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Article

Eco-Efficiency and Human Capital Efficiency on the example of small and medium-sized family farms in the selected European countries

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Abstract: Small and medium-sized family farms are the place of life and source of income for about half of the population. The aim of the analysis was to determine the relationship between Eco-Efficiency, Human Capital Efficiency in small and medium-sized family farms. The analyses were carried out using an economic measure (value of agricultural production per work hour calculated per 1 ha) and synthetic measures: human capital and environmental measures. The synthetic measures were determined using the CRITIC-TOPSIS method by defining weights for variables used in the synthetic measures. The analyses covered five countries, namely: Lithuania (960 farms), Moldova (532 farms), Poland (696 farms), Romania (872 farms), and Serbia (524 farms). All the countries qualified for analysis are characterised by a high fragmentation of agricultural holdings. The analyses carried out allowed us to formulate the following conclusions: the Eco-Efficiency and Human Capital Efficiency indexes increase with area for small and medium-sized family agricultural farms. An increase in the Eco-Efficiency index with an increase in farm area leads to a suspicion that the smaller the farm area is, the more extensive the agricultural production being carried out. In addition, an increase in human capital efficiency with an increase in the area of a farm indicates that there is inefficiency in the utilisation of human capital resources in the agricultural farms studied.

Keywords: Eco-Efficiency; Human Capital Efficiency; family farms; TOPSIS-CRITIC; sustainable development

1. Introduction

Small farms are most often identified with technological backwardness, low efficiency, and poverty [1,2]. Sometimes it is even suggested that they are an unnecessary element in the agricultural landscape [3]. However, it is important to remember that small farms provide a place for living and working for nearly half of the world's population [4].

Small and medium-sized family farms are most often indicated as a place of production of healthy food and a reservoir of biodiversity. The need to protect the environment forces everyone to take rational actions aimed at sustainable development; one of the measures of such development may be eco-efficiency. It should be understood as a measure of sustainability that directly links environmental impacts to economic performance [5]. Eco-efficiency can be applied as a control tool at the production management level to improve environmental impacts [6].

There is a widespread opinion that large farms are characterised by a low Eco-Efficiency index. However, this common opinion is not always confirmed by analyses [6]. Certainly, large farms cause strong environmental pressures, but such a phenomenon is not necessarily associated with a low Eco-Efficiency index. Does this mean that a favourable Eco-Efficiency index is present in all situations involving small and medium-sized family farms? Furthermore, it is commonly believed that the level of human capital is correlated with the productivity of an economy and the level of environmental protection [7,8,9]. Therefore, if this opinion were to be confirmed in real situations, then farms with

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a higher level of human capital should be characterised by higher productivity and, consequently, also by a higher level of Human Capital Efficiency. Of course, in discussing this problem we should distinguish between the theoretical possibilities of increasing production, namely the human capital resources, and the practical possibilities associated with the availability of means of production enabling an increase in productivity. In small and medium-sized family farms there may be a high value of human capital without the possibility of use, due to limitations in production resources, so there will be no possibility of increasing productivity. We may also imagine a situation when we have, at our disposal, a considerable production capacity expressed by the area of an agricultural farm, a rich machinery fleet, and a low value of human capital which would not allow for utilisation of these capacities.

Research was carried out in 5 European countries characterised by a similar political history and highly fragmented agriculture.

The article aims to answer the following research questions:

What is the level of Eco-Efficiency in small and medium-sized family farms in the selected European countries?

What is the level of Human Capital Efficiency in the investigated farms?

What is the relationship between Eco-Efficiency and Human Capital Efficiency?

Eco-Efficiency can be defined as the simultaneous pursuit to achieve the desired economic results with a simultaneously lowest environmental degradation [10]. As one of the many methods of determining Eco-Efficiency, the ratio of economic development to the pressure on the environment determined by taking into account soil pollution, water pollution, air pollution, and biodiversity as indicated in the calculations [11].

Some studies, related to sustainability, even emphasise the need for trade-offs between environmental, economic, and social efficiency [12]. Similar analyses may also focus on determining indicators of environmental burden, sustainability of organic production values, and sustainability of farm eco-efficiency [13].

