquista mierzącego poziom ogólnej produktywności czynników wytwórczych w badanych grupach.

Słowa kluczowe: DEA (data envelopment analysis), indeks Malmquista, zmiana efektywności skali, zmiana efektywności technicznej; UE

Detailed abstract

W pracy staraliśmy się odpowiedzieć na pytanie postawione w tytule bazując na danych publikowanych w ramach systemu FADN. Analizy zostały przeprowadzone w oparciu o dane dotyczące średnich gospodarstw reprezentujących 122 regiony należące do 25 państw UE i dotyczyły pierwszych sześciu lat funkcjonowania po poszerzeniu Unii Europejskiej w 2004r. Dla każdej grupy państw: UE-15 oraz 10 nowych członków, przedstawiono wyniki estymacji indeksu Malmquista, mierzącego ogólną produktywność czynników produkcji oraz komponenty tego współczynnika. Wszystkie obliczenia przeprowadzono w oparciu o metodę DEA (data envelopment analysis) wykonaną zarówno w odniesieniu do gospodarstw specjalizujących się w jednym rodzaju produkcji rolnej jak i gospodarstw wielokierunkowych. W obliczeniach wzięto także pod uwagę wielkość ekonomiczną analizowanych gospodarstw.
Główne pytanie postawione w tym badaniu dotyczyło siły wpływu poziomu specjalizacji i wielkości ekonomicznej na poprawę produktywności gospodarstw prowadzących działalność w regionach z UE15 („starych") regionach włączonych do UE w 2004r. („nowych"). Gospodarstwa specjalistyczne, w pracy reprezentowane przez gospodarstwa ukierunkowane na uprawy polowe, zostały porównane z ich odpowiednikami prowadzącymi wielokierunkową produkcję rolną.
Na podstawie przeprowadzonych badań ustalono, że w latach 2004-2009 w jednostkach reprezentujących regiony wcześniej uczestniczące we wspólnej polityce rolnej ogólna produktywność czynników produkcji wzrastała wraz ze wzrostem wielkości ekonomicznej gospodarstw rolnych. Z kolei w gospodarstwach reprezentujących „nowe" regiony UE, wzrost wielkości gospodarstw powodował obniżenie wydajności.
W odniesieniu do różnic w poziomie specjalizacji, największą poprawę odnotowano w obszarze zmian technicznych i technologicznych. Najwyższe tempo wzrostu wykazały gospodarstwa specjalizujące się w uprawach polowych prowadzące swą działalność

zarówno w „starych” i „nowych” regionach. Znacznie niższe wzrosty w tym obszarze odnotowano natomiast w gospodarstwach wielokierunkowych ze „starych” regionów, a najniższe w gospodarstwach wielokierunkowych z „nowych” regionów. To potwierdza hipotezę, że gospodarstwa jednokierunkowe, specjalizujące się w uprawach polowych, skuteczniej wdrażają nowe rozwiązanie techniczne i technologiczne niż gospodarstwa wielokierunkowe.
Podsumowaniem przeprowadzonej analizy było wyznaczenie i interpretacja Indeksów Malquista. Oszacowania poziomu ogólnej produktywności czynników wytwórczych w badanych grupach oscylowały wokół jedności. Jednak w przypadku gospodarstw reprezentujących „stare” regiony można mówić o niewielki postępie, a dla gospodarstw z "nowych" regionów o niewielkim ale regresie.

Keywords: DEA (data envelopment analysis), indeks Malmquista, zmiana efektywności skali, zmiana efektywności technicznej; UE.

Introduction

Efficiency and productivity have ranked among main interests of economists at least since the middle of the 20th century. In case of agricultural production this issue is especially complicated not only because of the instability of weather conditions, having a crucial influence on farming, but also due to the large variability of farms with respect to their sizes and production profiles. On the other hand, in the EU since the beginning it has been attempted to eliminate differences between regions, either supporting economically weaker regions or strengthening specific sectors of economy. In particular, the objective of the Common Agricultural Policy in the initial period was to assure food security, and in the course of further reforms to increase professional activity of rural communities, as well as improve efficiency of agricultural production.

In 2004 the EU was enlarged to incorporate ten new states. This extension has had an impact on agriculture in the new member states, which were characterized by a high share of this sector of economy in the generation of GDP and at the same time a high employment level as well as considerable diversity of organizational structures. A review and synthesis of several papers analyzing different factors determining efficiency of agricultural production in Central and East European Countries in the 1990’s was presented by Gorton and Davidova (2004). Following 2004 agriculture in the new EU member countries faced a new economic situation. Subsidies, new potential sale markets for goods and new possibilities to purchase means of production were found, but at the same time the pressure of competition increased, leading as a result to the necessity to improve efficiency, and as a consequence to improve profitability.

