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CAPITALIZATION WITH AGRICULTURAL MACHINES VS. SERVICES FOR AGRICULTURE

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Abstract

The purpose of the research is to determine the specific capital costs of carrying out agricultural work with the farmers'own agricultural machines compared to the costs of agricultural services. A stratified sample based on economic size was used, consisting of 60 farms specialised in large crops from the NE and SE development regions of Romania. The novelty elements of this research consist in the fact that the analysis of the efficiency of the use of agricultural machinery uses a shadow cost—the opportunity cost—to determine the specific income of the use of agricultural machinery. The results show that small farms spend more than twice as much to carry out agricultural work with their own agricultural machinery. The average expenses per ha specific to the agricultural works carried out by farmers with their own agricultural machines recorded an average of 376.3 euro/ha for farms with a size smaller than 100 thousand SO and 186.5 euro/ha for farms with a size greater than 700 thousand SO. For a representativeness level of 69.3%, farms with a size smaller than approx. 578 thousand SO register losses if they carry out agricultural work with their own agricultural machines. This threshold can be appreciated on an area of approx. 854 ha cultivated with grain corn, common wheat, and rapeseed in equal proportions. Using the rationales and cost analysis models presented can help farmers make rational investments and strengthen informed demand in the agricultural services market.

Key words**:** *capital cost, agricultural machinery, agrarian economy, services for agriculture, economic efficiency*

INTRODUCTION

Society's demands for sustainable food systems require the adaptation of strategic and tactical decisions within agricultural systems [23]. Both in conventional agriculture and in ecological agriculture [34], it is necessary to implement advanced technological measures such as precision agriculture [37, 25], digital decision support systems [24, 36], and modern technologies [15, 22]. All these measures require investments, and the investment behaviour of farms has a differentiated impact depending on their size and type [38, 4, 20]. The current stage of research includes models for determining the optimal dimensions of the agricultural machinery assembly, taking into account operation and maintenance costs [29]. They take into account the restrictions related to the management of agricultural machinery, production structure, and soil conditions [27, 28]. Thompson, Ned O states after conducting research in Arizona that a farmer's decision to contract certain operations or perform them with his own equipment depends on factors such as cost, efficiency, and the need for supervision. He found that purchasing agricultural services resulted in cost savings and increased production for many farmers [33]. Michael Duffy shows that in agriculture, by increasing production, costs initially decrease but reach a point where they remain relatively constant or even begin to increase [8, 28, 32]. Farmers must decide which activities they will carry out through their own efforts and which will be transferred to other units [6, 42]. For small farmers in China, mechanisation services have become an important solution because they are more cost-effective and allow farmers to focus on other aspects of agricultural production [41]. Agriculture in this country stands out through a new orientation based on more balanced and

sustainable processes [12], such as the outsourcing of agricultural production by rebuilding the service system for agricultural production [31]. In Spain, outsourcing is perceived as a mechanism to rationalise production in the context of small-scale agriculture and the generator of a new segment of skilled workers who provide specialised services, such as phyto-sanitary treatments, with the aim of reducing production costs. [19]. The outsourcing of agriculture has become a topic of intense debate globally [1, 5]. The outsourcing action consists in the decision to assign, with payment, some of the company's own activities to another third party [13]. This concept is most often used in relation to entrusting certain activities to a supplier and even includes the outsourcing of the manufacturing process of certain goods. This process may involve the transfer of an important business function to the external environment [18].

Costs are determining factors that influence the management of agricultural enterprises [21, 35]. The cost reduction of a product cannot be determined independently of the other production options, such as product mix, production capacity, and price [14]. This effort is based on results provided by applied scientific research [26, 40].

The purpose of the research presented in this article is to determine the capital costs specific to agricultural machinery compared to the costs of agricultural services. The results allow establishing the opportunity for investments in agricultural machines in the conditions where farms have the alternative of using agricultural services.

The novelty elements of this research consist in the fact that the analysis of the efficiency of the use of agricultural machinery uses a shadow cost—the opportunity cost—to determine the specific income of the use of agricultural machinery.

