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The effect of human capital on labour productivity of farms in Poland

This study aims to determine the relationship between total, average and marginal human factor productivity and the level of education of a farm manager in Poland. The study was carried out based on unit empirical data from the monitoring of the Polish Farm Accountancy Data Network (FADN) and covered the four Polish FADN macro-regions: Pomorze & Mazury, Wielkopolska & Śląsk, Mazowsze & Podlasie and Małopolska & Pogórze. The study involved the Cobb-Douglas production function method. Using the relationship between total production (in PLN) of a farm and the aggregated production factors such as total labour input in AWU (Annual Work Unit), area of arable land (ha) and fixed assets (PLN), labour productivity was determined based on the level of education of the farm manager. The results indicate that the flexibility of production in relation to the labour factor was significantly higher in the group of farms managed by farmers with higher-level education in two out of four analysed macro-regions and on a national scale. In addition, human capital approximated by the level of education had a positive effect on the average and marginal productivity of the analysed farms.

Keywords: human capital, commercial farm, labour productivity, Cobb-Douglas production function, FADN macro-regions

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Introduction

Productivity is one of the most important aspects of economic life (Bayyurt and Yılmaz, 2012). It is most often defined as the ability of production factors to produce (Latruffe, 2010). Improvement in the productivity of agriculture, and in particular labour productivity, is a condition for permanent economic growth (O'Donnell, 2010). Contemporary economics significantly changed the way the labour factor is perceived. These changes are underpinned by abandoning the term 'labour' for the sake of the term 'human capital' (Kołoszko-Chomentowska, 2008).

The significance of the human factor and characteristics such as the level of education or having adequate knowledge resources is extremely important in the process of management. It is certainly a source of all changes, so at the same time it emanates innovation (Kołodziejczyk, 2002; Kijek, 2012). The significance of the human factor in management has increased due to the development of engineering and technology, information technology, the necessity for innovative management and globalisation of the economy (Narski, 2001). In the economy of the 21st century, education and continuing improvement of skills have become important drivers and generators of the development of the country and respective sectors of the economy (Berezka, 2012). In the case of agriculture, human capital has become important in terms of improving the results of management and, in particular, in the aspect of adequate management and organisation of other production factors, i.e. land and capital (Górecki, 2004). With regard to the growing complexity of the environment in which agricultural producers operate, attention should be paid both to quantity and quality objectives in evaluating human capital in agriculture. The lack of proper qualifications and insufficient access to information reduce the chances of achieving the intended purpose.

Of the characteristics defining human capital the most measurable is education, which is commonly believed to be the most important driver of civilisation and economic growth. Apart from education, human capital comprises creativity, learning ability and methods, flexibility and many other characteristics due to which not only formal knowledge but also the capacity to continue development determine the economic success of humankind (Kołoszko-Chomentowska, 2008). In agriculture a relationship can be observed between the quality of human capital, defined by the characteristics of a farm manager, and the implementation of scientific and technological progress. A better educated farmer is more prone to introduce changes and innovation on the farm. This refers in particular to investment in biological and technical material, and changes in organisation and technology (Sikorska, 2011). The close relationship between the level of education and the inclination towards entrepreneurship, diffusion of innovation, changes in the nature of the farm or the intention to make use of information was also noted by Wawrzyniak (2001).

From the macroeconomic point of view, better quality of human resources facilitates development and implementation of technological innovations, increases capital earnings and promotes sustainable development of agriculture (Penda, 2012; Kijek and Kasztelan, 2013). Improvement in the quality of human capital leads to lower unit costs of production and decreases marginal cost of production, enabling firms to trade higher quality commodities at lower prices (Kleynhans, 2006).

