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LABOUR FORCE AS A FACTOR IMPROVING EFFICIENCY OF AGRICULTURAL ECONOMIC ACTIVITY IN THE EU

The study comprises an analysis of technical efficiency of EU agriculture at the regional level. Investigations were based on data concerning average farms representing individual regions of the European Union, retrieved from the FADN system. These entities covered crop farms and dairy farms. Efficiency of individual entities was assessed using the Data Envelopment Analysis (DEA). Results were compared to the basic unidimensional economic indexes of individual entities taking into consideration also different operation periods of the regions within the EU. Productivity of labour turned out to be the decisive factor in determining the level of farm efficiency. Conducted analyses may constitute a starting point for the evaluation of proposed reforms in the Common Agricultural Policy in the new financial perspective.

Keywords: *productivity of labour, productivity of capital, technical efficiency, DEA.*

The goal to be attained by every commercial enterprise active in economic space is to maximise profits. The necessary pre-condition for such an objective is to run the production process so that it is technically efficient. Such a result may in turn be achieved by maximising the volume of production at an assumed consumption of outlays or by minimising the consumption of outlays while maintaining a specific level of production. The activity of an entrepreneur following either of the principles is considered economical, while reaching high technical efficiency is required in all sectors of economy.

The same economic principles are also binding for production enterprises in the agricultural sector. However, due to its specific character, agricultural production is dependent not only on the obvious outlays, such as labour or capital, but also on climatic and atmospheric factors; moreover, it is strongly influenced by social factors. In agriculture we may also

find protectionist practices. In the European Union they are implemented by governments of individual member countries, but also by the entire European Union. Within the framework of the Common Agricultural Policy different other initiatives are also undertaken, concerning such issues as the level of employment, environmental protection or changing profitability of farms, which also influence the efficiency of agricultural production.

Economic analyses concerning the efficiency of agricultural production are based on the investigation of productivity in basic production factors, i.e. labour, land and capital[1]. The historical analysis of integration processes indicates that in the period of transformation and in the first years of full membership of the new EU countries, the agricultural sector was subjected to intensive changes both in relation to the level of involvement and to the productivity of individual production factors[2]. Studies conducted by other economists[3] also indicate that the variation in productivity of agricultural production is influenced by such factors as geographical location or agrometeorological conditions[4], level of technological development,[5] effectiveness of functioning of legal systems[6], or cooperation in border areas[7].

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[1] Macours Karen, Swinnen Johan F.M., *Impact of Initial Conditions and Reform Policies on Agricultural Performance in Central and Eastern Europe, the Former Soviet Union and East Asia*, American Journal of Agricultural Economics, 82/2000, pp. 1149-1155.

[2] cf. e.g. Poczta Walenty, *Rolnictwo polskie a rolnictwo EWG. Studium komparatywne*, Roczniki Akademii Rolniczej w Poznaniu, 247, Poznań 1994; Czyżewski Andrzej, Henisz-Matuszczak Anna, *Rolnictwo Unii Europejskiej i Polski, Studium porównawcze struktur wytwórczych i regulatorów rynków rolnych*, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań 2004, 54-60.

[3] cf. Hayami Yujiro, Ruttan Vernon W., *Agricultural Productivity Differences among Countries*, American Economic Review, 60/1970, pp. 895-911; Kawagoe Toshihiko, Hayami Yujiro, *An intercountry comparison of agricultural production efficiency*, American Journal of Agricultural Economics, 67/1985, pp. 87-92.

[4] Hayami Yujiro, Development *Economics: from the Poverty of the Wealth of Nations*, Oxford University Press, Oxford 1997, p. 83.; Gallup John L., Sachs Jeffrey D., *Agriculture, Climate, And Technology: Why Are The Tropics Falling Behind*, American Journal of Agricultural Economics 82/2000, pp. 731-738.

[5] Kawagoe Toshihiko, Otsuka Keijiro, Hayami Yujiro, *Induced Bias of Technical Change in Agriculture: The United States and Japan*, 1880–1980. Journal of Political Economy, 94/1986, pp. 523-544.

[6] Barro Robert J., *Economic Growth in a Cross Section Countries*, Quarterly Journal of Economics, 106/1991, pp. 407-443.

[7] Resmini Laura, *The Implications of European Integration and Adjustment for Border Regions in Accession Countries*, in: Traistaru Iulia, Nijkamp Peter, and Resmini Laura, (ed.), *Emerging Economic Geography in EU Accession Countries*, UK: Ashgate 2003, pp. 405 – -441.; Coelli Timothy J., Parelman Sergio, Van Lierde Dirk, *CAP Reforms and Total Factor*

Findeis[8] and Blanc et al.[9] stressed the importance of employment structure in the level of efficiency obtained by farms. Macours and Swinnen[10] as well as Gutierrez[11] also emphasized the effect of such factors as liberalisation of prices, changes in the subsidy system, the organisational form of farms, diversity in the capital potential or even factors connected with the efficiency of operation of the health care system.