MATERIALS AND METHODS

The objectives of the research were represented by: (1) quantifying the economic effect determined by saving costs with agricultural services from third parties; (2) determining the specific economic efficiency of carrying out works with agricultural machines owned by farmers; (3) identifying the level of economic size of the farms from which it is efficient to carry out the works with their own agricultural machinery.

The research was carried out on a sample stratified by economic size consisting of 60 farms specialised in large crops located in the NE and SE development regions of Romania, 30 per region, and 5 per county. Each group of 5 farms from each county was classified by category: under 100 thousand SO; 100 thousand SO-250 thousand SO; 250 thousand SO-500 thousand SO; 500 thousand SO-750 thousand SO; more than 750 thousand SO [3]. The economic size was determined based on the crop structure, the area owned by each crop, and the SO conversion coefficient [9, 10].

The research plan included a stage of gathering information through a questionnaire, cost analysis, and a focus group session with relevant people for the researched field.

The objectives of the questionnaire were representative of obtaining information regarding: (a) the level of agricultural service tariffs; (b) the size of the costs determined for carrying out agricultural work with machines owned by farmers; and (c) the economic dimension of the researched farms. The obtained indicators were: my tariff of agricultural works for the main crops (lei/ha), the value of the subsidy for diesel (lei/l), showing the financial expenses with which farmers obtain credits (%), diesel consumption for agricultural works on crops (l/ha), the amount of depreciation at the farm level (lei), the expenses with the salaries of the mechanics at the company level (lei), the expenses with the repairs at the farm level (lei), the expenses with the maintenance of the agricultural machines at the company level (lei), expenses with fees and taxes at the company level (lei), and the area of each crop established in the agricultural year 2023 (ha).

The need to gather a lot of specific information from the research subjects and analyse these data effectively drove the use of

the questionnaire [39]. It allowed for an understanding of farmers' mental processes and how they influence their decisions and actions on the farm [16].

The researched subjects were the managers or administrators of the 60 farms sampled by county, economic size, and development region. The content of the questionnaire was structured in two sections: questions about the tariffs of agricultural services, questions about the costs of carrying out agricultural work, and questions about the profile of the farm. The type of question chosen was a short text answer. The questionnaire creation and administration forms were online on the Google Forms platform [30].

The questionnaire was created in the 1st quarter of 2023, tested in the 2nd quarter on 6 managers from the sample, and administered in the 3rd quarter of the same year. The administration was done by email and messages through social networks, accompanied by the necessary explanations. Calls asking for accurate and complete answers came before the messages.

The subjects were assured that their answers would be used exclusively for the research objectives, and individual persons and organisations were managed in a protected flow.

The validation of the questionnaires required telephone discussions with the farmers to correct some information. The information used was processed during the economic analysis stage.

For the determination of economic efficiency, indicators were given when converting values into European currency at the exchange rate of the central bank on July 1, 2023.

The objectives of the cost analysis consisted of determining the actual costs, the opportunity costs, and the threshold of economic size of the farm from which it is profitable to carry out agricultural work with its own equipment. The indicators were determined according to the following reasoning: a. The income obtained from carrying out agricultural work with one's own cars was determined as the sum of the opportunity cost specific to agricultural service tariffs, to which the diesel subsidy and interest were added to the first two values. b. the specific costs achieved in the works with the own agricultural machines totalled the diesel expenses, the salary expenses, the depreciation expenses, the repair and maintenance expenses of the agricultural machines, the financial expenses, and the fees and taxes expenses. All these expenses were related to the agricultural area to determine the costs in lei/ha. The resulting synthetic indicators were the profit specific to the realisation of agricultural works and the profitability rate specific to the realisation of agricultural works. The first was determined as the difference between the specific incomes of carrying out agricultural work with their own machines and the costs necessary for these activities. In the second indicator, it was determined as a percentage ratio between this profit and the specific costs of carrying out agricultural work with own machines [2].

