

The Use of Data Envelopment Analysis for Selection of Investment Objects

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Due to limited resources the State support can be delivered only to part of the enterprises that apply for it. To increase the effectiveness of investment policy, support has to be provided for enterprises having not only good financial results, but also perspectives of effective work in future. Commonly, more attention is paid to analysis of financial results. However, financial indexes describe the enterprise's position in the past and do not reflect its possibilities of development. The estimation of an enterprise's future effectiveness requires accounting for not only its financial results, but also for the efforts of employees to improve their qualification, to use information technologies, to use rationally natural resources. Those who analyse the enterprise's activity in different aspects encounter problems of the object's intercomparison due to the variability of the indexes. Data Envelopment Analysis allows to put the objects into a line according to a lot of criteria expressed in various measures, and to choose a number of input and output indexes. The paper presents the aspects estimating the future of an enterprise, the results of enterprise activity effectiveness evaluation using the Data Envelopment Analysis method, and a discussion about the possibilities to use this method.

Introduction

Agriculture in most countries is regulated by the State. Each country, to provide this regulation, uses various changeable purposes and priorities. One of the most effective ways to provide help for agriculture is support of investment projects [33, 30, 46]. The main purpose is to create economically strong farms which can conform to the market conditions and are able to produce marketable products for the internal market and competitive products for the world market.

In scientific publications, much attention is paid to analysis of investment projects and evaluation of their effectiveness from the financial point of view. Moosburger A. [30] and other authors analysed the influence of investment support on the transformation process. Due to limited financial resources the State support for investment cannot be provided for all economical units. So, it is important to have a correct evaluation of business plans and to provide support for those who best match the State priorities. The selection depends on various factors describing the effectiveness of in-

vestment projects and enterprise activities in future. However, these problems from the scientific point of view are analysed not enough.

In the process of evaluation of the effectiveness of enterprise investments, attention is paid mostly to financial results. However, in some scientific publications [3, 16] there is the opinion that it is only one-sided approach to the future of enterprises. Data from balance sheets describe an enterprise in the past and cannot reflect the possibilities of its development. In most cases the future of an enterprise depends on non-material things such as human capital (knowledge and abilities of workers and employers to make effective decisions). The complex analysis and evaluation is complicated due to the variety of factors reflecting the enterprise's activities and the absence of common indexes. It is easy to compare the effectiveness of different objects when the results are expressed by one index. In the case of several indexes, the optimal variant would be a combination of these indexes, but there is no necessity for each component to be optimal [5]. In the case of some alternatives, it is necessary to choose those that can be reached with minimal expenses.

Farell [14] in 1957 proposed the method of Data Envelopment Analysis and adjusted it for evaluation of the effectiveness of agriculture in the USA in comparison with other countries. Farell examined the case with one resource and one product. Charnes, Cooper and Rhose modified the idea of Farell and suggested a method which allows to estimate the effectiveness of objects with several resources and several products [8]. Since optimisation using a large number of indexes is a very complicated process, this method was not used for a long time. Now, when computer possibilities have increased enough, it can be applied in

practice. In scientific publications of the last years [10, 12, 17, 19, 21 et al.] many cases of the use of Data Envelopment Analysis for the evaluation of effectiveness of various objects are presented. Data Envelopment Analysis is perhaps the most popular method for efficiency assessment. Lien and Peng [25] examined the production efficiency of telecommunications in 24 OECD countries, Lansink and Reinhard [23] analysed the technical, economic and environmental performance of Dutch pig farms, Homburg [18] studied the activity-based management and Vennesland [15] the rural economic development in Norway, Brodersen and Thiele [6] – the efficiency of agricultural activity in Germany, Lissitsa and Odening [27] – in the Ukraine. In Lithuania this method was used by Deltuvus and Laurinavičius [13] for evaluation of the effectiveness of forestry enterprises and by Ramanauskas for analysis of the activity effectiveness of cooperatives [32].

The object of the current research is *effectiveness of agricultural enterprises*.

The purpose of research is *to estimate the possibilities to apply the Data Envelopment Analysis method for estimating the future activities of agricultural enterprises*.

The tasks of the research are *to describe Data Envelopment analysis method and to analyse the possibilities of its use, to examine the problems of agricultural business and the directions of State support; to define the main aspects affecting the competitiveness of agricultural enterprises; to assess the future effectiveness of agricultural enterprises using the Data Envelopment Analysis method; to present suggestions for improvement of analysis of investment objects*.