It was attempted in this paper to address the question whether higher specialization and a bigger economic size class of farms contribute to improved total factor productivity at the same rate for farms from the new and old countries of the EU. This hypothesis is analyzed at the regional level in reference to only two types of farming, i.e. farms specializing in field crops and those having multi-directional production. Investigations covered the first six years following the enlargement of the EU in 2004. The economic and statistical data were gathered from the FADN.

The paper is organized as follows. Section 2 presents a short introduction to the non-parametric estimation of the Malmquist total factor productivity (TFP) along with its basic components. Section 3 presents economic and statistical data constituting the foundation of the analyses. Section 4 contains results of estimation of the Malmquist index characterizing the rate of changes in productivity as well as its specific components such as: pure technical efficiency change, scale efficiency change and technical change. The last section, Section 5, was devoted to conclusions summing up the entire body of conducted analyses in view of the proposed hypothesis.

Methodology

The concepts of efficiency and productivity growth have focused the attention of the economic community since the early papers by Koopmans (1951) and Debreu (1951). In the course of years several analytical methods have been developed to evaluate technical efficiency. Many details on the early history of efficiency analysis may be found in an interesting study by Førsund and Sarafoglou (2002). These methods represent two fundamentally different approaches. The first one, i.e. the parametric approach, initiated by studies of Aigner and Chu (1968), Timmer (1971) and Afriat (1972), uses the concept of the frontier production function and is based on a respectively modified regression analysis.

The other approach was initiated by Farrell (1957) and is related with the envelopment of all data points with a non-parametric frontier function. This idea, fully elaborated by Charnes, Cooper and Rhodes (1978), is accomplished by solving a series of linear programming problems, in which the frontiers, i.e. the most efficient producers, are identified by comparing the observed vectors of outputs and inputs characterizing all units under investigation. This method is known as data envelopment analysis (DEA). The only assumptions of DEA concern the type of technology, which can be constant return to scale (CRS) or variable return to scale (VRS), and the type of orientation, which can be focused on outputs maximization given the values of inputs, or on inputs minimization given the values of outputs. Many other formulations of the DEA were reviewed by Thanassoulis, Portela and Despić (2008) (see also Coelli, Rao, O'Donnell, and Battese, 2005).

Let TEC(i) and TEV(i) denote the technical efficiency of the i-th producer following from DEA under the CRS and the VRS assumption, respectively. The latter index, called also pure technical efficiency, is not less than TEC(i), because under the VRS assumption the data set is enveloped more tightly than in the case of CRS. If TEV(i) = 1, then the firm operates at the best practice technology. The ratio, SE(i) = TEC(i)/TEV(i), is known as the scale efficiency index. If it is equal to one, then the producer operates at the optimal scale.

In the case of panel data it is possible to compare the results of the i-th unit obtained in the period t technology with the results of the sample of units operating in the technology of period s. In such a case the efficiency scores TECs(i,t) and TEVs(i,t) may not only be smaller, but also greater than one. For example, they may be greater than one when the results obtained in the later period are compared with those obtained in the earlier period, while the later technology is actually better than the previous one.

The ratios of two efficiency scores corresponding to two successive periods, i.e.

$$\Delta TE_C(i) = TE_C^{t+1}(i,t+1)/TECt(i,t) \text{ and } \Delta TE_V(i) = TE_V^{t+1}(i,t+1)/TE_V^{t}(i,t)$$

are known as technical efficiency change and pure technical efficiency change, respectively. In turn, the ratio of technical efficiency change and pure technical efficiency change provides a measure of scale efficiency change,

$$\Delta SE(i) = \Delta TE_C(i)/\Delta TE_V(i).$$

The third index, measuring the change in technology, is composed of two ratios of technical efficiency, corresponding to the technology of two successive periods. Their geometrical mean is known as technical change

$$\Delta T_C(i) = [TE_C^{t}(i,t)/TE_C^{t+1}(i,t) \cdot TE_C^{t}(i,t+1)/TE_C^{t+1}(i,t+1)]^{1/2}.$$