It is necessary to mention that this analysis compared the realisation of agricultural works with own agricultural machines with services for agriculture. An intermediate alternative for farmers would be to rent machinery for their own agricultural work. This was not analysed in this research because it involves the use of internal farm resources that farmers do not quantify properly, and the results would not have been relevant.

The third stage of the research consisted of conducting a two-way focus group session, which involved collecting data from a small group of participants who were relevant to the research objectives and could provide opinions on the topic.

The motivation for using a focus group in this research is based on the advantages that this method presents, such as facilitating the exchange of opinions, the possibility of obtaining adjacent information, and the interactive approach that can reveal deep perceptions and needs. Farmers' participation in the research process ensures a clear picture of the technological changes in agriculture and the agricultural systems adopted [31].

The objectives of this stage were also included in the moderation guide for the focus group and consisted of: knowing the reaction of the participants to the results obtained in

the research through the questionnaire; justification of the main results; determining the implications of these results; and identifying the necessary measures to improve the graduates' skills.

The focus group participants were selected from the following categories: 6 representative employers for the agri-food sector, 3 students selected from the interview stage for belonging to the three faculties and interested in the theme of this research, and 3 professors who taught disciplines specific to the agri-food field. The organisers of the session were 3 members of the research team, with the roles of moderator, responsible for recording information (logistics insurance), and observer of the participants' behaviour.

The interaction with the participants took place online after prior information about the time, duration, objectives, and way of working.

The session took place in the first quarter of 2023 and lasted three hours, with two 10-minute breaks based on the moderation guide that included clarifications on the interaction method and guiding questions structured around the four objectives of the action. Participants shared their views on these objectives, which were summarily scored. After the first hour of discussions, lists of opinions were drawn up for each research objective (4 lists of the opinions of the 12 people), and the participants were then asked to choose the components with which they most agreed. They were given a limited number of 3 options per list [7, 17]. After the debates ended, the research team conducted a short debate where the results were centralised, correlated with the observations, and the final results were determined. The collected data were structured and centralised in order to draw up the investigation report. The focus group period was in the first quarter of 2023 and lasted three hours with two 10-minute breaks.

The statistical processing of the data was carried out with the software IBM SPSS Statistics 29 and Microsoft Office Pro Plus 2021. The statistical analysis included the size of the phenomenon, multiple Pearson correlations, and regression analysis between the economic dimensions of the farms and economic efficiency indicators.

The researchers ensured the relevance of the research for the economic environment and the observance of the principle of intellectual property [11].

RESULTS AND DISCUSSIONS

The income determined by the costs saved on agricultural services varies by firm size, in favour of large firms because they have stronger bargaining power than small farms. The opportunity cost or tariff of agricultural services is on average 201.9 euros/ha, 4.8% higher for firms with a size smaller than 100 thousand SO and 7.2% less for farms with a size greater than 700 thousand SO. Other revenues associated with agricultural services are subsidies for diesel, which have the same value regardless of the size of the farm (12.8 euro/ha).

In contrast, the opportunity cost of the financial expenses that would have been incurred with the allocation of working capital for agricultural services differs according to the size of the farm because large-sized farms have better economic creditworthiness and will receive more favourable credit offers. Thus, if the average financial income for the whole sample was 2.3 euro/ha, the difference between the financial income for farms less than 100 thousand SO and the financial income for farms over 700 thousand SO is 55.1%. Consequently, the average income determined by saving costs with agricultural services is 216.9 euro/ha, with a positive variation of 10.6 euro/ha for companies less than 100 thousand SO and a negative variation of 9.4 euro/ha for companies over 700,000 SO. Larger farms currently enjoy advantages over the others, but these revenues only reflect shadow costs avoided and do not represent the full scope of the phenomenon. On the other hand, the actual costs of carrying out agricultural work make it possible to better appreciate the differences in efficiency recorded between farms of different sizes (Table 1).