The methods of the study were *analysis and summarizing of scientific ideas provided in publications, data grouping, Data Envelopment Analysis, graphical analysis*.

Data Envelopment Analysis method

For example, the enterprise uses the resource (input) X and in the production process obtains the result (output) Y . The theoretical dependence between input and output is known: $Y = F_T(X)$. The enterprise A , using input X_A has reached the output Y_A . According to the dependence $Y = F_T(X)$, it could reach the output Y_E . So, the effectiveness of enterprise A , obtained from the reached output, can be expressed as a proportion of its practical and theoretical results. The use of this proportion is convenient, because the result of evaluation of any enterprise would be a number not smaller than zero and not larger than unity. This result can be easily compared. According to the presented principle, when the result is equal to unity, we can say that the enterprise has worked effectively and fully used its resources.

However, the theoretical function of production $Y = F_T(X)$ is unknown. So, it is impossible to calculate the output. This calculation can be completed using the real function of production $Y = F_R(X)$. This function can be determined using the method proposed by Charnes, Cooper and Rhose [8]. All points of this function are on the curve or below it. The acceptability of this method is based on the fact that the results of evaluation of an economical unit are obtained not in comparison with some ideal examples, but in comparison with real achievements of enterprises which are working in the same business conditions.

The effectiveness of outputs can be calculated using the formula:

$$(E_s^O)_R = \sum_{j=1}^m (\nu_j Y_{sj}) / (\sum_{i=1}^n u_i X_{si} + u_0) \rightarrow \max,$$

$$\sum_{j=1}^m (\nu_j k_{sj}) / (\sum_{i=1}^n u_i X_{ki} + u_0) \leq 1, \quad \forall k = 1, \dots, t,$$

$$\sum_{i=1}^n u_i X_{si} + u_0 = 1,$$

$$u_i, \nu_i \geq 0, \quad (1)$$

there: Y_{kj} – amount of output j in enterprise k ,
 ν_j – weight of output j ,
 X_{ki} – amount of input i in enterprise k ,
 u_i – weight of input i ,
 t – number of enterprises,
 m – number of outputs,
 n – number of inputs,
 u_0 – free parameter.

The effectiveness of inputs can be calculated using the formula:

$$(E_s^I)_R = (\sum_{j=1}^m \nu_j Y_{sj} - \nu_0) / \sum_{i=1}^n (u_i X_{si}) \rightarrow \max,$$

$$(\sum_{j=1}^m \nu_j Y_{sj} - \nu_0) / \sum_{i=1}^n (u_i X_{si}) \leq 1, \quad \forall k = 1, \dots, t,$$

$$\sum_{j=1}^m \nu_j Y_{sj} - \nu_0 = 1,$$

$$u_i, \nu_j \geq 0, \quad (2)$$

there: Y_{kj} – amount of output j in enterprise k ,
 ν_j – weight of output j ,
 X_{ki} – amount of input i in enterprise k ,
 u_i – weight of input i ,
 t – number of enterprises,
 m – number of outputs,
 n – number of inputs,
 ν_0 – free parameter.

Analysis of scientific publications [6, 8, 12, 13, 17, 27, 43] showed that the Data Envelopment Analysis method offers the following possibilities:

- evaluation using input and output in various measures;
- objects can be compared using a big number of criteria;
- objects can be sorted according to the best outputs or rational usage of inputs;

- ♦ in the evaluation process, various combinations of indexes describing the inputs and outputs can be used;
- ♦ analysis and evaluation of these objects can be provided using a detailed or generalized comparison.

To be sure whether it is possible to apply this mathematical model for evaluation of effectiveness of agricultural enterprises as investment objects, it is necessary to analyse the current problems of agricultural business in Lithuania and to define the main aspects of evaluation.