Developed societies are characterised by a high level of concern for environmental protection and this issue occupies a very important place in the public dialogue of these societies as well as management and policy programmes [14]. A close relationship with environmental awareness is human capital and, in fact, education (which constitutes an important component of human capital) has a particularly strong relationship with environmental problems [9]. Human capital can be described by many definitions. Here we will quote a definition that captures the most important ideas. Human capital can be understood as the aggregation of activity effects related to education, health, workplace training, and migration, which improve productivity in the labour market [15,8]. Some authors add to the definition innate capabilities, understood as physical, intellectual, and psychological abilities that a person obtains at birth [16]. Even though unambiguous definitions of human capital are known, its measurement itself turns out to be a complicated process, due to the different factors used to measure it and the difficulty in expressing these factors numerically. The following are used as determinants of human capital: leadership experience, length of service, work experience in line with the speciality, organisational commitment of employees, IT skills, education, employee skills, attitudes, motivation, and international experience [17,18]. Despite the broad catalogue of listed variables, it is not a closed set and the use of further variables depends on the researchers and the compatibility of the variables used with the idea of human capital itself.

Observations indicating productivity growth associated with human capital have been known for a long time, pointing out the benefits of investing in human capital at both the organisational and individual levels [7]. It is often pointed out that a company's performance, especially at the operational level (not subject to inflation) positively influences the increase in human capital efficiency [17]. A quantitative increase in human capital increases the productivity of employees, the efficiency of machines, and also results in an appropriate approach to customers and also translates into the quality of manufactured products [19]. Some studies confirm that the intellectual capital of companies (a

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component of human capital) has a positive impact on the market value and financial performance of companies, as a result, these relationships allow building durable advantages of companies, especially in emerging economies where different levels of technological progress may affect the process of intellectual capital valuation [20]. It should also be assumed that the sphere related to agriculture is subject to these favourable influences on human capital. Some researchers also make reference to organisational social capital, the relationship between organisational costs and human capital, in these studies. The importance of social capital increases with changes in the nature of work, the organisational structures of workplaces, and competitiveness between organisations [21]. However, it should be remembered that not all analysts agree with the statement that human capital plays a positive role [17]. There are well-known research findings that indicate industry-specific capital plays a special role in specific organizations [22]. Industry-specific capital can also refer to agricultural production. This type of specific capital allows decisions to be made that are consistent with the company's unique strategy, organisational context, and the organisation's competitive environment [23].

There are many reports in the academic literature on human capital issues, but few of these reports address the problem of human capital efficiency itself. We only found reports that focus on the problem of human capital efficiency from a labour market perspective [24] or analyses related to the search for efficiency related to intellectual capital linked to human capital [25].

2. Materials and Methods

Small and medium-sized family farms from Lithuania, Moldova, Poland, Romania, and Serbia were analysed. The qualification criteria for this group of farms were the area of the farm (up to 20 ha), the value of standard production (up to 25 thousand EUR), and the share of own labour involved in agriculture (at a minimum of 75%). The data for the analyses were obtained from a survey conducted on a sample of 960 farms from Lithuania, 532 farms from Moldova, 696 farms from Poland, 872 farms from Romania, and 524 farms from Serbia. Thus, the total sample was 3584 farms. The survey was carried out in 2019.

Data were collected through face-to-face interviews by farm advisors or specialised companies. The interview used a structured questionnaire that contained four thematic blocks of questions: economic and social sustainability, environmental sustainability, market links, and general farm characteristics. To ensure correct data collection pilot studies preceded the main research. The pilot studies included several interviews in selected agricultural holdings in order to check the correctness and clarity of the questions included in the questionnaire. As a result of the pilot studies, incomprehensible questions were removed or corrected and appropriate comments were added to other questions. The economic measure was the value of agricultural production per work hour per ha. The obtained value of the measure was subjected to zero unitisation according to formula (1).

$$\text{stimulant}: z_{ij} = \frac{x_{ij} - \min_i\{x_{ij}\}}{\max_i\{x_{ij}\} - \min_i\{x_{ij}\}}, (i = 1,2, \dots, n; j = 1,2, \dots, k; \text{from} \in [0,1] \quad (1)$$

where:

mini{xij} – minimum value of function j,

maxi {xik} – maximum value of function j,

i – object (the farm in the case under consideration).

The variables used for the synthetic measures of human capital and environmental capital were, in the case of stimulants, subjected to zero unitisation according to formula (1), while in the case of destimulants, formula (2) was applied.

$$\text{destimulant: } z_{ij} = \frac{\max_i\{x_{ij}\} - x_{ij}}{\max_i\{x_{ij}\} - \min_i\{x_{ij}\}}, (i = 1,2, \ldots, n; j = 1,2, \ldots, k; \text{from} \in [0,1] (2)$$

where:
mini{xij} – minimum value of function j,
maxi {xik} – maximum value of function j,
i – object (the farm in the case under consideration).