These circumstances are the reason for undertaking studies into human capital in agriculture. Few papers exist concerning the role of human capital in the development of agriculture and its respective entities. This study evaluates the effectiveness of using the labour factor on commodity farms depending on the level of education of the farm manager. Education as a characteristic determining the level of human capital was recognised to be the growth driver increasing labour productivity and decreasing social inequalities and poverty (Amin and Awung, 2005). With regard to the aforementioned, and considering the strong internal diversification of agriculture in Poland demonstrated, among others, by Poczta and Bartkowiak (2012) and Kamińska and Nowak (2014), an analysis was carried out in the four macro-regions of the Polish Farm Accountancy Data Network (FADN): Pomorze & Mazury, Wielkopol-

ska & Śląsk, Mazowsze & Podlasie, and Małopolska & Pogórze[1]. These macro-regions were separated on the basis of factors determining the production effects of farms. Each of them consists of four NUTS 2 regions or *voivodeships*. The analysis of the effect of education on productivity in the macro-regions allows an estimation of whether the quality of human resources determines labour productivity in agriculture in different economic and natural conditions and whether it can be the driving force behind the development of this sector, in particular in regions where agriculture is less competitive, such as the *voivodeships* that constitute the Małopolska & Pogórze macro-region and the Mazowsze & Podlasie macro-region (apart from Mazovian *voivodeship*) (Nowak *et al*., 2015).

From the point of view of methodology, this paper is genuine in terms of using the production function and comparing the output elasticity of labour and average and marginal productivity of labour in groups of farms run by managers with and without higher education. Many empirical studies in this area are limited to comparative analyses according to average productivity indicators calculated based on collected empirical information. For instance, such analyses were carried out by Wenbiao and Pandey (2015). However, they did not refer to farms but to the agricultural and non-agricultural sectors. These studies indicate that labour productivity differences between agriculture and non-agriculture in European countries are not an indicator of resource misallocation but possibly an artefact of sectoral differences in human capital. It is worth noting that some authors decided to introduce an additional binary or ordinal variable describing the level of education of the farm manager into the production function. However, although such a solution makes it possible to draw conclusions about differences in average values of productivity for different categories of education, it provides no information regarding differences in elasticity or marginal productivity values.

Methodology

The research was carried out using accounting data from commodity farms participating in the Polish FADN in 2012. FADN data are collected according to uniform principles and the sample farms constitute a statistically representative sample of commodity farms operating in the European Union (EU).

The studies made use of the Cobb-Douglas (C-D) production function constituting the theoretical basis for explaining most regularities concerning effectiveness in the economics of agriculture (Bezat and Rembisz, 2011). Formally the Cobb-Douglas function is a special case of a translog function (Greene 2008). The model makes use of a resource-based approach, which, next to the labour factor (total labour input in Annual Work Units, AWU[2]) and capital (fixed assets in PLN) takes into account the land factor (area of arable land in ha). The C-D function was estimated using the ordinary least squares method. The utilisation of human labour was estimated based on output elasticity of the labour factor, and total, average and marginal productivity. The production function is as follows:

$$Y = aX_1^{\alpha}X_2^{\beta}X_3^{\delta}\varepsilon \quad (1)$$

where: a – constant describing the level of technical and organisational progress;
Y – value of production in PLN;
X_1 – total labour input in AWU;
X_2 – area of arable land (UAA) in ha;
X_3 – fixed assets in PLN;
α, β, δ – regression coefficients (elasticity coefficients);
ε – random component.

In view of the fact that this work aims to evaluate the effect of human capital on the effectiveness of the operation of farms, the analysed sample was split into two groups of farms according to the criterion of education of the farm manager, at the same time taking into account the spatial division of the analysed units. Next, the production function parameters were estimated for each group of farms. In order to determine the significance of differences between the estimated parameters for respective production functions the Z test was performed according to the following formula (Clogg *et al*., 1995):

$$Z = \frac{a_1 - a_2}{\sqrt{\frac{V_1(SEa_1^2) + V_2(SEa_2^2)}{V_1 + V_2}}} \quad (2)$$

where: a_1, a_2 – estimated parameters from model 1 and model 2; SEa_1^2, SEa_2^2 – variance of parameter estimations; V_1, V_2 – degrees of freedom.

Results

Table 1 presents data on the number of farms in the sample together with a statistical description of the variables taken into account in the analyses, comprising the resources of production factors (arable land in ha, labour resources in AWU, value of fixed assets in PLN) and the production effect expressed as the total value of production in PLN.