Problems of agricultural business in Lithuania

In market conditions, the possibilities and abilities to compete are important factors not only for newly established but also for functioning enterprises. The competitive ability can be described as a permanent ability to pre-occupy and hold part of market in the liberal environment [38]. Analysis of scientific publications of Lithuanian authors has shown that the main factors influencing quite a low ability of agricultural enterprises to compete are the following:

- ♦ the deficit of manufacturing capital (financial resources) [11, 31]. Low profitability of agricultural activity, too late payments and unfavourable borrowing conditions at the commercial banks lay obstacles to agricultural enterprises in storing the resources for business development [31]. The State and foreign investors avoid putting their money into risky business without a large return. Besides, the State support is not large due to the limited possibilities of the State budget [28, 32];

- ♦ low effectiveness of management of agricultural enterprises due to the lack of interest, low competency and education level of employees [11, 31, 37, 46], and other factors;
- ♦ lack of information for decision making [31].

Thus, it is necessary to agree with the proposition of R. Naujokienė that if we want agriculture to remain an important economical sector and produce competitive goods for home and foreign markets, it is necessary to solve the following tasks:

- ♦ to keep the amounts of produce on maximal level;
- ♦ to provide modernization of enterprises and optimisation of the production process to reach the level of quality of the Western European countries;
- ♦ to persuade managers of enterprises that agriculture is business and not the way of living.

Essentially in all countries agriculture is under State regulation [41]. Over the last ten years in Lithuania the forms and amounts of direct and indirect State support has permanently changed. This hampered the implementation of durable programmes of economical development and raised the incredulity of farmers and agricultural enterprises to State agrarian policy [31].

One of the most perspective ways to increase effectivity in agriculture is to provide support for investment projects [30, 33, 42]. The main purpose of this support, declared by the State, was to create economically strong farms and enterprises, to avoid bankruptcies of agricultural units in the complicated intermediate situation and to stimulate activity of their business planning. Besides, following Moosburger [30], support for investment stimulates structural

changes and increases the competitive abilities of enterprises.

However, provision of support was connected with some problems. According to Moosburger, selection of recipients is one of the most complex and hardest tasks in any investment programme [30]. Administration of utilization of the Rural Support Foundation in 1997–2000 was based on a primary evaluation of investment projects, but the monitoring of success in implementation of these projects was ignored. In this aspect, it is hard to say which investments projects have reached their goals [33]. In the opinion of Vitunskienė [46], the support from Rural Support Foundation was not always allocated for perspective projects due to objective and subjective reasons. A large part of support was lost when the agricultural enterprises that received it went bankrupt.

Moosburger [30] claims that to inspire structural changes in agriculture, it is important that support be provided for enterprises with an economically strong potential. According to Naujokienė, support can be treated as material inducement for successful business development. However, in this case it is very important to evaluate the possibilities of enterprises to develop their business in the changing conditions and to use this support effectively.

Aspects of evaluation of enterprise activity in the future

In scientific publications, there is no common opinion as to how many and which indexes should be used for evaluation of the effectiveness of enterprise activity. In general, the choice of a suitable system of criteria and indexes is based on the purpose of evaluation,

sufficient quantify and quality of information, resources allocated for this evaluation: time, work and finance [2]. Traditionally, for evaluation of enterprise's activity financial indexes are used. But in scientific publications of the last years there appeared the idea that for evaluation of efficiency, data from the enterprise's financial statement are not sufficient. In the opinion of Garškienė [15], sometimes the quality of management is a more important factor than financial results. Some other authors have used a lot of other indexes for a complex evaluation of the effectiveness of agricultural enterprises or have proposed to take into account a lot of other aspects.

Brodersen and Thiele [6] in their evaluation of the effectiveness of agricultural enterprises in Germany used the following indexes: for description of outputs they used proceeds from plant growing and from other activities and for description of inputs the common expenses indexes of work force, the enterprise's comparative ability and permanent capital (without soil). Odening and Lissitsa [27] for evaluation of the effectiveness of Ukrainian agricultural enterprises used the following indexes: to describe outputs, proceeds from plant growing and animal breeding and to describe inputs the indexes of work force, the value of agricultural land, capital and expenses were used.

Linna and Hakkinen [26] suggest to take into account the results of research work and improvement of qualification. Author of this paper agrees with this opinion, because the abilities and knowledge of employees exert a positive effect on increasing the benefit of the enterprise. Besides, stimulation of employees to improve their qualification shows the approach of the owners or managers of this enterprise to its perspective. Discussing the ex-

pedience to provide investment support, a very important argument is the ability of employees to realize the investment project.