The synthetic measure of human capital was determined using the following variables: work experience, education, agricultural qualifications, participation in continuing education of the farm owner and their family members, participation in social events of the farm owner and their family members, membership in organisations, associations, and clubs of the farm owner and their family members. A person achieves mastery at the age of retirement and pre-retirement, because at that point they are able to provide their professional and social experience. Between the age of 35 and 55, both women and men reach their highest productivity and make the most significant contribution to social life [26]. Literature concerning changes in the ability to perform work tasks with age states that it increases during the first 10 years of professional life due to general education and learning by doing, and reaches a maximum at around 30-35 years of age. It then stabilises until around age 50, at which point it begins to decline. The process of productivity decline is rather slow and strongly depends on both personal and occupational characteristics [27]. There are well-known studies indicating a pattern in labour productivity rates in different age groups starting from a low level of about 20 per cent in the age group 15-19 and rising to about 80 per cent in the age group 25-55 before falling below 20 per cent at around the age of 65 [28].

On the basis of the above-mentioned literature, it was assumed that agriculture is a laborious task and therefore it was assumed that labour productivity increases from the age of 20 to 35, remains stable between the ages of 36 and 50, and then decreases until retirement at the age of 67 (this age was used to determine the lowest indicator). Therefore, the following indicators were used: age up to 25 years - indicator 0.6, 26-30 years - 0.8, 31-35 years - 0.9, 36-50 years - 1.0, 51-55 years - 0.9, 56-60 years - 0.8, 61-65 years - 0.7, 66 years and over - 0.6. The farmer's age was then multiplied by the corresponding indicator.

The synthetic environmental measure was determined using the following variables: CH_4 emissions per ha, N emissions per ha, soil organic substance balance in tonnes per ha, mineral fertiliser consumption in tonnes per ha, crop protection product expenditure per year per ha, fuel expenditure per year per ha, and electricity expenditure per year per ha.

Methane (CH_4) emissions from enteric fermentation and animal manure were calculated according to the Intergovernmental Panel on Climate Change (IPCC) tier 1 method (IPCC, 2006). Manure from grazing and confined animals was considered to be returned to the pasture system as fertiliser (nutrient cycle) [29].

Gaseous emissions of N_2O, NO, NH_3, and CO_2 from fertiliser application were modelled based on IPCC tier 1 emission factors (IPCC, 2006). The emission rate of N to surface water was assumed to be 10% of applied N [29].

Subsequently, weights for the selected variables were determined using the TOPSIS-CRITIC method (designation of criteria by correlating criteria). In the TOPSIS-CRITIC method, weights are determined on the basis of standard deviations and correlations between variables. A characteristic feature of this method is that relatively higher weights are assigned to characteristics that have a high coefficient of variation while having a low correlation with other characteristics [30]. Variable weights were determined according to the following formulas:

$$w_j = \frac{c_j}{\sum_{k=1}^{m} c_k}, j = 1,2, \ldots, m; c_j = s_{j(z)} \sum_{k=1}^{m} (1 - r_{ij}), j = 1,2, \ldots, m, (3)$$

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where:
cj – a measure of the information capacity of feature j,
sj(z) – standard deviation calculated from the normalised values of the feature j,
rij – correlation coefficient between features j and k.

The next step was to multiply the established normalised values of the variables by the appropriate weighting coefficients. Using the values of the variables after the weighting process, the Euclidean distances of the individual units from the development pattern and anti-pattern were calculated according to the following formulas:

$$d_i^+ = \sqrt{\sum_{j=1}^{k}(z_{ij}^* - z_{ij}^+)^2} - \text{distancefromdevelopmentpattern}, (4)$$

$$d_i^- = \sqrt{\sum_{j=1}^{k}(z_{ij}^* - z_{ij}^-)^2} - \text{distancefromthedevelopmentantipattern}, (5)$$

where:

$$z_j^+ = (\max(z_{i1}^*), \max(z_{i2}^*), \dots, \max(z_{ik}^*)) = (z_1^+, z_2^+, \dots z_i^+)$$
$$z_j^- = (\min(z_{i1}^*), \min(z_{i2}^*), \dots, \min(z_{ik}^*)) = (z_1^-, z_2^-, \dots z_i^-)$$

In the next step, the value of the synthetic characteristic q1 is determined according to the following formula:

$$q_i = \frac{d_i^-}{d_i^+ + d_i^-}, (i = 1,2, \dots, n)(6)$$

Table 1 presents the list of variables used in the TOPSIS-CRITIC analysis and the weights of the different elements.