In case of agriculture the economic size of farms and their specialisation have a considerable effect on technical efficiency[12]. The former of these economic indexes to a considerable degree determines decisions made in respect to the involvement of production factors or the utilisation of by-products from agricultural activity. In turn, the type of farm or its specialisation determines the level of utilisation for primary production factors. For this reason we may talk about more labour-intensive production types, such as milk production, or more land-consuming, such as crop production. From this point of view in certain types of agricultural production even a high employment level is not always a negative phenomenon. The criterion of evaluation should in this case be based on the volume of production, guaranteeing a satisfactory level of income obtained by farmers, rather than on the evaluation of the level of involvement for individual outlays.

In the European Union the integration process covered first of all the flow of goods and capital. Moreover, barriers connected with the flow of labour force, particularly those concerning economic migration, were

Productivity Growth in Belgium Agriculture: A Malmquist Index Approach, Contributed Paper: International Association of Agricultural Economics - 2006, pp. 1-20.

[8] Findeis Jill L., *Hired Farm Labour Adjustment and Constrains*, in: Findeis Jill L., Vandeman Ann, Larson Janelle, and Runyan Jack (ed.), *The Dynamic of Hired Farm Labour Constraints and Community Response*, Washington DC 2002, pp. 3-15.

[9] Blanc Michel, Cahuzac Eric, Elyakime Bernard, Tahar Gabriel, *Why Family Farms are Increasingly Using Wage Labour?*, Contributed paper: European Association of Agricultural Economics 11th Congress – 2005, Copenhagen: EAAE.

[10] Macours Karen, Swinnen Johan F.M., *Impact of Initial Conditions and Reform Policies on Agricultural Performance in Central and Eastern Europe, the Former Soviet Union and East Asia*, American Journal of Agricultural Economics, 82/2000, pp. 1149-1155; Macours Karen, Swinnen Johan F.M., *Agricultural Labour Adjustments in Transition Countries: The role of Migration and Poverty*, Review of Agricultural Economy 27/2005, pp. 405-415.

[11] Gutierrez Luciano, *Why is agricultural labour productivity higher in some countries than others?* Agriculture Economics Review, 3/2002, pp. 58-72.

[12] cf. e.g. Coelli Timothy J., Parelman Sergio, Van Lierde Dirk, *CAP Reforms and Total Factor Productivity Growth in Belgium Agriculture: A Malmquist Index Approach*, Contributed Paper: International Association of Agricultural Economics - 2006, pp. 1-20.

eliminated[13]. It needs to be stressed here that in view of reforms resulting from the Common Agricultural Policy, elimination of differences in the aspect of capital in agriculture is relatively simple and may lead to expected results attained within a relatively short time. This is facilitated by the appropriately formulated and directed subsidies to investments in fixed capital of farms in individual member states. The elimination of differences in respect to labour is a much more complicated phenomenon. These changes frequently require an improvement of personnel qualifications or are related with the necessity of their retraining. This is often connected with the need for the employees to relocate. As a consequence we may hardly talk of simple quantitative transfers of workers from one branch of economy to another or from one location to the next. Social changes usually take more time (we refer to generation changes); they require more financial outlays, cause strong social tensions and their effects are much more difficult to foresee. Such a long-term perspective along with the above mentioned limitations as a result hinder a simple definition of reforms themselves, which generally are to create the broadly understood human capital.

In view of the expected, next stage of the economic crisis and the actions undertaken to rationalize outlays on individual EU programs a question may be asked, to what extent labour force influences the efficiency of farms, and whether this is a decisive factor, or whether greater importance may be attributed to capital factors. Finally we may ask a question whether cuts to be implemented within the next budget perspective in the European Union, concerning strengthening of the human capital, are economically justified. The complex character of agricultural activity also leads to questions concerning the importance of labour in relation to individual types of agricultural production.

An answer to the above mentioned questions may be supplied by an analysis of productivity for basic outlays and technical efficiency of agricultural production in selected sectors of agriculture taking into consideration particularly the human capital. In this study such an analysis was based on data coming from the Farm Accounting Data Network (FADN) system from the year 2006, i.e. the period following a 2-year functioning of the European Union as an organisation of 27 states. Investigations were conducted on the regional level in relation to two types of production, i.e. crop farms and dairy farms.

[13] Niebuhr Annekatrin. and Stiller Silvia, *Integration and Labour Markets in European Border Regions*, HWWA Discussion Paper 284/2004, Hamburg Institute of International Economics, Hamburg: HWWA 2004.