All the above indexes, when greater than one, indicate respectively some improvement in technical efficiency, in scale or in technology. In the other case, they indicate stagnation or even regression between periods t and t+1. Finally, the product of $\Delta TE_C(i)$ and $\Delta T_C(i)$ represents one possible decomposition of the so-called Malmquist productivity index,

$$M_C(i) = [TE_C^{t}(i,t+1)/TE_C^{t}(i,t) \cdot TE_C^{t+1}(i,t+1)/TE_C^{t+1}(i,t)]1/2 = \Delta TE_C(i) \cdot \Delta T_C(i).$$

The alternative decomposition is delivered by the product

$$M_C(i) = \Delta TE_V(i) \cdot \Delta SE(i) \cdot \Delta T_C(i),$$

where the first term expresses the technical efficiency change with respect to the best practice technology (for details see e.g. Färe, Grosskopf and Margaritis, 2008). The values of MC(i) greater or lower than one indicate, respectively, an increase or decrease in total productivity between two periods considered.

Data

Two types of economic and statistical data, published annually by FADN, were used in this study. The system supplies data with different levels of aggregation focusing on the biggest commercial farms, which jointly in a given region or member state generate at least 90% standard gross margin (SGM). The total value of SGM for each farm makes it possible to determine its economical size, which is expressed in European size units (ESU). The system distinguishes six classes of farm size, i.e. very small farms (0-4 ESU), small farms (4-8), medium-sized farms (8-16), large farms (16-40), very large farms (40-100) and the biggest farms (over 100 ESU). On the other hand, the share of individual types of production in the total value of ESU makes it possible to determine the specialization of each farm to one of the eight distinguished types. As a result, the FADN system distinguishes 24 combinations of types and economic sizes of farms. However, due to the specific agro-technical and climatic conditions, usually only certain types and sizes of farms are found in individual regions. As a result, in the FADN system each region is represented by a certain set of average farms, of which each is determined on the basis of a set of farms classified to a specific combination of type and economic size.

Investigations were conducted for all regions of countries, which operated within the EU in the years 2004-2009. Due to the enlargement of the Union in 2004, these regions are divided into two groups, i.e. the “old” and “new” regions, respectively. Average farms in individual classes of economic size and representing two types of farming, i.e. specializing in field crops and those with multiple direction production (the mixed type), were assumed as the basic research units in each region. Such a selection of units resulted from the decision to possibly confirm or refute the conjecture that the mixed farms, considered less economically risky than specialist farms, are more difficult to increase their productivity. Hereinafter the basic units of analysis, i.e. average farms representing individual regions, will simply be referred to as farms.

According to the FADN system, the EU after its enlargement in 2004 included a total of 122 regions, of which only 104, or 90, respectively, were represented by average farms classified to at least one of the classes of economic size and specializing in field crops or running mixed production. Among these two groups of regions only 290 and 125 regions, respectively, were represented throughout the entire period of 2004-2009 by the same average farms in terms of economic size. State affiliation of considered regions with the division into the “old ” and “new” group is presented in Table 1.

Table 1. Regions represented by field crop and mixed farms

Country	EU-15 regions
Austria	660
Belgium	341, 343
Denmark	370,
Finland	670
France	121$^{(F)}$, 131, 132, 133, 134, 135$^{(M)}$, 136, 141, 151, 152$^{(F)}$, 153$^{(M)}$, 162, 163, 164, 182, 183, 192, 193, 201$^{(F)}$, 203$^{(F)}$
Germany	010, 130, 050, 060, 070, 080, 090, 112, 113, 114, 115, 116
Greece	450, 460, 470$^{(F)}$, 480,
Ireland	380
Italy	222$^{(F)}$, 230$^{(F)}$, 243$^{(F)}$, 244$^{(F)}$, 250$^{(F)}$, 260$^{(F)}$, 270$^{(F)}$, 281$^{(F)}$, 282$^{(F)}$, 291$^{(F)}$, 292$^{(F)}$, 301$^{(F)}$, 302$^{(F)}$, 303$^{(F)}$, 311$^{(F)}$, 312$^{(F)}$, 320$^{(F)}$, 330$^{(F)}$
Luxembourg	350$^{(M)}$
Netherlands	360
Portugal	630$^{(F)}$,
Spain	515$^{(F)}$, 520$^{(F)}$, 525$^{(F)}$, 530, 535$^{(F)}$, 545, 550$^{(F)}$, 555$^{(F)}$, 560$^{(F)}$, 570, 575,
Sweden	710
United Kingdom	411, 412, 413, 431
	New regions
Czech Republic	745
Cyprus	740$^{(F)}$
Estonia	755$^{(F)}$
Hungary	760$^{(F)}$, 761$^{(F)}$, 762$^{(F)}$, 763$^{(F)}$, 764$^{(F)}$, 765$^{(F)}$, 766$^{(F)}$
Latvia	770
Lithuania	775
Malta	780$^{(F)}$
Poland	785, 790, 795, 800
Slovakia	810, 820$^{(M)}$,