The total number of farms in each macro-region was as follows: Pomorze & Mazury: 1601; Wielkopolska & Śląsk: 3861; Mazowsze & Podlasie: 3644; and Małopolska & Pogórze: 1045. The share of farms where the manager completed higher education ranged from 8.54 per cent in Wielkopolska & Śląsk to 11.06 per cent in Mazowsze & Podlasie. In total, the study covered 10,151 farms, 9.7 per cent of which were managed by managers who had completed higher education.

The most variable characteristic was the total value of agricultural production, while the least variable was the total labour input expressed as the number of full-time employees. The analysed characteristics were more variable in the group of farms managed by farmers who had not completed higher education; here, the research sample was considerably larger.

Table 2 presents the estimated parameters of the Cobb-Douglas function for the four macro-regions in 2012 accord-

[1] See http://fadn.pl/en/organisation/polish-fadn/schemat-ang/

[2] AWU is the total human labour input in farm operations, 1 AWU is one full-time employee working 2,120 hours per year.

Table 1: Statistical characteristics of analysed variables in rural farms producing goods in 2012.

Feature name		Poland	Macro-region			
			Pomorze & Mazury	Wielkopolska & Śląsk	Mazowsze & Podlasie	Małopolska & Pogórze
Farms run by managers with higher education						
Sample size		986	152	330	403	101
Total production (Y)	A (PLN)	372,895	609,045	410,036	282,662	256,184
	B (PLN)	665,805	1,184,890	527,782	521,528	317,400
	C (%)	1.78	194.0	129.0	184.0	124.0
Total labour input (X_1)	A (AWU)	2.18	2.29	2.15	2.21	2.06
	B (AWU)	2.04	2.26	1.86	2.24	1.31
	C (%)	0.93	98.0	86.0	101.0	64.0
Arable lands area (X_2)	A (ha)	49.69	100.83	53.68	32.15	29.67
	B (ha)	70.61	126.72	62.69	35.76	33.36
	C (%)	1.42	126.0	117.0	111.0	112.0
Total fixed assets (X_3)	A (PLN)	812,431	1,150,080	884,090	684,118	582,140
	B (PLN)	900,965	1,326,840	881,953	726,043	590,707
	C (%)	1.11	115.0	99.0	106.0	101.0
Farms run by managers without higher education						
Sample size		9165	1449	3531	3241	944
Total production (Y)	A (PLN)	369,085	589,356	450,679	221,139	233,712
	B (PLN)	1,076,290	1,456,370	1,380,060	397,737	366,506
	C (%)	2.92	247.0	306.0	179.8	157.0
Total labour input (X_1)	A (AWU)	2.35	2.71	2.51161	2.09	2.13
	B (AWU)	4.03	3.97	5.58	2.01	1.61
	C (%)	1.71	146.0	222.0	96.0	75.0
Arable lands area (X_2)	A (ha)	51.03	98.66	57.25	28.94	30.51
	B (ha)	137.3	213.45	161.03	49.86	43.63
	C (%)	2.69	216.0	281.0	17.02	143.0
Total fixed assets (X_3)	A (PLN)	738,987	1,011,870	830,126	569,227	562,046
	B (PLN)	1,300,380	1,740,140	1,599,730	672,169	612,373
	C (%)	1.76	172.0	193.0	118.0	109.0

Note: A: arithmetical mean; B: standard deviation; C: coefficient of variation
Data source: Polish FADN

Table 2: Estimation of production function parameters for the analysed macro-regions.

Variables	Model 1 (Poland)	Model 2 (Pomorze & Mazury)	Model 3 (Wielkopolska & Śląsk)	Model 4 (Mazowsze & Podlasie)	Model 5 (Małopolska & Pogórze)
Farms run by managers with higher education					
X_1	0.465	0.454	0.469	0.497	0.542
	(0.033)	(0.098)	(0.054)	(0.052)	(0.113)
X_2	0.276	0.282	0.225	0.295	0.250
	(0.023)	(0.063)	(0.040)	(0.041)	(0.062)
X_3	0.568	0.592	0.535	0.542	0.659
	(0.028)	(0.074)	(0.046)	(0.043)	(0.083)
R^2	0.762	0.767	0.752	0.754	0.770
F(n,k)	1,052.249	162.606	330.057	409.416	108.779
Farms run by managers without higher education					
X_1	0.413	0.428	0.403	0.448	0.532
	(0.012)	(0.028)	(0.017)	(0.022)	(0.045)
X_2	0.333	0.442	0.256	0.331	0.323
	(0.008)	(0.019)	(0.012)	(0.015)	(0.025)
X_3	0.579	0.458	0.614	0.603	0.522
	(0.008)	(0.019)	(0.013)	(0.014)	(0.028)
R^2	0.781	0.829	0.792	0.752	0.710
F(n,k)	10,909.490	2,343.400	4,476.949	3,271.387	768.845