METHODOLOGY

The answer to the above mentioned questions will be based on a standard economic analysis of productivity for basic outlays supplemented with an estimation of technical efficiency for each of the agricultural regions included in this study, both in relation to crop production and milk production. Technical efficiency is defined[14] as a ratio of the volume of production obtained at specific outlays and the specific technology to maximum volume of production, which may be obtained under comparable conditions. Such understood efficiency may be assessed directly by the mutual comparisons of production results obtained by a group of producers applying the so-called Data Envelopment Analysis (DEA), or indirectly by an estimation using regression methods, the so-called frontier production function, which specifies the maximum potential level of production under given conditions. The former approach is one of the so-called non-parametric methods, while the latter, due to the presence of parameters in the frontier production function, is included in the group of the so-called parametric methods. This study was based on DEA at the assumed variable return to scale, i.e. DEA-VRS (see e.g.: Coelli, Parelman, Van Lierde, 2006), which does not require the determination of the form of production function.

DATA

Analyses were conducted based on statistical data supplied by the European FADN system collecting accounting data from farms. Due to the high number of details and reliability of this system, it is frequently used in such studies (see e.g.: Coelli et al. 2006). The FADN system covers first of all the biggest commercial farms, which jointly produce in a given region or country at least 90% Standard Gross Margin (SGM). This value is defined as an excess of the value of production in a specific agricultural activity over the value of direct costs, which are incurred under average (for a given region) production conditions[15]. The total value of stand-

[14] see e.g. Greene William, *A stochastic frontier model with correction for sample selection*, Journal of Productivity Analysis, 34(1)/2010, pp. 15-24.

[15] *Definitions of Variables used in FADN standard results*, Community Committee for the Farm Accountancy Data Network (FADN),European Commission, Directorate-General for Agricultural and Rural Development, Brussels 2006.

ard gross margins in individual types of agricultural activity constitutes the basis for the determination of the economic size of each farm, which is expressed in European Size Units (ESU), with one ESU corresponding to the value of € 1200. In turn, the dominant values of gross margins in individual types of agricultural activity make it possible to classify each farm to a specific type of production.

The FADN system makes available data on farms at various levels of aggregation. Data from the regional level were used in this study. This means that the objects of analysis comprised average, in relation of individual regions of the European Union, crop farms (the first type of farms) and dairy farms (the second type). Analysis was conducted for all regions, which in 2006 were represented by the two above mentioned types of farms. Crop farms were found in 109 regions representing 24 EU member states, while dairy farms were found in 90 regions representing 23 EU countries.

In the conducted investigations a result of economic activity was assumed to be the value of agricultural production (in the FADN methodology this variable is denoted as SE131), expressed in current prices [in € 1000]. It needs to be stressed here that the value of attained production does not include subventions or subsidies collected by farmers. The volume of outlays for basic production factors was also determined according to the FADN methodology. Land, i.e. the utilised agricultural area (SE025), expressed in hectares [ha of UAA], and labour (SE011) was expressed in the number of man-hours [h], while capital [in € 1000] was expressed as the difference between the total value of outlays (SE270) and the value of wages (SE360).

Tables 1 and 2 list the basic characteristics of economic entities participating in the study, but averaged in relation to the national affiliation of regions. Table 1 supplies characteristics of crop farms, while table 2 does this for dairy farms. The EU member states were ordered in terms of their year of accession. As a result all regions/countries are divided into three groups. The first comprises regions with the longest EU membership periods (accession years 1957 - 1973), the second group consists of countries with a medium-length membership (accession years 1981 - 1995), while the third group comprises countries with the shortest membership (accession year 2004).

Standard economic analyses focus on selected physical indexes, such as utilised agricultural area, or the level of employment, and on financial indexes, such as the value of produced annual agricultural production or the

value of a gross margin generated in a given year. In the case of crop production an average farm operating in 2006 within the European Union ran production over an area of 85.25 ha UAA. A similar area, i.e. 85.84 ha UAA, was occupied by dairy farms. Average productivity of capital measured by the ratio of the value of production to the value of capital was also similar. It amounted to 1.28 for crop production and 1.21 for milk producers. In turn, the other characteristics were different. The average economic size of dairy farms was almost 1/4 greater than the economic size of crop farms, while the value of milk production and outlays on labour were greater by over 1/3 than the analogous values for crop production. These figures confirm higher labour consumption of milk production, which - it should be stressed here - is accompanied by a greater productivity of labour.

When comparing indexes contained in Table 1 in terms of the year of accession to the EU it may be stated that crop farms in regions with the longest membership period in the EU in 2006 were on average the greatest in terms of UAA and economic size, and they generated the highest value of production at the greatest volume of engaged capital. Moreover, in regions from that group, except for Italian regions, also the highest productivity of labour was recorded. In turn, farms from regions with the shortest EU membership on average obtained the lowest productivity for all the three basic outlays. The very high variation in the size of analysed entities also needs to be indicated here. Average Czech and Slovak farms were very large both in terms of their UAA and economic size, while farms in Malta were very small, as on average their area was slightly over 4 ha UAA, but it was at the simultaneous highest productivity of land and capital.