According to Burmann [7], investors take into account as very important a specific input – knowledge-based competence as a basis for a quick growth of the enterprise in future. In the opinion of Stancikas [41], in the case of usage of the current strategies dominates the orientation to the abilities of employees in a short time, and the strategic efforts of staff competence improvement are suspended for future. However, permanent changes inside and outside the enterprise and the qualification of employees are greatly important for competitive abilities [20, 29].

Laux and Liermann [24] estimate the qualification of employees as a multidimensional category. They stress that the definition of the purposes of an investment project, evaluation of the business environment and the search of alternatives require creativeness and abilities of employees to work with information. The lack of information in the period of project implementation may result in taking wrong solutions. It is clear that at present information search and processing are impossible without using information technologies [9]. Systematic and purpose-oriented use of information technologies can help to recognize and estimate market changes and to manage the business process effectively [24, 44]. Some authors stress the opinion that the use of information technologies is one of the most important preconditions for a successful development of enterprises [4, 39]. However, without comprehensive research, it is hard to say what is the real situation with the use of these technologies in agricultural enterprises of Lithuania. The critical approach of rural inhabitants to their computer education [36] and the low level of

computers and software usage in rural areas of Lithuania imply that this factor at present should be estimated very carefully and its influence should be examined more comprehensively.

Agriculture is closely related with the natural environment, so its activity must be estimated also from the viewpoint of environmental protection. Some agricultural enterprises are interested in protection of the environment (to save the quality of the soil, to protect it from weathering, to decrease the amount of injurious matters in the soil, water and air). However, in conditions of strong competition the aspects of further perspective and ecological criteria can be ignored. In many cases the use of new and intensive technologies which allow to increase productivity increases the use of chemicals [42]. So, it is advisable to include the criteria of environmental protection when evaluating activity of agricultural enterprises.

The results of analysis of scientific publications allow to conclude that evaluating activity of agricultural enterprises it is necessary to account not only for data from the enterprise's balance sheet, but also for the efforts of employees to increase their qualification and competitive abilities, to use information technologies and ensure a rational use of natural resources.

Assessment of future effectiveness of agricultural enterprises

To estimate the possibilities to use the Data Envelopment Analysis method, we used data of 19 agricultural enterprises which participated in a competition organised by Association of Agricultural Enterprises of Lithuania and were nominated as the best in the area of modernization of production technology and

increase of the number of working places. At the first stage, the indexes for evaluation of inputs and outputs were selected. In this case, as inputs were used the indexes that had to be

decreased and as outputs those that had to be increased. The list of these indexes is presented in Table 1.

Table 1. Indexes for evaluation of activity effectiveness of agricultural enterprises

<i>Indexes</i>	<i>Measures</i>	<i>Weight</i>
<i>Input</i>		
Expenses for fuel	Lt	25
Amount of used electricity	kWh	25
Land area	ha	25
Employees	number	25
<i>Output</i>		
Income	Lt	60
Investments	Lt	25
Employees, increased their qualification	number	10
Ecological situation	score	5

Using the Data Envelopment Analysis method, objects can be compared including various combinations of inputs, outputs and their grouping. To examine in detail the possibilities to use this method, we performed calculations of the following cases:

- one output and one input (1:1);
- one output and all inputs (1:n);
- all outputs and one input (m:1);
- all outputs and all inputs (m:n).

Some results of this examination are presented in Table 2.

In column *Var1* the results of evaluation of effectiveness of outputs (results of activity) and in column *Var2* the results of evaluation of effectiveness of inputs (economy of resources) for the case of inclusion of all inputs and all outputs are presented. Column *Var3* shows the

Table 2. Results of evaluation of effectiveness of agricultural enterprises

<i>Agricultural enterprise</i>	<i>Var1</i> <i>m : n</i>	<i>Var2</i> <i>m : n</i>	<i>Var3</i> <i>m : 1</i>	<i>Var4</i> <i>m : 1</i>	<i>Var5</i> <i>1 : n</i>
	%	%	%	%	%
B1	100.0	100.0	100.0	100.0	100.0
B2	100.0	100.0	100.0	100.0	100.0
B3	76.8	76.9	76.9	100.0	100.0
B4	100.0	100.0	100.0	100.0	100.0
B5	71.1	71.3	64.9	77.6	66.7
B6	89.3	89.4	89.1	70.7	66.7
B7	100.0	100.0	100.0	100.0	33.3
B8	77.0	80.7	63.4	100.0	100.0
B9	77.5	77.8	68.1	73.8	66.7
B10	44.8	42.7	42.5	100.0	100.0
B11	90.1	90.1	90.1	66.7	66.7
B12	63.7	64.0	63.9	66.7	66.7
B13	54.7	55.4	54.8	49.4	66.7
B14	48.1	48.9	48.3	68.0	66.7
B15	52.1	55.4	100.0	100.0	66.7
B16	59.9	60.0	60.0	66.7	66.7
B17	30.0	31.0	30.4	66.7	66.7
B18	51.0	51.7	51.2	66.7	66.7
B19	27.4	28.3	27.8	66.7	66.7