Note: standard errors in parentheses
Data source: Polish FADN

ing to farms led by managers with higher education and by managers without higher education. The results indicate that the output elasticity of the labour factor, characterising average relative increases (Niezgoda, 2009), is higher for all groups of farms whose managers completed higher education compared to the group of farms whose managers have not completed such education.

The Z statistics method was used in order to determine whether the differences between estimated parameters (elasticity) for respective production functions were statistically significant. According to the calculations in Table 3, an increase in the level of education leads to improvement in the output elasticity of the labour factor in model 1, which does not take into account the regional division of the

Table 3: Differences between production flexibility of the labour factor on farms led by managers with and without higher education, taking into account the regional diversification of the research sample.

Difference	Model 1 (Poland)	Model 2 (Pomorze & Mazury)	Model 3 (Wielkopolska & Śląsk)	Model 4 (Mazowsze & Podlasie)	Model 5 (Małopolska & Pogórze)
a_1-a_2	0.05	0.03	0.07	0.05	0.01
Z-value	3.386**	0.645	2.912**	1.814*	0.180

* p<0.05 (one-tailed), ** p<0.01 (one-tailed)
Data source: Polish FADN

Table 4: Total, average and marginal productivity of labour in surveyed commercial farms in 2012.

Type of productivity	Poland	Macro-region			
		Pomorze & Mazury	Wielkopolska & Śląsk	Mazowsze & Podlasie	Małopolska & Pogórze
Farms run by managers with higher education					
Total productivity (PLN/farm)	327,847	496,115	380,648	241,549	236,729
Average productivity (PLN/AWU)	150,083	216,550	177,273	109,479	115,022
Marginal productivity (PLN)	79,425	120,826	89,636	63,634	67,490
Farms run by managers without higher education					
Total productivity (PLN/farm)	318,636	480,507	400,028	198,118	206,492
Average productivity (PLN/AWU)	135,274	177,015	159,272	94,758	96,976
Marginal productivity (PLN)	64,795	93,012	72,385	47,342	58,403

Data source: Polish FADN

analysed farms. The observed regularity is consistent with expectations formulated based on theoretical considerations according to which human capital approximated through the level of education has a positive effect on the productivity of farms. At the same time, it should be noted that different economic and natural conditions typical of respective regions in which the analysed entities operate have an influence on the analysed relationship since differences between the estimated parameters turned out to be insignificant in model 2 (Pomorze & Mazury) and model 5 (Małopolska & Pogórze).

We then evaluated labour productivity according to the level of education of the managers of the analysed farms. Labour productivity is generally the most important measure of productivity (Poczta, 2003). Its significance is due to the fact that the measure determines the income situation and options for internal accumulation (Poczta and Kołodziejczak, 2008). It determines both the economic force and the development prospects (Kowalski, 1998). Table 4 presents the indicators of total, average and marginal labour productivity of farms in the analysed macro-regions in 2012. In order to calculate the labour productivity, we estimated the production function with only one input, i.e. labour. This allows us to hold all the other inputs fixed. The estimated production functions were further used in the calculation of the indicators at the average values of the observed variables.

Total labour productivity (product) is diversified by regions and depending on the level of education of the farm manager. The highest total productivity of the analysed factor was characteristic of farms in Pomorze & Mazury, where farms led by managers with higher education predominated. The average difference amounted to PLN 15,608 per farm. Interestingly, in this region the coefficients of the output elasticity of the labour factor were not significantly different for the group of farms led by managers with higher education and for the group of farms whose managers did not claim to have completed such education. The existing situation can be explained by the fact that the level of education does not have an influence exclusively on the effects of the human factor use but also affects the utilisation of the other production factors.