Indexes listed in Table 2 do not provide such evident conclusions as it was the case with crop production. Such a situation is obviously influenced, to a much greater extent than in case of crop production, by the spectrum of available technologies in milk production. However, it may be observed here that in the group of regions with the longest EU membership period on average economically strong farms predominated. Only Irish, Italian and French farms generated direct gross margins below 80 ESU. Moreover, in farms from that group of regions the highest average productivity of labour was recorded, amounting to 39.12 €/h, and this despite the low value of this index in the regions of Belgium, Italy and Ireland. At the same time in the regions of countries which accessed the EU in the years 1981 - 1995 the average productivity of labour was only 29.02 €/h, while in the group of countries, which joined the EU in 2004, it was only 9.78 €/h.

Table 1. Basic average economic characteristics of crop farms (2006)

	Year of accession	Number of regions	Value of-Production	Economic size	Basic outlays			Productivity of		
					land	labour	capital	land	labour	capital
			[1000 €]	[ESU]	[ha UAA]	[h]	[1000 €]	[€/1ha UAA]	[€/1 h]	[€/1€]
Germany	1957	12	300.92	163.20	250.64	7686.91	296.60	1523.41	39.46	1.07
Holland	1957	1	230.21	96.00	55.23	3849.96	176.31	4168.19	59.80	1.31
France	1957	20	118.16	82.86	101.69	2721.73	116.60	1264.42	43.67	1.01
Belgium	1957	2	127.11	79.80	55.74	3310.40	94.98	2395.62	38.52	1.34
Italy	1957	19	35.47	25.23	20.44	2726.00	23.62	2212.64	12.96	1.63
Great Britain	1973	5	205.15	104.24	146.07	4504.75	182.22	1548.32	45.09	1.14
Denmark	1973	1	133.19	55.90	68.67	1842.17	129.27	1939.55	72.30	1.03
Ireland	1973	1	59.33	32.80	50.59	1701.40	50.53	1172.68	34.87	1.17
	mean	**61**	**136.90**	**81.32**	**105.67**	**3852.60**	**127.82**	**1728.24**	**33.81**	**1.24**
Greece	1981	4	16.51	11.73	9.68	2679.34	11.94	1947.53	6.31	1.52
Spain	1986	13	34.88	25.26	45.31	2425.01	21.58	1004.97	14.30	1.86
Portugal	1986	5	23.37	13.60	23.41	3198.32	17.81	2222.80	6.42	1.52
Sweden	1995	2	126.59	54.80	128.82	2731.17	145.75	970.64	46.21	0.86
Austria	1995	1	61.31	34.90	49.13	2663.62	58.52	1247.87	23.02	1.05
Finland	1995	4	33.80	22.30	56.72	1294.52	56.83	586.81	25.76	0.58
	mean	**29**	**37.45**	**23.34**	**44.08**	**2466.80**	**34.30**	**1293.28**	**15.92**	**1.48**

Czech Republic	2004	1	240.20	112.40
Slovakia	2004	1	225.32	86.40
Hungary	2004	7	52.64	24.57
Malta	2004	1	22.85	20.30
Latvia	2004	1	35.92	17.20
Cyprus	2004	1	19.63	17.00
Estonia	2004	1	33.66	16.50
Lithuania	2004	1	23.71	15.10
Poland	2004	4	23.61	10.13
Slovenia	2004	1	10.68	5.80
	mean	**19**	**56.57**	**26.48**
	total	**109**	**96.44**	**56.34**

Source: Own preparation

248.46	14866.89	223.02	966.74	16.16	1.08
358.58	17576.14	277.36	628.36	12.82	0.81
80.16	3723.91	51.43	649.78	13.86	1.03
4.12	4122.86	13.21	5545.15	5.54	1.73
87.69	4761.05	36.77	409.60	7.54	0.98
13.34	2665.52	16.23	1471.36	7.36	1.21
111.19	4092.66	34.06	302.73	8.22	0.99
69.91	3851.86	23.98	339.08	6.15	0.99
25.98	3997.90	18.40	1042.23	5.84	1.34
8.84	3364.42	12.56	1208.14	3.17	0.85
82.48	**5124.20**	**56.36**	**1030.97**	**9.86**	**1.11**
85.25	**3705.58**	**90.48**	**1490.98**	**24.88**	**1.28**

Table 2. Basic average economic characteristics of dairy farms (2006)