(F) The region represented only by field crop farms
(M) The region represented only by mixed farms

Indexes of efficiency change were estimated separately for each of the two types of farming using output-oriented, single-output, and multi-input DEA. As the output variable we used the sum of values of plant and animal production as well as those resulting from the other forms of agricultural production activities, except for income from any type of subsidies. This variable in the FADN nomenclature is referred to as total output (marked by SE131). Production factors (inputs) were assumed to include labor (SE011), expressed in the number of man-hours, i.e. work units (AWU), land (SE025), i.e. total utilized agricultural area (UAA), expressed in hectares, the consumption of fixed assets, referred to as depreciation (SE360), as well as working capital, determined as the difference between the total value of inputs (SE 270) and total wages (SE370) and fixed capital costs (SE360).

Due to the value-oriented character of variables referring to the volume of production and the values of involved fixed and working capitals, values of these variables were corrected by the price index, i.e. they were expressed in fixed prices from the year 2000 taking into consideration annual national inflation indexes in relation to individual inputs. This conversion makes it possible to treat the above mentioned variables as synthetic aggregates for the volume of production and the amount of fixed and working capitals, respectively.

It should be noted that the analyzed regions vary in area. For example, Poland is divided into four regions and France, being almost two times bigger, is divided into 22 regions. This means that the numbers of farms, on the basis of which average farms were identified, were not uniform. This does not change the fact that averaging, leading to the units assumed in this study, reduces the effect of erroneous observations and outliers. Moreover, regions vary in terms of their geographical location, which significantly affects climatic and agronomic conditions. We may mention here regions of southern Spain or Greece and at the same time regions of northern Germany. As a consequence, we may expect high variation in values of analyzed economic indexes. This variation, in view of the above mentioned variables, is reflected in the basic characteristics averaged in relation to years and economic size of analyzed units, which are presented in Table 2.

A comparison of relative values presented in Table 2 indicates that in field crop farms on average the ratios of land to labor and capital to labor from both groups of the “old” and “new” regions were comparable, whereas the ratios of working capital to land and to labor in the “new” regions were higher from 35% to 40% than in the analogous farms from the “old” regions. These differences resulted in higher productivity of labor and land of farms from the “new” regions.

In case of mixed farms the disproportions between farms from the “old” and “new” regions are much bigger. The biggest differences were related to the level of fixed and current production factors. In farms from the “old” regions such a ratio of capital to labor, as well as that of working capital to labor, were six times higher than for farms from the “new” regions. In view of the above it is not surprising that productivity of land in farms from the “old” regions was two times higher and productivity of labor was even five times higher than in farms from the “new” regions.

Table 2. Basic descriptive statistics of farms

Variables	EU-15 regions				New regions			
	Mean	Standard deviation	Min	Max	Mean	Standard deviation	Min	Max
				Field crop farms				
Total output (€ 1000)	119,98	181,48	5,30	1792,26	200,65	282,95	7,57	1387,68
Labor (100 AWU)	40,67	35,60	7,28	294,12	96,44	154,40	5,70	867,48
Land (ha)	93,46	129,02	3,10	924,19	210,86	336,45	2,24	1482,90
Working capital (€ 1000)	87,22	144,70	2,34	1522,54	154,75	236,68	3,70	1186,22
Capital (€ 1000)	17,65	22,28	0,03	173,10	28,43	39,42	1,20	314,55
Output/Labor	4,03	5,71	0,04	49,81	5,66	9,52	0,01	53,90
Output/Land	5,08	10,16	0,01	95,73	7,78	18,06	0,01	207,19
Land/Labor	2,18	1,69	0,10	8,51	1,95	1,25	0,09	6,32
Working capital/Labor	2,86	4,11	0,02	28,16	4,37	8,05	0,00	44,15
Capital/Labor	0,62	0,84	0,00	8,38	0,77	1,20	0,00	6,24
Working capital/Land	3,70	7,45	0,01	66,19	6,12	15,66	0,00	181,09
				Mixed farms				
Total output (€ 1000)	278,14	412,81	13,97	2902,37	171,64	416,20	4,50	1920,89
Labor (100 AWU)	63,43	104,07	11,43	774,24	134,95	287,51	23,81	1639,37
Land (ha)	154,70	231,06	2,92	1523,51	173,10	401,17	5,35	1856,07
Working capital (€ 1000)	226,66	333,68	4,99	2218,06	136,74	346,62	3,03	1795,70
Capital (€ 1000)	41,08	55,13	0,79	395,11	24,25	71,67	0,70	608,92
Output/Labor	4,44	2,40	0,39	15,19	0,83	0,56	0,17	6,96
Output/Land	2,09	1,32	0,34	10,65	0,98	0,43	0,23	3,76
Land/Labor	2,54	1,30	0,08	6,63	0,94	0,63	0,18	2,99
Working capital/Labor	3,67	2,16	0,14	17,20	0,61	0,43	0,11	5,38
Capital/Labor	0,72	0,45	0,02	1,98	0,13	0,08	0,02	0,85
Working capital/Land	1,63	1,01	0,20	8,87	0,70	0,31	0,19	2,91