Table 1. Analysis of income (opportunity cost), costs, profit, and efficiency of the use of own agricultural machinery within farms by economic size (thousand SO)

Economic size (thousand SO)/actual costs and opportunity costs (euro/ha)	under 100	100 - 250	250 - 500	500 - 750	over 750
The price of agricultural works with farm's own machines	**211.6**	**206.2**	**205.8**	**193.0**	**192.8**
Expenses – agricultural works with farm's own machines	**376.3**	**326.5**	**217.6**	**202.9**	**186.5**
Diesel	143.9	138.6	111.5	108.8	107.3
Wages	28.5	26.9	19.4	15.8	14.6
financial expenses	15.5	10.6	8.7	9.2	10.1
amortisation	114.6	88.7	60.2	52.4	38.5
Repairs	52.1	48.6	10.3	9.7	9.1
maintenance	18.5	11.4	6.0	5.6	5.6
insurance	2.6	1.2	1.0	0.9	0.9
taxes and fees	0.6	0.5	0.5	0.4	0.4
Incomes specific to agricultural works	**15.9**	**15.2**	**14.8**	**14.7**	**14.7**
revenues from operating subsidies	12.8	12.8	12.8	12.8	12.8
income from financial assets	3.1	2.4	2.0	1.9	1.9
Gross profit specific to agricultural works with farm'sown machines	**-148.8**	**-105.1**	**3.0**	**4.8**	**20.9**
Rate of return specific to agricultural works (%)	**-39.6**	**-32.2**	**1.4**	**2.3**	**11.2**

Source: Own calculations.

The diesel costs determined by the use of own agricultural machinery in the researched farms were on average 122.0 euros/ha, 17.9% higher for farms with a size smaller than 100 thousand SO and 12.11% less for farms with larger sizes of 700 thousand SO. These differences are mainly due to the age of agricultural machinery and the degree of fragmentation of cultivated land. On the one hand, large and some medium-sized farms own newer and more technologically efficient farm machinery. Small and some medium-sized farms own older machines, models that are less technologically advanced and less efficient. On the other hand, large farms make constant efforts to compact soils in order to increase production yields. Small farms do not have the human, capital, and logistical resources necessary for this effort.

In terms of wages, the costs should not differ much because they are aligned with the mechanised labour market. However, the productivity of mechanics is proportional to the productivity of the agricultural machines they handle. Thus, compared to an average salary expenditure of 21.0 euro/ha per sample, farms with a size smaller than 100 thousand SO spend 35.5% more, and those with a size larger than 700 thousand SO spend 31.4% less.

Finance costs are, as in the case of the income obtained from the saving of financial expenses that would have been necessary to finance the services, determined by the creditworthiness of the farms and consequently will be higher for small farms and lower for large farms. If the average of the sample was 10.8 euros/ha, farms with a size smaller than 100 thousand SO spent 43.2% more, and those with a size larger than 700 thousand SO 6.7% less compared to the average.

The variation in absolute values of depreciation expenses registers the highest values (76.1 euros/ha). Compared to the average of 70.9 euros/ha for the sample, farms with a size smaller than 100 thousand SO spend 61.7% more, and those with a size larger than 700 thousand SO 45.7% less. This gap is due to the level of correlation between the production capacity of agricultural machines and the exploited agricultural area. Although farmers with small holdings use older agricultural machines and the depreciation value is related to a greater number of hours of use, their management does not have the economic tools to optimise the level of investment. The focus group analysis showed that investments are often made based on emotional criteria, such as the frustration felt when farmers do not have the

agricultural machinery needed for important work that significantly influences the condition of crops. An analysis that would clarify the situation, such as the comparative one between the costs of the additional capital needed to solve these problems and the effect of these events on the profitability of agriculture, is totally non-existent.