	Year of accession	Number of regions	Value of-Production	Economic size	Basic outlays			Productivity of		
					land	labour	capital	land	labour	capital
			[1000 €]	[ESU]	[ha UAA]	[h]	[1000 €]	[€/1ha UAA]	[€/1 h]	[€/1€]
Germany	1957	13	366.23	170.84	174.87	9490.22	324.94	2194.28	39.24	1.12
Holland	1957	1	208.33	121.30	45.93	3938.40	177.19	4535.84	52.90	1.18
Belgium	1957	2	128.60	86.65	48.33	4621.58	98.73	2854.17	28.17	1.30
Luxemburg	1957	1	205.04	80.50	90.61	3657.71	210.37	2262.93	56.06	0.97
France	1957	18	124.77	68.92	77.55	2869.37	123.62	1643.78	43.46	1.01
Italy	1957	12	132.03	55.17	38.27	4761.29	89.16	4106.56	26.15	1.52
Denmark	1973	1	436.56	194.40	112.03	4575.40	420.07	3896.79	95.41	1.04
Great Britain	1973	6	280.51	136.73	110.04	6442.18	246.74	2553.47	43.10	1.14
Ireland	1973	1	96.17	54.40	51.32	3643.30	76.95	1873.97	26.40	1.25
	mean	**55**	**208.68**	**101.23**	**94.28**	**5379.42**	**183.30**	**2563.47**	**39.12**	**1.18**
Spain	1986	9	144.51	57.31	30.98	3799.79	101.13	5241.59	37.14	1.58
Portugal	1986	3	50.98	25.63	25.37	3391.05	41.11	3354.01	14.92	1.27
Sweden	1995	3	188.60	71.07	103.47	5029.81	202.25	1832.02	37.62	0.93
Finland	1995	4	87.04	53.10	47.61	4723.75	104.41	1838.65	18.39	0.84
Austria	1995	1	58.50	26.00	31.49	3903.19	49.78	1857.76	14.99	1.18
	mean	**20**	**121.30**	**52.22**	**44.36**	**4112.95**	**105.38**	**3597.24**	**29.02**	**1.27**

Slovakia	2004	1	494.82	156.70
Czech Republic	2004	1	207.83	79.50
Hungary	2004	4	109.79	42.28
Estonia	2004	1	122.53	37.50
Malta	2004	1	153.89	33.30
Poland	2004	4	26.16	13.30
Slovenia	2004	1	26.36	12.40
Latvia	2004	1	25.08	9.80
Lithuania	2004	1	21.24	6.30
	mean	**15**	**106.37**	**37.19**
	total	**90**	**172.21**	**79.66**

Source: Own preparation

814.84	56868.35	677.73	607.25	8.70	0.73
198.28	17850.01	189.04	1048.17	11.64	1.10
68.35	7991.34	82.06	1556.26	13.39	1.33
177.63	12631.54	105.23	689.78	9.70	1.16
5.14	7322.55	138.05	29939.30	21.02	1.11
22.25	4079.61	17.86	1185.30	6.34	1.48
13.72	4085.32	23.14	1921.06	6.45	1.14
45.44	4652.59	23.23	552.02	5.39	1.08
35.46	4292.36	15.39	598.87	4.95	1.38
110.19	**10399.10**	**104.77**	**3088.18**	**9.78**	**1.26**
85.84	**5934.59**	**152.90**	**2880.65**	**31.99**	**1.21**

Moreover, the conducted analysis shows that not all examined entities in 2004 generated an average return of incurred capital outlays. This was observed both in crop farms and in dairy farms. Productivity of capital much below 1 was recorded in both types of farms in regions of Sweden, Finland and Slovakia, as well as crop farms from Slovenia, and slightly less than 1 in farms from regions of Latvia, Estonia and Lithuania (crop production) as well as Luxemburg (milk production). This may indicate certain significant effects of direct payments and subsidies on the final economic results. On the other hand, it needs to be observed here that average productivity of capital in regions with the longest membership period in the EU is lower than in the other groups of regions, except for crop farms from regions with the shortest membership period. This may be connected with a high engagement of capital, particularly in dairy farms.

Thus, what can be said is that in both crop production and milk production, it is difficult to indicate the share of individual factors in achieving high production efficiency based on individual productivities. In particular it is not possible to determine the importance of outlays on labour in comparison to the other basic outlays, i.e. capital and land. In order to solve this problem, technical efficiencies were determined for average farms representing individual regions. As it was already mentioned, this index is a synthetic measure defining the efficiency of a production process on the basis of outlays.