It is also of interest to compare farms in terms of the form of production they run. In the EU-15 regions productivity of labor in mixed farms was slightly higher than in field crop farms, whereas productivity of land and the ratio of working capital to land in field crop farms were at least two times as high as in mixed farms. In turn, the ratio of working capital to labor in mixed farms was 20% higher than in farms specializing in field crops.

In turn, in field crop farms from the “new” regions productivity of labor and of land as well the provision of fixed and working capital to labor and to land were approx. seven to eight times grater than in mixed farms. This confirms a rather obvious statement that in field crop farms it is easer to achieve higher productivity of land and that it is not possible to achieve satisfying results without an adequate supply of fixed and current production factors.

Since the class of the smallest economic units turned out to be represented by very limited numbers of farms both in case of field crop and mixed farms, in further considerations the class of the smallest farms was included in the class of small farms, thus forming the class of 0-8 ESU. As it turned out, these economically smallest farms are represented, except for one Greek region, by Polish regions. In view of earlier investigations, presented in particular in a study by Latruffe, Balcombe, Davidova and Zawalinska (2005) it is not surprising, since small and very small farms in terms of their area predominate in Polish agriculture, especially because of the farmers' pension scheme in Poland.

Main findings

The basic index determined here is the Malmquist index, which value greater that one indicates an improvement of TFP. The components of the Malmquist index, i.e. indexes of pure technical efficiency change, scale efficiency change and technical change, are of equal interest. Average values of these indexes from the years 2004 - 2009 for field crop and mixed farms are presented in Tables 3 and 4, respectively. Additionally, standard deviations and sample sizes were given along with the results of testing for hypotheses on equality to one the values of analyzed indexes. Testing was performed using the analysis of variance (ANOVA) under the standard assumption of normality of distribution. Although the assumption may be doubtful, standard deviation is involved in such a procedure irrespective of the type of distribution, which improves objectivity of the comparison.

Indexes of efficiency change in relation to the best practice technology for field crop farms from the “old” EU regions are close to one, except for the biggest farms where 6% decrease was observed. In “new” regions, the pure technical efficiency change was less then one for farms of all sizes. The biggest decrease was found for very large and the biggest farms (on average by 7% and 8%, respectively) and for the others the decrease fluctuated from 2% to 5%. In case of mixed farms of the “old” regions the indexes of the pure efficiency change are close to one for farms of all economic sizes. For farms from the “new” regions the pattern is not so uniform. For farms economically small an increase (on average 2%) was observed, while for large and very large farms, just opposite, a decrease of 3% and 5%, respectively, was found. This suggests a conclusion that accession to the EU generally did not contribute to an improvement of efficiency. However, the mixed farms, running diverse production and reducing economic risk, performed slightly better than those specializing in fied production.

Indexes of scale efficiency change for most classes of farms did not differ from one, which suggests that in the analyzed period on average no progress was found in terms of an improvement of productivity. The only exception in this respect is a decrease (on average by 2%) for large field crop farms from the EU-15 regions.

The biggest changes were observed in relation to the technical change index. For all field crop and mixed farms from the EU-15 regions, except for the small farms running a mixed production, the indexes of technical change were considerably bigger than one (from 3% to 9% for field crop farms and from 2% to 4% for mixed farms), which means a marked improvement in technology. For almost all farms from the “new” EU regions the estimates of these indexes turned out to be bigger than one, but the increases ranged from 2% to 8%. It also needs to be stressed here that the biggest improvement was noted for field crop farms representing the economically large units from the “old” EU regions. In turn, among mixed farms the biggest improvement (on average by 4%) was observed for very large farms from the “new” regions.