Table 1. List of variables used to create synthetic measures

Name of the synthetic measure	Name of the variable	Type of the variable	Weight
Human capital	Professional experience	Stimulant	0.693
	Education	Stimulant	0.082
	Agricultural qualification	Stimulant	0.030
	Participation in continuing education - owner of the farm	Stimulant	0.023
	Participation in continuous education - spouse	Stimulant	0.017
	Participation in continuing education - other adults	Stimulant	0.007
	Participation in social - cultural events - owner of the farm	Stimulant	0.024
	Participation in social - cultural events - spouse	Stimulant	0.028
	Participation in social - cultural events - other adults	Stimulant	0.030
	Membership in any organisation, association, club, etc. - owner of the farm	Stimulant	0.030
	Membership in any organisation, association, club, etc. - spouse	Stimulant	0.025
	Membership inf any organisation, association, club, etc. - other adults	Stimulant	0.012

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Name of the synthetic measure	Name of the variable	Type of the variable	Weight
Environmental	CH4 emission per ha	Destimulant	0.221
	N emission per ha	Destimulant	0.228
	Soil organic matter balance in tonnes per ha	Destimulant	0.130
	Mineral fertiliser consumption in tonnes per ha	Destimulant	0.097
	Expenses for plant protection products per year per ha	Destimulant	0.096
	Fuel expenses per year per ha	Destimulant	0.099
	Electricity expenses per year per ha	Destimulant	0.129

Source: own elaboration based on the conducted analyses

Eco-efficiency analysis makes it possible to compare different solutions by determining the relationship between economic factors and environmental factors. Measures of eco-efficiency can indicate the level of innovation and also makes it possible to assess the environmental impact of technologies used [31]. Based on the above formulations, the eco-efficiency (EE) index was determined according to formula (7):

$$\mathrm{EE} = \frac{\mathrm{economicmeasure}}{\mathrm{environmentalmeasure}} \quad (7)$$

Analysis of literature reports indicates that environmental concern is strongly correlated with human capital [32]. The determination of human capital efficiency (HCE) was motivated by literature reports on socio-eco-efficiency (SEE) [33]. Although socio-eco-effectiveness problems seem similar to HCE problems they are however different, as different variables were used in the analyses of these problems [34]. Socio-eco-efficiency studies have considered workers' working conditions (occupational accidents, fatalities, occupational diseases, toxicity potential, wages and salaries, companies' expenditure on vocational training, strikes, and lockouts), data covering the international community (child labour, foreign direct investment, and supplies from developing countries), data on future generations (number of interns, business R&D expenditures, and capital investment), and data on local and national communities (workers, worker qualifications, gender equality, integration of people with disabilities, part-time workers, and family support) [35, 36]. Taking the above into account, it was decided to introduce a new measure, referred to in this paper as the Human Capital Efficiency (HCE) index. The HCE index was determined according to formula (8):

$$\mathrm{HCE} = \frac{\mathrm{economicmeasure}}{\mathrm{humancapitalmeasure}} \quad (8)$$

3. Results and Discussion

Contemporary literature points to small and medium-sized family farms as a special place for creating public goods [37]. An important element when assessing the function of small and medium-sized family farms is the often emphasised low pressure on the environment [38,39]. The low pressure on the environment is also related to the correlated impact of human capital; it is commonly emphasised, among other things, that the higher the farmer's education, the lower the pressure on the environment [40]. The observations carried out in this publication indicate an increase in the value of the economic measure with an increase in the area of the farm (Table 2). This relation was observed in all analysed countries, despite the fact that the average area of farms in each class (determined according to the economic measure) varied, we observe a constant tendency indicating an increase in the economic measure with an increase in farm area. Such a phenomenon can be partly explained by the use of economies of production scale, although, on the other

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hand, small farms usually have a greater opportunity to carry out production requiring higher labour input. Only one exception to the aforementioned rule has been found, and this exception has been observed in analyses pertaining to Serbia, wherein the class with the highest economic measure had an area of a farm lower than the preceding class (marked with letter C in analyses) (Table 2). However, it should also be noted that in analyses concerning Serbia, we observe a very small differentiation of farm area between the analysed classes, since the average area of farms is between 3.93 ha in class A compared to 4.39 ha in class D. It is also important to pay attention to the construction of the economic measure itself, which expresses only one value, namely, the value of agricultural production per 1 ha and, at the same time, per 1 working hour. Thus, the conducted observations clearly indicate that the value of agricultural production per 1 ha and, at the same time, per 1 working hour increases with an increase in the area of a farm.