TECHNICAL EFFICIENCY

In the analysis of technical efficiency using DEA the volume of agricultural production was adopted as the outcome variable, while outlays were limited to labour and capital. Utilised agricultural area was disregarded due to the limited capacity for changes in this area, which results in land being treated in many studies as a constant factor[16]. The analysis was conducted separately for regions represented by average crop farms (109 regions) and for milk farms (90 regions). Mean values of estimated technical efficiencies for individual EU countries, with the numbers of regions in the four distinguished classes of technical efficiency, are presented in Table 3. In the ef-

[16] see e.g.: Allen Richard G. D., *Teoria makroekonomiczna. Ujęcie matematyczne.* PWN, Warszawa 1975.

ficiency class of (0.8 – 1) additionally the data is given in brackets to show the numbers of regions represented by reference farms, i.e. the so-called Leaders, which in the analysed period achieved full 100% efficiency.

The average level of technical efficiency in the analysed entities in terms of crop production amounted to 76% maximum efficiency, while fourteen entities were granted the status of leaders. In the group of milk producers the level of efficiency amounted to 77%, while there were sixteen entities considered to be leaders.

In the case of crop production on average the most efficient entities came from regions belonging to the group of countries being the oldest EU members. The mean level of technical efficiency in that group was slightly over 82%, while in the class of efficiency of (0.8 – 1), there were 30 entities, including eight leaders representing the following regions: one Danish, one Dutch, one Irish, two German regions (Mecklenburg, Turing), the French Picardy, the Italian Sicily and North Ireland located within Great Britain.

In the group of farms from regions belonging to countries which accessed the EU in the years 1981 - 1995 mean technical efficiency amounted to 75%. These entities included farms representing six leader regions. These comprised four Spanish regions (La Rioja, Madrid, Valencia and Murcia), the Portuguese Azores as well as the Finnish region of Sisa-Suomi.

In turn, the lowest level of average technical efficiency was recorded in the group of countries which accessed the EU in 2004. It was as low as 56%. In this group no entity reached maximum efficiency, but we need to stress here high efficiency of entities from the Czech region.

In terms of milk production, similarly as in the case of crop production, on average the most efficient entities came from the countries with the longest membership period in the EU. In this group there were ten leaders representing the Danish region, three Italian regions (Molise, Lazio, Lombardy), five French regions (Franche-Comté, Upper Normandy, Picardy, Champagne-Ardennes, Aquitaine) as well as one German region (Mecklenburg).

Among dairy farms from the regions of countries, which accessed the EU in the years 1981 - 1995, average technical efficiency reached almost 73%. In that group there were five leaders. These were entities representing four Spanish regions (Andalusia, Castile and León, the Balearic Islands, Galicia) as well as one region of Portugal (the Azores).

The average level of technical efficiency in the group of entities with the shortest term in the EU was almost 69%, i.e. more than in crop pro-

Table 3. Mean technical efficiencies

Country	Year of accession	Crop production				Milk production			
		Mean efficiency	Classes of efficiency			Mean efficiency	Classes of efficiency		
			0.2 - 0.6	0.6 - 0.8	0.8 - 1		0.4 - 0.6	0.6 - 0.8	0.8 - 1
Holland	1957	1.000			1(1)	0.880			1
Belgium	1957	0.949			2	0.690		2	
Germany	1957	0.885		2	10(2)	0.820		5	8(1)
France	1957	0.817	1	8	11(1)	0.840		9	9(5)
Italy	1957	0.730	3	13	3(1)	0.780	2	5	5(3)
Luxemburg	1957					0.810			1
Denmark	1973	1.000			1(1)	1.000			1(1)
Ireland	1973	1.000			1(1)	0.650		1	
Great Britain	1973	0.884		2	3(1)	0.790		2	4
	Mean	**0,822**	**0.553**	**0.738**	**0.921**	**0.812**	**0.582**	**0.717**	**0.907**
Greece	1981	0.532	3	1					
Spain	1986	0.842		5	8(4)	0.890		2	7(4)
Portugal	1986	0.642	2	2	1(1)	0.730	1	1	1(1)
Finland	1995	0.809		3	1(1)	0.440	4		
Sweden	1995	0.771		2		0.650	1	2	
Austria	1995	0.693		1		0.560	1		
	Mean	**0.750**	**0.473**	**0.708**	**0.948**	**0.727**	**0.494**	**0.703**	**0.947**

Czech Republic	2004	0.877		
Slovakia	2004	0.694		1
Hungary	2004	0.607	4	3
Malta	2004	0.571	1	
Latvia	2004	0.519	1	
Estonia	2004	0.509	1	
Poland	2004	0.493	4	
Lithuania	2004	0.436	1	
Slovenia	2004	0.273	1	
Cyprus	2004	0.481	1	
	mean	**0.557**	**0.502**	**0.670**
	total	**0.757**	**0.504**	**0.722**

Source: Own preparation

1	0.680		1	
	0.620		1	
	0.650	2	2	
	0.630		1	
	0.550	1		
	0.600		1	
	0.820		2	2(1)
	0.760		1	
	0.580	1		
0.877	**0.688**	**0.551**	**0.698**	**0.915**
0.927	**0.773**	**0.525**	**0.711**	**0.916**

duction. The highest efficiency was recorded for entities representing two Polish regions. One of them, the Małopolska and Pogórze, received the status of a leader.