Table 3. Indexes of change for field crop farms

Size (ESU)	EU-15 regions			New regions		
	Mean	Standard deviation	Sample size	Mean	Standard deviation	Sample size
			Pure technical efficiency change			
0-8	1.01	0.026	80	0.98	0.026	85
8-16	1.00	0.018	165	0.98	0.026	85
16-40	0.99	0.015	250	0.95*	0.025	90
40-100	1.01	0.013	315	0.93*	0.026	85
100<…	0.94*	0.015	245	0.92*	0.034	50
			Scale efficiency change			
0-8	0.97	0.015	80	0.99	0.015	85
8-16	0.99	0.010	165	0.99	0.015	85
16-40	0.98*	0.008	250	1.01	0.014	90
40-100	1.01	0.008	315	1.02	0.015	85
100<…	1.01	0.009	245	1.02	0.019	50
			Technical change			
0-8	1.03	0.016	80	1.03	0.016	85
8-16	1.03*	0.011	165	1.08*	0.016	85
16-40	1.09*	0.009	250	1.06*	0.015	90
40-100	1.04*	0.008	315	1.06*	0.016	85
100<…	1.04*	0.009	245	1.05*	0.021	50
			Malmquist productivity index			
0-8	0.98	0.026	80	0.99	0.025	85
8-16	1.00	0.018	165	1.03	0.025	85
16-40	1.02	0.015	250	0.99	0.024	90
40-100	1.04*	0.013	315	0.98	0.025	85
100<…	0.97	0.015	245	0.96	0.033	50

* The estimated parameter differs significantly from one. $\alpha = 0.05$

As a conclusion we may state that on average field crop farms from the “new” regions introduced technological progress in a similar intensity as analogous farms of the “old” regions. The same can be stated about mixed farms, however, the field crop farms, in general, absorbed new technical, technological and organizational solutions faster than those running mixed production.

The presented changes in the composite indexes determined the Malmquist total factor productivity index. This index for field crops farms from the EU-15 regions turned out to be markedly bigger than one only for large and very large units (on average by 25 and 4%, respectively). For the other farms estimates of this index were close to or less than one. However, the Malmquist indexes for farms from “new” regions, in majority, appeared to be less than one, while those for farms from “old” regions were found as larger than one.

Rather disheartening conclusions arise from the presented evaluations of the Malmquist index, especially for farms running mixed production. In those representing the EU-15 regions, except the economically smaller farms, it was observed the annual growth of total productivity index (on average by 1 - 3%), while in farms from the “new” regions, except the economically biggest farms, the total productivity index has dropped (generally a decrease of approx. 1 - 3%).

Table 4. Indexes of change for mixed farms

Size	EU-15 regions	New regions

(ESU)	Mean	Standard deviation	Sample size	Mean	Standard deviation	Sample size
Pure technical efficiency change						
0-8	1.00	0.043	5	1.02*	0.019	70
8-16	1.01	0.022	50	0.99	0.023	40
16-40	0.99	0.010	90	0.97*	0.021	40
40-100	0.99	0.008	160	0.95*	0.023	20
100<…	0.99	0.008	160	1.00	0.027	20
Scale efficiency change						
0-8	1.00	0.029	5	1.00	0.008	70
8-16	0.99	0.014	50	1.00	0.010	40
16-40	1.00	0.007	90	1.00	0.010	40
40-100	1.00	0.005	160	0.99	0.014	20
100<…	0.99	0.005	160	0.98	0.014	20
Technical change						
0-8	0.98	0.033	5	0.98*	0.009	70
8-16	1.02	0.017	50	1.00	0.012	40
16-40	1.03*	0.008	90	1.02*	0.012	40
40-100	1.03*	0.006	160	1.04*	0.017	20
100<…	1.03*	0.006	160	1.03*	0.017	20
Malmquist productivity index						
0-8	0.97	0.045	5	0.98	0.012	70
8-16	1.03	0.023	50	0.99	0.016	40
16-40	1.01	0.011	90	0.99	0.016	40
40-100	1.01	0.008	160	0.97	0.023	20
100<…	1.01	0.008	160	1.00	0.023	20

* The estimated parameter differs significantly from one. $\alpha = 0.05$

Thus, if in farms from the “old” regions we may talk of slight progress in total productivity of inputs, in farms from the “new” regions a decrease was observed for this index. The observed discrepancies in the Malmquist indexes could have been caused by the different directions of modernization taking place in the agriculture of the “old” and “new” member states. In farms from “new” regions the modernization is connected first of all with investments which scope is not the same in small and large units and which can cause an improvement of the productivity index in longer time.