Consequently, it is reasonable to suspect that investments are made disproportionately to the economic effects they would cause. Added to all this is the purchase of second-hand agricultural machines that have a lower value, but this is related to a much smaller number of remaining operating hours. And these determine the high values of depreciation expenses. Repair costs are also determined by the level and efficiency of farm capitalization, as well as by the age of agricultural machinery. Average repair costs were 26.0 euros/ha, more than twice as high on farms with a size of less than 100 thousand SO (100.7% higher) and 64.9% lower on farms with a size of more than 700 thousand SO. It is likely that the incidence of repairs has effects not only on costs but also on the volume of productions because it causes the interruption of agricultural works and their shift from the optimum period from a technical and economic point of view. This theme may be the subject of future research. Maintenance expenses are higher for small farms because they rarely call on specialised services and most of the time carry out the maintenance of agricultural machinery with their own mechanists who are semi-specialised or unspecialized. In addition, it does not allocate the salary paid to them to activities of this kind, but these salaries are actual expenses. This results in a positive difference of 96.3% for farms with a size less than 100 thousand SO and a negative difference of 41.8% for farms with a size greater than 700 thousand SO. These are compared to a sample average of 9.4 euros/ha. Insurance is less accepted by farmers but is required for the purchase of new agricultural machinery with financing from grants or loans. The same factors that determine depreciation expenses also affect these expenses. The differences depending on the size are notable, but the low volume of these expenses (1.3 euros/ha) mitigates the impact on the total costs. Because all types of farms must abide by national legislation, the costs shouldn't vary much in terms of taxes and fees; rather, a more effective allocation of fixed capital results in a reduction in taxes on its object. Consequently, compared to an average of 0.5 euro/ha per sample of tax expenses, farms with a size smaller than 100 thousand SO spend 29.9% more, and those with a size larger than 700 thousand SO by 15.6% less.

As the sum of the expenses presented previously, the total expenses specific to the realisation of agricultural works carried out by farmers with their own agricultural machines recorded an average of 262.0 euros/ha, with positive variations of 43.7% for farms with a size smaller than 100 thousand SO and negative variations of 28.8% for farms larger than 700 thousand SO. Basically, small farms spend more than twice as much to carry out these tasks. In other similar research, it was also found that the purchase of agricultural services led to cost savings [15].

Consequently, the gross profit specific to the use of own agricultural machines within the researched farms is negative for the sample average, showing a loss of -45.1 euros/ha. Obviously, the economic efficiency indicator is also negative, expressing an average loss of 11.4 euros for every 100 euros spent on carrying out the work with the agricultural machines that the farmers own. These results are in correlation with other research showing that farm work done with machine systems causes losses for small farms [13].

The presentation of these results in the focus group session had a significant impact and led to discussions about the technical aspects involved in owning farm machinery and the malfunction of the agricultural services market. Some farmers, especially those with small and medium holdings, stated that the results are mainly focused on the economic implications of farm capitalization, but the ownership of agricultural machinery is a necessity to ensure control and the ability to intervene in unforeseen situations. Most participants agreed that the agricultural

services market is not sufficiently well represented in terms of supply, competition is low, and the quality and promptness of services are not always satisfactory. A demand with high variability and low predictability can also be the cause of this phenomenon. Farmers call on these services sometimes at the last minute or episodically as needed.

Service providers cannot properly manage their production capacities under these conditions. For this reason, this branch of services is not attractive enough for investors. These phenomena delay the consolidation of a competitive market with beneficial effects for both parties. Farmers with holdings larger than 750 thousand SO stated that they have digital decision support applications and that they provide information about the need for agricultural machinery depending on the cultivated agricultural area and crop structure. These applications entail significant financial and human resource costs but provide useful information about the size of agricultural machinery production capacity.

The efficiency of using one's own agricultural machinery does not only derive from economies of scale determined by large production capacities but also from the level of utilisation of these capacities.

Small farms own agricultural machinery that they use to a small extent, which has an impact on capital costs.

The correlation made between the economic size of the farms and the profit resulting from the use of their own agricultural machines (Fig. 1) resulted in a Pearson coefficient with a value of 0.749.

The correlation is significant at the 0.01 level (2-tailed). This correlation indicates that, in approximately 75% of cases, the increase in economic size makes it possible to increase the profit specific to the use of agricultural machinery.

The regression analysis generated a logarithmic function of the form -441.7 + 69.1 x log(x) with the coefficients: R 0.833, R Square 0.693.