TECHNICAL EFFICIENCY AND PRODUCTIVITY OF OUTLAYS

Technical efficiencies make it possible to establish a ranking of analysed entities, but also determine the relationship of this synthetic index with the productivities of individual factors of production. These relationships may be grasped thanks to the analysis of correlations, whose results are given in Table 4.

Values of linear correlation coefficients between technical efficiencies and the previously analysed unidimensional indexes, referring to the outlays on land, labour and capital, were calculated separately for crop farms and dairy farms and in terms of the period of their operation within the Common Agricultural Policy. Additionally, the last rows of Table 4 contain correlation coefficients between technical efficiencies and two indexes describing labour force. This is the so-called equipment possession index, i.e. the ratio of capital outlays to outlays on labour (capital/labour), as well as an index characteristic of the agricultural sector, and determined as the ratio of outlays on labour per 1 hectare of utilised agricultural area (labour/land).

Determined correlations indicate that both in the case of crop production and milk production, the strongest relationship with technical efficiency achieved by average entities in the regions was recorded in the case of productivity of labour. Correlation coefficients jointly for all entities amounted to 0.623 and 0.536, respectively. At the same time correlations between efficiency and the volume of engaged labour force for both types of farms turned out to be insignificant. Thus it may be stated that an improvement of farm efficiency is first of all influenced by the productivity of labour, and not the amount of labour force engaged in the production process. For crop production this conclusion is confirmed by the correlation of efficiency with the equipment possession index, which ranked second and amounted to 0.511; while for milk producers the correlation with productivity of capital was 0.443. This means that in the case of milk production the factor ranking second in significance is connected with

Table 4. Correlation coefficients for technical efficiency and basic economic indexes

Type of production		Crop production				Milk production			
Years of accession		1957-73	1981-95	2004	total	1957-73	1981-95	2004	total
Value of production	[€ 1000]	0.535	0.144	0.790	**0.477**	0.443	0.241	-0.211	**0.346**
Economic size	[ESU]	0.483	0.245	0.818	**0.481**	0.450	0.164	-0.221	**0.374**
Land	[ha UAA]	0.370	0.184	0.678	**0.318**	0.346	-0.239	-0.208	**0.078**
labour	[h]	0.295	-0.243	0.625	**0.124**	0.271	-0.551	-0.202	**-0.046**
capital	[€ 1000]	0.475	0.029	0.726	**0.422**	0.425	-0.143	-0.223	**0.251**
Production/Land	[€/1ha UAA]	0.113	0.086	-0.034	**0.185**	0.170	0.381	-0.106	**0.053**
Production/Labour	[€/1 h]	0.667	0.230	0.835	**0.623**	0.541	0.515	-0.199	**0.536**
Production/Capital	[€/1 €]	-0.060	0.384	-0.106	**0.186**	0.165	0.831	0.738	**0.443**
Labour/Land	[100 h/ 1 ha UAA]	0.363	0.062	-0.283	**-0.148**	-0.153	-0.009	-0.012	**-0.145**
Capital/labour	[€/1 h]	0.540	0.099	0.774	**0.511**	0.431	0.027	-0.411	**0.374**

Source: Own preparation

the equipment increasing the volume of production, while in crop production it is capital supporting the labour force, as well as economic size (correlation with efficiency of 0.481).

If we focus only on entities from regions with the longest EU membership period, the primary determinants of higher technical efficiency have different distributions for both types of farms. In crop farms the main factors contributing to improved efficiency rank as follows: productivity of labour (correlation of 0.667), the equipment possession index for work places (0.540) and the value of production (0.535). In entities specialising in milk production the main determinants included the productivity of labour (0.541) and economic size (0.450).

In the group of regions which accessed the EU in the years 1981 - 95 the relationships of technical efficiency with other economic indexes are not as clear. Only for dairy farms was there a high correlation recorded for productivity of capital (0.831), followed by productivity of labour (0.515).

In the group of regions with the shortest terms as EU members correlations of efficiency with the other economic indexes were not consistent. In crop production a strong relationship was found between efficiency and economic size (0.818), and with the value of production (0.790). This fact may be related with the stereotype, according to which bigger farms create better conditions for the improvement of efficiency resulting from more efficient machines and equipment. Thus high correlations were recorded between efficiency and the equipment possession index (0.774), and with all the three outlays. In the case of milk production the only significant correlation (0.738) is the one linking efficiency with the productivity of capital. This means that the most important factors are those related with capital and its efficient use. We may mention such components of capital as herd, milking equipment and cooling equipment.