Conclusions

In this study an analysis was conducted for economic results of average farms representing individual regions of the EU in the years 2004-2009. The analysis was made based on data available in the FADN system and concerned farms of different economic sizes and two types of farming, i.e. those specializing in field crops and running mixed production. In these investigations four basic inputs were included, i.e. labor (AWU), utilized agricultural area (UAA) and the consumption of both fixed and working capital. In view of the enlargement of the EU in 2004, the regions were divided into two groups. One group, EU-15, comprised regions, which were parts of the EU before 2004, referred to as the “old” regions, while the other group included the “new” regions, incorporated in the EU in 2004.

The main objective of the analysis was to find an answer to the question whether bigger specialization and a higher class of economic size of farms contribute to an improvement in productivity at the same rate for farms from the “new” and “old” EU member states. Specialist farms, represented here by field crop farms, were compared with mixed farms. Such a hypothesis included several more basic issues. The first is connected with the determination whether the Malmquist total factor productivity increases with an increase in the economic size of farms independently of their time of stay in frames of the EU. The other parallel questions concern the specific components of the total factor productivity. These questions, referred to both field crop farms and mixed farms, constituted a key for a determination of the rate of change throughout the entire period of analysis.

The indexes of change were estimated using output oriented DEA by determining the primary components of the Malmquist TFP, i.e. indexes of pure technical efficiency change, scale efficiency change and technical change.

It turned out that in the analyzed period for farms from the “old” regions the total factor productivity, in general, increased with an increase in the economic size of farms. The exception is the class of biggest crop field farms, where a decrease (on average by 3%) was observed. This decrease in the TFP was caused by drop in pure efficiency change (on average by 4%).

In farms from the “new” regions, just the opposite, the increase in the size of farms caused a decrease of productivity, with except for field crop farms of medium size, where an increase by 3% was noted. This increase as well as the increases of the TFP in farms from the EU-15 regions resulted from high and very high increases in technical efficiency change in farms of almost all classes of economic size.

It turned out that the biggest changes in the analyzed period were observed in relation to the technology of production, with an average rate of change being biggest in economically larger farms specializing in field crops. The rate of change in terms of scale efficiency was mach smaller, while for field crop farms, particularly of small and large economic sizes, the indexes were even observed to deteriorate markedly.

The observed discrepancies in the Malmquist indexes and its components could have been caused by the modernization taking place in the agriculture of the “new” member states, connected first of all with investments in technology, which scope is not identical in small and large units as well as in crop field and mixed farms. Since in agriculture it typically takes several years to see the economic effects of such actions, in farms from the “new” regions we may hardly expect a growth rate for total productivity already in the first years after the accession to the European Union.

In order to focus on differences in the types of farming the further part of the remarks will be limited to conclusions based on values averaged in relation to farm size. These results are presented in Figs. 1 and 2.

The obtained estimates first of all indicate that the pure technical efficiency (pech) was less than one for farms of both types from the “old” and “new” regions. For mixed farms and crop field farms from the EU-15 regions this reduction of efficiency was approx. equal to 1% on average, but for field crop farms from “new” regions this reduction was markedly bigger, amounting to as much as 4% on average. In turn, indexes of scale efficiency change (sech) indicate a deterioration of scale by 1% for field crop farms from the “old” regions and a lack of scale improvement for the other farms. In a case of technical change (techch) the highest rate of increase (on average by 5%) was obtained for field crop farms from the “old” and “new” regions. For mixed farms the highest growth rate for technical change (on average by 3%) was found for farms from the “old” regions, while for farms from “new” regions this increase amounted only 1% on average. As a result the Malmquist index (tfp) for the farms from the “old” regions indicated an improvement of total productivity (on average approx. 1%) for farms of both types, i.e. those specializing in field crops and those running mixed production. For farms from the “new” regions, just the opposite, the inferior results were recorded. For both types of farms the total factor productivity decreased on average by 1%.