Table 2. Characteristics of farms grouped by classes of economic measure *

K	N	P	Measures				
			E	KL	S	EE	HCE
Lithuania							
A	240	7.56	0.0451	0.7676	0.0889	0.8219	0.0638
B	240	8.82	0.1112	0.8040	0.0829	2.5532	0.2120
C	240	12.16	0.2033	0.7352	0.0857	4.0938	0.3487
D	240	12.42	0.4334	0.7132	0.0821	7.0416	0.9399
Moldavia							
A	133	4.15	0.0116	0.7080	0.7892	0.0148	0.0194
B	133	4.97	0.0294	0.7115	0.7945	0.0371	0.0508
C	133	5.27	0.0585	0.6562	0.7845	0.0747	0.1154
D	133	6.34	0.1966	0.6643	0.7821	0.2524	0.4139
Poland							
A	174	12.18	0.0300	0.7975	0.7958	0.0392	0.0586
B	174	13.78	0.0512	0.8126	0.8035	0.0649	0.0698
C	174	13.39	0.0785	0.7798	0.8039	0.1000	0.1889
D	174	16.84	0.1872	0.7607	0.7957	0.2425	0.3696
Romania							
A	218	1.39	0.0563	0.7337	0.7286	0.0775	0.1776
B	218	4.06	0.0531	0.7161	0.7414	0.0717	0.1239
C	218	8.11	0.0698	0.7558	0.7441	0.0939	0.1422
D	218	37.08	0.1360	0.7530	0.7447	0.1826	0.2769
Serbia							
A	131	3.93	0.0074	0.6906	0.7481	0.0099	0.0179
B	131	3.71	0.0146	0.7080	0.7409	0.0198	0.0231

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K	N	P	Measures				
			E	KL	S	EE	HCE
C	131	4.50	0.0263	0.6919	0.7419	0.0355	0.0440
D	131	4.39	0.0791	0.6701	0.7385	0.1080	0.1445

*K – class designated by economic measure, N - number of objects in class, P - farm area, E - economic measure, KL - human capital measure, S - environmental measure, EE - Eco-Efficiency, HCE - Human Capital Efficiency
Source: own elaboration based on the conducted analyses

Taking into account the above relationship, it is very interesting to check how the Eco-Efficiency measure develops, understood as the relation of the economic measure to the pressure on the environment, in this paper expressed by the environmental measure (the construction of the measure is discussed in the methodological part of this paper). Analysing the above relation, we find that the Eco-Efficiency (EE) indicator also increases with an increase in the area of a farm; this expresses the difference between the analysed classes as determined by the aforementioned economic measure. Similar relationships have also been observed in other studies conducted in Poland, these studies show that farms with higher Eco-Efficiency are characterised by a larger area of farmland, a higher value of production and a higher intensity of economic expenditures incurred per 1 ha, but at the same time lower expenditures incurred per production unit [41]. The EE differentiation in this study will be supported by an assessment of contrasts (Table 3).

Table 3. Contrasts assessment

Name	N	Class	Mean values	SSeffect	Contrast 1 (1;0;0;-1)	Contrast 2 (0;1;0;-1)	Contrast 3 (0;0;1;-1)	Contrast 4 (1;-1;0;0)	Contrast 5 (0;1;-1;0)
Lithuania									
Eco-Efficiency	240	A	0.8219	5015.8	0.93	0.48	0.21	0.07	0.06
	240	B	2.5532						
	240	C	4.0938						
	240	D	7.0416						
Human Capital Efficiency	240	A	0.0638	106.1	0.87	0.60	0.40	0.02	0.02
	240	B	0.2120						
	240	C	0.3487						
	240	D	0.9399						
Moldavia									
Eco-Efficiency	133	A	0.0148	4.651	0.81	0.66	0.45	0.01	0.02
	133	B	0.0371						
	133	C	0.0747						
	133	D	0.2524						

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Human Capital Efficiency	133	A	0.0194	13.001	0.80	0.67	0.46	np	0.02
	133	B	0.0508						
	133	C	0.1154						
	133	D	0.4139						
Poland									
Eco-Efficiency	174	A	0.0391	4.299	0.84	0.64	0.41	0.01	0.03
	174	B	0.0649						
	174	C	0.1000						
	174	D	0.2425						
Human Capital Efficiency	174	A	0.0586	10.899	0.77	0.72	0.26	np	0.11
	174	B	0.0698						
	174	C	0.1889						
	174	D	0.3696						
Romania									
Eco-Efficiency	218	A	0.0775	1.7435	0.69	0.77	0.49	np	0.03
	218	B	0.0717						
	218	C	0.0939						
	218	D	0.1826						
Human Capital Efficiency	218	A	0.1775	3.0469	0.35	0.84	0.65	np	np
	218	B	0.1239						
	218	C	0.1422						
	218	D	0.2769						
Serbia									
Eco-Efficiency	131	A	0.0099	0.7745	0.81	0.66	0.44	np	0.02
	131	B	0.0198						
	131	C	0.0354						
	131	D	0.1079						
Human Capital Efficiency	131	A	0.0179	1.3773	0.76	0.70	0.48	np	np
	131	B	0.0230						
	131	C	0.0439						
	131	D	0.1445						