Results of the presented correlation analysis should be compared with mean values of basic economic indexes depending on the level of achieved technical efficiency in analysed entities. Respective figures are given in Table 5.

On the basis of values contained in Table 5 it may be observed that in both types of entities efficiency increases with an increase in the value of production, economic size, productivity of labour (Production/Labour), as well as the equipment possession index (Capital/Labour). In the case of crop farms these dependencies are confirmed by total values of correlation coefficients from Table 4, with the dependence of efficiency on productivity of labour being the strongest. In case of dairy farms also the produc-

Table 5. Mean economic indexes at different levels of technical efficiency

Economic indexes	Units of measure	Crop production			Milk production		
		0.2 - 0.6	0.6 - 0.8	0.8 - 1	0.4 - 0.6	0.6 - 0.8	0.8 - 1
Number of regions		21	43	43(14)	13	38	39(16)
Value of production	[1000 €]	25.71	75.50	155.20	77.57	135.96	239.09
Economic size	[ESU]	15.50	46.53	87.99	36.10	61.57	111.82
Production/land	[€/1haUAA]	1.27	1.28	1.82	2.04	2.97	3.07
Production/labour	[€/1h]	7.93	22.76	36.06	15.76	27.99	41.30
Production/capital	[€/1 €]	1.21	1.21	1.40	1.02	1.18	1.30
Labour/Land	[100 h/ 1 ha UAA]	2.26	0.85	1.13	0.90	1.30	1.42
Capital/Labour	[€/1h]	7.36	23.02	31.92	16.39	25.15	35.08

Source: Own preparation

tivity of labour had the strongest relationship with efficiency, but the other correlations of efficiency with the above mentioned indexes, although positive, were much lower.

Since at the same time average efficiency increased with the length of EU membership period of the regions (see Table 3), it may be stated that one of the elements contributing to improved efficiency includes advanced knowledge and experience of employees, facilitating adequate utilisation of production factors.

CONCLUDING REMARKS

When summing up the results we first of all need to stress again that all the conducted analyses were based on data from the year of 2006. This means that the presented dependencies may not be similar in other years. What is more, it may be expected that such an analysis repeated on the basis of data from later years may lead to significantly different conclusions due to economic fluctuations found in the successive years of the economic crisis.

The investigations were conducted using data from the FADN system. Objects of analyses comprised crop farms and dairy farms, being average in individual regions of the European Union. The analysis was conducted for all the regions, which in 2006 were represented by both the above mentioned types of farms. Crop farms were found in 109 regions representing 24 EU member states, while dairy farms were found in 90 regions representing 23 EU countries.

The level of technical efficiency, estimated by DEA, of average farms from regions which had accessed the EU in 2004, turned out to be lower than the efficiency of farms from regions with a medium-length EU membership period, whose efficiency in turn was lower than in the countries with the longest membership period. The exceptions in this respect were the large Slovak farms and Czech crop farms.

The strongest positive relationship between the estimated level of technical efficiency and basic economic indexes was recorded for productivity of labour force and it was both for crop farms and dairy farms. Secondly, technical efficiency in the case of milk production depended on productivity of capital; while in crop production it was on the equipment possession index and economic size of farms. Thus it may be stated that despite the fact that both production factors are required in the pro-

duction process, labour and its quality has a stronger, if not decisive, effect on the efficiency of the farm as a whole.

In crop production the most efficient farms in comparison to least efficient farms were characterised by a high value of production and economic size measured in ESU. They had a greater utilised agricultural area and a markedly higher capital, at the simultaneous low consumption of labour. As a consequence, those farms in comparison to farms with the lowest mean efficiency were characterised on average by an over four-fold greater productivity of labour and also an over four-fold greater consumption of capital per a unit of labour.

In the case of milk production the most efficient farms on average generated the highest value of production; they had the greatest economic size, consumed least labour and most capital. As a consequence in comparison to least efficient farms they obtained an almost two and a half times greater productivity of labour at an over two times higher workplace equipment possession index.

These observations mean that high efficiency in crop production and in dairy farms is determined not by the amount of labour input, but by advanced know-how, experience and skills of employed workers capable of effectively utilising the other outlays, particularly capital. In other words, conducted studies confirmed that the main factor improving farm efficiency is related with changes in the human capital. Although improvement in this area requires long-term actions, it simply has to be done. It should be accompanied by an improvement of the production structure both in terms of physical and economic size, and its better adaptation to the type of production. These elements need to be considered when establishing principles of the Common Agricultural Policy, which - in view of the next stage of the economic crisis and cuts on expenses - has to include efforts aimed at an improved quality of the human capital, particularly in regions with lower efficiency.

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