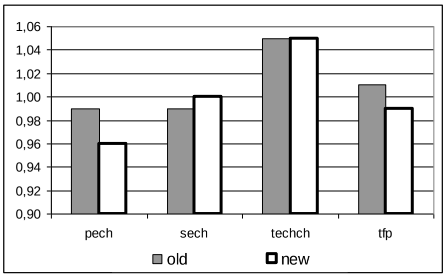

Figure 1. Mean indexes of change for field crop farms.

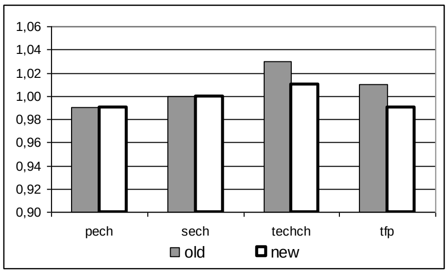

Figure 2. Mean indexes of change for mixed farms.

Based on the evaluations of pure technical efficiency change it may be stated that if in the units from the “old” regions typically we could observe a slight regression, then in mixed farms from the “new” regions a much bigger decreases was found. It is difficult to determine precisely the causes of the observed difference, since it may be connected both with management or organization of production process as well as it may result from the more difficult agricultural or weather conditions.

The biggest improvement was observed in the technical and technological aspects, to a more significant degree found in case of specialist farms than those running mixed production. In the latter type those from the “old” EU regions improve technology by much bigger rate than farms from the “new” regions. This confirm the assumption that specialist farms, represented here by field crop farms, more effectively adopted new technological and technical solutions than those running mixed production ensuring lower risk level.

Finally, basing on the Malmquist index we may state that although it is close to one for farms from both the “old” and “new” regions, still for farms from the “old” regions the TFP is bigger than one, while for farms from the “new” regions, it is smaller than one. Thus, if in farms from the “old” regions we observed a progress in total productivity of inputs, in farms from the “new” regions we found a decrease for this index.

These conclusions, formulated for average farms and in relation to the specific period after the enlargement of the EU, obviously do not mean that there were no economic farms operating more efficiently. However, a question arises whether the current stimulating mechanisms in the EU are sufficient to lead at a further perspective to the uniformity of productivity in the EU agriculture.

Acknowledgments

This paper was supported by Funds for Sciences 2008-2011 under grant # N N111 114034. The authors are very grateful to the anonymous referee for his useful comments.

References

Aigner D J, Chu S F (1968) On estimating the industry production function. American Economic Review, 58, 226-239.

Afriat S (1972) Efficiency estimation of production function. International Economic Review, 13(3), 568-598.

Charnes A, Cooper W W, Rhodes E (1978) Measuring the efficiency of decision making units. European Journal of Operational Research, 2, 429-444.

Coelli T J, Rao D S P, O'Donnell C J, Battese G E (2005) An Introduction to Efficiency and Productivity Analysis. Second Eds. Springer Science+Business Media, New York.

Debreu G (1951) The coefficient of resource utilization. Econometrica 19, 14-22.

Farrell M J (1957) The measurement of productive efficiency of production. Journal of the Royal Statistical Society. Series A, 120(III), 253-281.

Färe R, Grosskopf S, Margaritis D (2008) Efficiency and productivity: Malmquist and more. In: The Measurement of Productive Efficiency and Productive Growth. Fried H., Lovell K, Schmidt S (eds.), Oxford University Press, Oxford, New York.

Førsund F R, Sarafoglou N (2002) On the origins of data envelopment analysis. Journal of Productivity Analysis, 17, 23-40.

Gorton M, Davidova S (2004) Farm productivity and efficiency in the CEE applicant countries: a synthesis of result? Agricultural Economics, 30, 1-16.

Koopmans T C (1951) An analysis of production as an efficient combination of activities. In: Activity Analysis of Production and Allocation. Koopmans T C (ed.), Cowles Commission for Research in Economics Monograph, No. 13, Wiley, New York.

Latruffe L, Balcombe K, Davidova S, Zawalinska K (2005) Technical and scale efficiency of crop and livestock farms in Poland: does specialization matter? Agricultural Economics, 32, 281-296.

Thanassoulis E, Portela M, Despić O (2008) Data envelopment analysis: the mathematical programming approach to efficiency analysis. In: The Measurement of Productive Efficiency and Productive Growth. Fried H, Lovell K, Schmidt S (eds.), Oxford University Press, Oxford, New York.

Timmer P (1971) Using a probabilistic frontier production function to measure technical efficiency. Journal of Political Economy, 79, 776-794.