Source: own elaboration based on the analysed data

We also note that the value of EE increases with increasing farm area. Other studies indicate that EE increases with increasing farmland area, income per farmer family member and family size [42]. Reports on the evolution of EE are varied, and studies are known that show a completely different relationship, that is, in which EE is indicated to decrease

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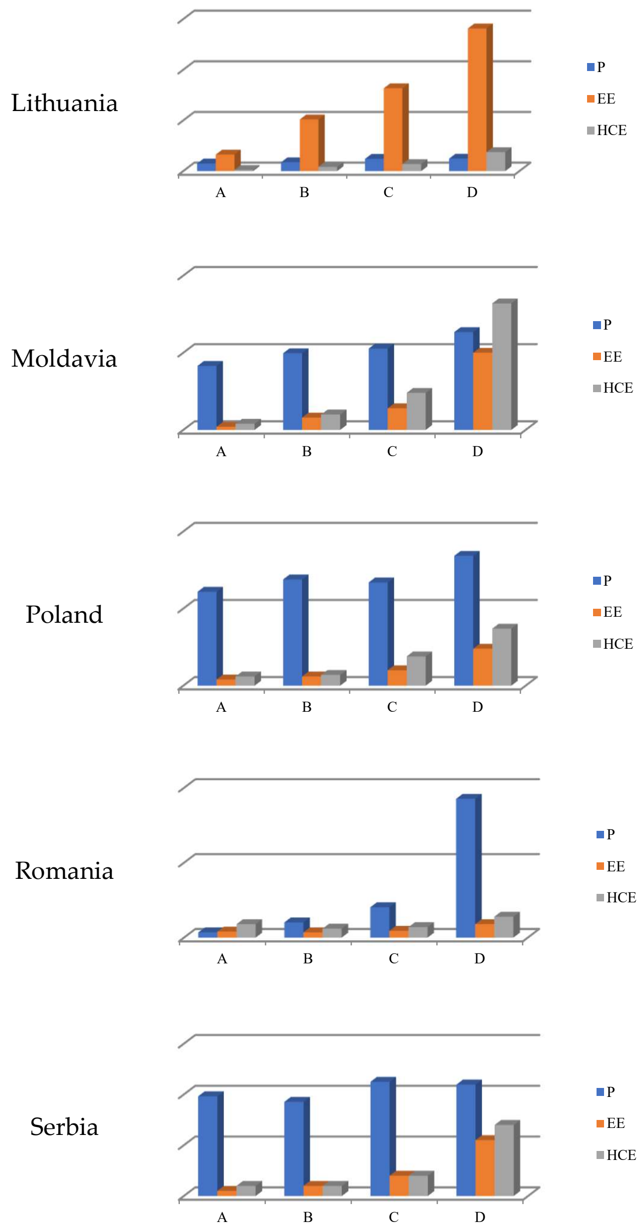
with increasing farm area [43]. In the presented research, the highest difference occurs between the value of EE in class A in relation to class D (class with the highest value of the economic measure), interestingly the same relationship was observed in all analysed countries. The above differentiation was supported by the results of the contrast assessment. The differences between classes A, B, and C in relation to class D turned out to be statistically significant in each of the analysed countries, i.e. Lithuania, Moldavia, Poland, Romania, and Serbia. The contrast between class A (the lowest economic measure) and class D varied from 93% (Lithuania) of the variation in group averages to 63% (Romania). Similar relationships were also found in the data from the other countries analysed, namely Moldavia (81%), Poland (84%), and Serbia (81%), the explanation of the variation of group averages between the analysed classes (Table 2). Also, when evaluating the contrast between class B and D we find statistically significant differences in all analysed countries. The highest level of variation between class B and D was found in the Romanian data (77%) and the lowest in the Lithuanian data (48%) (Table 3). Further analysis shows that an even lower level of variation in EE is found between classes C and D, although these differences are still statistically significant. The highest value of explaining the differences between the classes in question was found in Romania (49%) and the lowest value of explaining the differences between classes C and D was found using data from Lithuania (21%) (Table 3). As we note in Table 3, the value of explained variation is getting lower and lower as we approach the D (highest) EE class. There is a common opinion that large-scale farms exert high pressure on the environment and consequently have a low EE [43]. In the described research we notice a reverse tendency, which is also confirmed in the literature, i.e. EE increases with an increase in the area of farms [10,41]. However, it should be taken into account that the small and medium-sized family farms that were analysed are generally farms with extensive management, in contrast to large-scale farms, which have intensive management and thus create strong environmental pressure [44]. Some researchers point out that not only small and medium-sized family farms, as in this study, but also farms with high economic power are characterised by an increase in eco-efficiency, but this does not mean that these farms show lower absolute pressure on the environment [45].