Also, in Mazowsze & Podlasie and Małopolska & Pogórze total labour productivity was higher among farmers with higher education. It is worth emphasising that the difference in the total labour productivity between the macro-region displaying the highest level of this indicator (Pomorze & Mazury) and that having the lowest level (Małopolska & Pogórze) amounted to PLN 259,386 in the first group of farms. On the other hand, in the second research group (farms with a manager without higher education), the difference between total labour productivity in Pomorze & Mazury (the highest) and in Mazowsze & Podlasie (the lowest) was PLN 282,389.

A higher level of labour productivity, both on a national scale and in all macro-regions, was achieved on farms managed by farmers who had completed higher education. In that group the highest effectiveness of utilisation of the labour factor was characteristic of entities in Pomorze & Mazury (PLN 216,550/AWU), where the average labour productivity was twice that of Mazowsze & Podlasie and nearly twice that of Małopolska & Pogórze. At the same time, this indicator was PLN 39,535/AWU higher than that recorded in the same macro-region but for farms managed by producers without higher education. It points to a clear relationship between the level of education of a farm manager and the economic results of the farm.

Marginal labour productivity of farms is also diversified depending both on the macro-region and on the level of education of the manager. In this case, higher productivity was also recorded for farms whose managers had completed higher education.

Discussion and conclusions

Our study aims to evaluate the effect of human capital on the production results of commodity farms using the Cobb-Douglas function. The results indicate that the output elasticity of the labour factor was significantly higher in the group of farms managed by farmers with higher-level education in

two out of four analysed macro-regions and on a national scale. In addition, human capital approximated by the level of education had a positive effect on the average and marginal productivity of the analysed farms.

The study makes a significant contribution to the literature related to agricultural economics since it is one of the few empirical studies focusing on the role of human capital in explaining the productivity of farms. Some researchers undertook surveys regarding the impact of education on the production and economic results of farms. However, according to our knowledge such surveys were not based on the production function and did not refer strictly to the productivity of labour. For example, Stawicka and Wołoszyn (2007) studied the impact of human capital on the production and economic results of farms in Poland and found that farmers who completed higher education in agriculture achieved the highest income. Marcysiak (2007) found that the highest level of income was recorded for farms run by men aged 46-55 with secondary or higher education. Gołębiewska and Klepacki (2001) demonstrated a clear impact of the level of education of farmers on the economic situation of their farms. Mathijs and Vranken (2000), in their analysis of family farms in Bulgaria and Hungary, showed that there was a significantly positive relationship between education and technical efficiency in family farms for both crop and dairy farming, where the farmer was measured as years spent in formal education.

Our results clearly indicate a need to upgrade the formal qualifications of farmers. Operating farms in an increasingly complex and variable market environment requires from the producers both specialist knowledge of agriculture and economic and social knowledge, the skill of establishing market contacts and the willingness to update one's knowledge. Improved quality of human capital can simultaneously provide a chance to increase the effectiveness of agriculture in regions where it is less developed, where the improvement of relationships between production factors is difficult due to the structural problems of this sector. From the point of view of agricultural and educational policy the key task is creating mechanisms facilitating an improvement in the level of education among the farming population. Such activities are particularly desirable in countries such as Poland and other countries with system transformation experience (e.g. Hungary, Czech Republic and Slovakia) where, as a result of long-term negligence, the educational needs of farmers were satisfied only to a very limited extent. An example of such means can be providing the inhabitants of rural areas with access to fast, broadband Internet and introduction of e-learning.

Our study is not free of weaknesses. The most serious limitation is the one-element set of quality indicators of the human capital. Despite education being the most frequently used measure of human capital, empirical studies should take into consideration that this approximant is not perfect. Hence, further studies regarding the human capital productivity of farms should take into account additional variables describing the experience and skills of farmers. In addition, it seems reasonable to continue research based on pooled cross-sectional data, which would make it possible to take into account the specific nature of respective units and periodic effects.

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