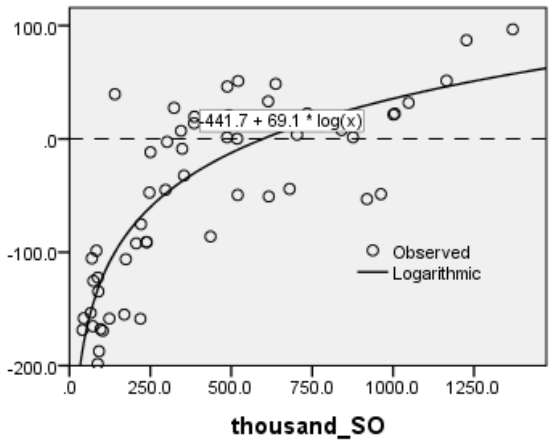


Fig. 1. Regression analysis between the economic size of farms and the average profit resulting from the use of their own agricultural machinery (Euro/ha)
Source: Own calculation.

Adjusted R Square 0.688, Std. Error of the Estimate 43,958. The level at which the profit is zero for carrying out agricultural work with own machines was determined based on the regression equation at approx. 578 thousand SO. This size can be expressed in an area of approx. 854 ha cultivated with grain corn, common wheat, and rapeseed in equal proportions. For 69.3% of farms above this size, doing agricultural work with their own machines becomes profitable. These thresholds are also presented in other models for determining the optimal dimensions of the agricultural machinery assembly, taking into account operation and maintenance costs [30].

The shape of the estimated regression curve indicates fairly low levels of average profit in the size range of 250–750 thousand SO, and farmers with holdings close to the minimum value of this range estimated that they are willing to assume the loss of this profit for the benefit of increasing control over the activity, in particular, in unforeseen situations. They stated that they are willing to "lose a few euros per ha" but to have machinery on the farm in case of unforeseen situations. We believe that this reasoning is determined by a lack of confidence in the quality of services that the market can offer. Only a competitive market could guarantee the promptness and calibre of agricultural services to replace farmers' capacity for intervention with their own machinery and, consequently, the calibre of the agricultural work they perform.

The practical utility of these results resides primarily in the need to carry out these reasoning at the farm level. Farmers need to know the impact of equity costs on economic performance. Also, this cost analysis model can be used to determine the appropriateness of some investments when their impact on economic results cannot be determined in other ways. Perhaps last but not least, the consolidation of an agricultural services market can be achieved on the basis of a rational and informed demand. This approach is a step forward in analysing the opportunity for this type of service.

The scope of the phenomenon that was the subject of these studies determined their limitations. For this reason, the analysis was carried out in full on agricultural machines and only on this category of capital elements. We consider and recommend for further research, on the one hand, the research of all capital elements specific to agriculture and, on the other hand, the realisation of a systemic analysis on each group of agricultural machines (tractors, combines, and agricultural machinery) and the determining relationships among these. It can also be considered a limitation that a differentiated analysis was not carried out on the rental of agricultural machines, but this alternative of farmers was included in the analysis of services for agriculture. The arguments have been presented previously, but future research may also consider this alternative.

CONCLUSIONS

Small farms spend more than twice as much to do farm work with their own farm machinery. The average expenses per ha specific to the agricultural works carried out by farmers with their own agricultural machines recorded an average of 376.3 euro/ha for farms with a size smaller than 100 thousand SO and 186.5 euro/ha for farms with a size greater than 700 thousand SO. Economies of scale are expressed in particular at the level of depreciation expenses, repair expenses, and diesel consumption.

The gross profit specific to the use of own agricultural machines within the researched farms is negative. For the average of the sample, a loss of -45.1 euro/ha is recorded. As a result, economic efficiency is negative, expressing an average loss of 11.4 euros for every 100 euros spent to carry out the work with the agricultural machines that the farmers own.

For a representativeness level of 69.3%, farms with a size smaller than approx. 578 thousand SO register losses if they carry out agricultural work with their own agricultural machines. This threshold can be appreciated on an area of approx. 854 ha cultivated with grain corn, common wheat, and rapeseed in equal proportions.

Using the reasoning and cost analysis models presented in this article can lead to making rational investments and creating an informed demand for the agricultural services market.

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