There are known scientific reports indicating farmers' age and family size have a positive impact on EE, both of which can be considered as components of human capital [46]. Also, there are studies indicating the broad importance of human capital for agriculture including the impact of this factor on EE [47]. In view of the above, the next value analysed is Human Capital Efficiency (HCE). The rationale for analysing this value was based on literature reports indicating the impact of human capital even on GDP, if the analyses were conducted on a macroeconomic scale [48]. There are also analyses indicating the influence of human capital on EE, especially through its close relationship with eco-innovativeness [49]. This makes human capital even more crucial in small and medium-sized family farms [50]. Thus, analogous analyses to those already discussed and related to EE were conducted. The highest value of explaining group variation between class A HCEs was found in data from Lithuania (90%) in relation to class D of this size. The lowest degree of explained variability in class A in relation to class D was found in data from Romania (31%). It can be assumed that in general there are similar relationships as with EE, that is, the level of explained variability decreases in successive classes (B and C) approaching HCE's class D (the class with the highest value of the economic measure). The only exception is the data from Romania, where it was found that the explained variability between class B and D significantly exceeds the level of variability between class A and D (Table 3). Similar relationships to EE, as related to HCE, indicate that a large reservoir of human capital are the smallest farms managed either by elderly people or by people with their main source of income outside agriculture, probably very often lacking the motivation to increase farm size. With the same potential of human capital, its efficiency therefore increases with an increase in farm area, since each of the areas of small farms could be served by human capital from small farms (excluding farmers with physical limitations due to age and health conditions). The potential of human capital in small farms is also probably not adequately used due to limitations related to the implementation of innovative solutions improving the economic measure of the analysed farms.



Legend: P - area, EE - Eco-Efficiency, HCE - Human Capital Efficiency

Figure 1. Relation of farm area to Eco-Efficiency and Human Capital Efficiency.
Source: own elaboration based on analysed data

4. Conclusions

The analyses carried out in five European countries covering small and medium-sized family farms allow us to conclude that Eco-Efficiency increases with the area of the farm, and it should be assumed that the increase in EE has a limit value, after which EE

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decreases. This suggestion can be substantiated by literature reports on the significant environmental pressure caused by large-scale farms [44].

It was also found that HCE increases with EE, this can be explained by the accumulation of human capital in small farms which greatly exceeds the capacity to use it, resulting in low HCE in small farms and a gradual increase in this indicator in farms with a larger area (Figure 1).

The low value of EE in small farms also confirms the rather extensive nature of agricultural production due to the treatment of small family farms as an additional activity, not oriented towards commodity production. Moreover, considering the fact that owners of small farms most often work off-farm, this fact should be associated with above-average education for small farms, which contributes to a higher value of the Human Capital index.

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Appendix A **Tests of significance**

Effect	Multivariate Tests of Significance; Sigma-restricted parameterization; Effective hypothesis decomposition					
	Test	Value	F	Effect df	Error df	p
Lithuania						
Intercept	Wilks	0.03197	7215.209	4	953.000	0.00
	Pillai's	0.96803	7215.209	4	953.000	0.00
	Hotellng	30.28419	7215.209	4	953.000	0.00
	Roy's	30.28419	7215.209	4	953.000	0.00
Class - economic measure	Wilks	0.44485	75.272	12	2521.693	0.00
	Pillai's	0.57154	56.190	12	2865.000	0.00
	Hotellng	1.21130	96.063	12	2855.000	0.00
	Roy's	1.18056	281.859	4	955.000	0.00
Moldavia						
Intercept	Wilks	0.0015	87392.70	4	525.000	0.00
	Pillai's	0.9985	87392.70	4	525.000	0.00
	Hotellng	665.8491	87392.70	4	525.000	0.00
	Roy's	665.8491	87392.70	4	525.000	0.00
Class - economic measure	Wilks	0.4659	38.75	12	1389.311	0.00
	Pillai's	0.5445	29.22	12	1581.000	0.00
	Hotellng	1.1243	49.06	12	1571.000	0.00
	Roy's	1.1043	145.49	4	527.000	0.00
Poland						
Intercept	Wilks	0.01241	13703.89	4	689.000	0.00
	Pillai's	0.98759	13703.89	4	689.000	0.00
	Hotellng	79.55813	13703.89	4	689.000	0.00
	Roy's	79.55813	13703.89	4	689.000	0.00
	Wilks	0.55019	38.50	12	1823.214	0.00

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Effect	Multivariate Tests of Significance; Sigma-restricted parameterization; Effective hypothesis decomposition					
	Test	Value	F	Effect df	Error df	p
Class - economic measure	Pillai's	0.45182	30.63	12	2073.000	0.00
	Hotellng	0.81391	46.64	12	2063.000	0.00
	Roy's	0.80941	139.83	4	691.000	0.00
Romania						
Intercept	Wilks	0.001	255497.0	4	865.000	0.00
	Pillai's	0.999	255497.0	4	865.000	0.00
	Hotellng	1181.489	255497.0	4	865.000	0.00
	Roy's	1181.489	255497.0	4	865.000	0.00
Class - economic measure	Wilks	0.788	17.9	12	2288.866	0.00
	Pillai's	0.221	17.2	12	2601.000	0.00
	Hotellng	0.257	18.5	12	2591.000	0.00
	Roy's	0.199	43.1	4	867.000	0.00
Serbia						
Intercept	Wilks	0.0024	53456.87	4	517.000	0.00
	Pillai's	0.9976	53456.87	4	517.000	0.00
	Hotellng	413.5928	53456.87	4	517.000	0.00
	Roy's	413.5928	53456.87	4	517.000	0.00
Class - economic measure	Wilks	0.7117	15.64	12	1368.145	0.00
	Pillai's	0.2904	13.91	12	1557.000	0.00
	Hotellng	0.4022	17.28	12	1547.000	0.00
	Roy's	0.3948	51.22	4	519.000	0.00

Source: own elaboration based on analysed data

Appendix B **Tukey's 1HSD Test for dependent variables of Eco-Efficiency**

Approximate Probabilities for Post Hoc Tests Error: Between MS = 7.7283, df = 956.00				
Class	**A**	**B**	**C**	**D**
Lithuania				
A		0.000008	0.000008	0.000008
B	0.000008		0.000008	0.000008
C	0.000008	0.000008		0.000008
D	0.000008	0.000008	0.000008	
Moldavia				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.00800, df = 528.00				
A		0.175025	0.000008	0.000008
B	0.175025		0.003461	0.000008
C	0.000008	0.003461		0.000008
D	0.000008	0.000008	0.000008	
Poland				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.00831, df = 692.00				
A		0.042334	0.000008	0.000008
B	0.042334		0.001839	0.000008
C	0.000008	0.001839		0.000008
D	0.000008	0.000008	0.000008	

Romania				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.01336, df = 868.00				
A		0.953136	0.449550	0.000008
B	0.953136		0.186084	0.000008
C	0.449550	0.186084		0.000008
D	0.000008	0.000008	0.000008	
Serbia				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.00384, df = 520.00				
A		0.568489	**0.004685**	**0.000008**
B	0.568489		0.170860	**0.000008**
C	**0.004685**	0.170860		**0.000008**
D	**0.000008**	**0.000008**	**0.000008**	

Source: own elaboration based on analysed data

Appendix C **Tukey's HSD Test for dependent variables of Human Capital Efficiency**

Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.37664, df = 956.00.				
Class	**A**	**B**	**C**	**D**
Lithuania				
A		**0.040667**	**0.000010**	**0.000008**
B	**0.040667**		0.069839	**0.000008**
C	**0.000010**	0.069839		**0.000008**
D	**0.000008**	**0.000008**	**0.000008**	
Moldavia				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.05969, df = 528.00				
A		0.721033	**0.007419**	**0.000008**
B	0.721033		0.135821	**0.000008**
C	**0.007419**	0.135821		**0.000008**
D	**0.000008**	**0.000008**	**0.000008**	
Poland				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.19308, df = 692.00				
A		0.995328	**0.029125**	**0.000008**
B	0.995328		0.055737	**0.000008**
C	**0.029125**	0.055737		**0.000739**
D	**0.000008**	**0.000008**	**0.000739**	
Romania				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.23331, df = 868.00				
A		0.652231	0.870734	0.138152
B	0.652231		0.978958	**0.005210**
C	0.870734	0.978958		**0.018855**

D	0.138152	**0.005210**	**0.018855**	
Serbia				
Approximate Probabilities for Post Hoc Tests Error: Between MS = 0.01240, df = 520.00				
A		0.982202	0.231287	**0.000008**
B	0.982202		0.426294	**0.000008**
C	0.231287	0.426294		**0.000008**
D	**0.000008**	**0.000008**	**0.000008**	

Source: own elaboration based on analysed data

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