results of evaluation of the effectiveness of inputs, including all inputs and one output (employees). In column *Var4* are presented results of evaluation of effectiveness of outputs, including all outputs and one input (landed area). Column *Var5* shows the results of evaluation of the effectiveness of inputs when one output (ecological situation) and all inputs are accounted for.

From the data provided in Table 2 it is possible to conclude that the results of activity of enterprises B1, B2, B4 and B7 are optimal.

Results of evaluation of effectiveness of three indexes of outputs (income, investments and employees that improved their qualifica-

tion). It is necessary to stress the fact that enterprise B15 has a relatively low income, however, results of evaluation of investments and employees' qualification show a rather high level.

The research provided by the author of this paper shows that the Data Envelopment Analysis method allows:

- ♦ to include various combinations of indexes that describe inputs and outputs of the enterprise's activity;
- ♦ to use indexes expressed not only in monetary, but also in other measures;
- ♦ to express results not as an absolute but also as a relative value suitable for an

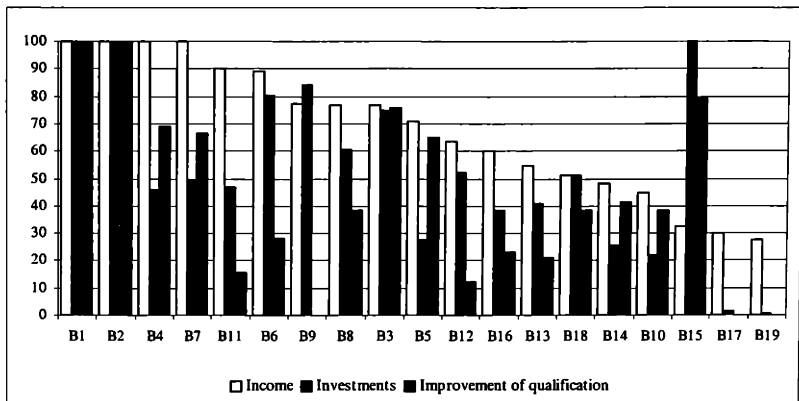


Figure. Results of evaluation of effectiveness of agricultural enterprises in case of inclusion of three outputs and all inputs

tion) in case of inclusion of all inputs are presented in Figure. The results of enterprises B1 and B2 are best in the case of inclusion of all these outputs. Enterprises B4, B7 and B11 have a relatively good income, however, they have to pay more attention to investments and to improvement of the employees' compe-

easy and open determination of enterprise activity effectiveness;

- ♦ to analyse enterprise activity effectiveness taking into account various aspects and combinations of indexes and to sort these enterprises according to a chosen number and combination of indexes.

For a more precise evaluation of the effectiveness of enterprise activity in the future, a more detailed list of indexes should be compiled. It is advisable to pay attention to the innovation policy of enterprises, the use of information technologies, including not only hardware but also software.

The success of this method depends on the quality of data. Determination of some suitable indexes, for example, for evaluation of the influence of nature protection or the usage of information technologies, is too complicated and requires separate research. Another problem that requires separate and more detailed research is the necessity to estimate more precisely the weight of importance of the indexes.

Conclusions

1. The rather low level of the economical development of agricultural enterprises in the last ten years was influenced by the lack of financial resources, insufficient education and competence of managers and the lack of information for decision-making.
2. Financial support for investments not only increases the effectiveness of agricultural enterprises, but also leads to their structural changes and increases competitiveness.
3. To characterise the competitive ability of enterprises in the changeable business environment, it is not sufficient to use the financial indexes of previous years; factors that influence formation of these indexes should be also accounted for. These factors include qualification of employees, quality of management, introduction of new production and information technologies, rational use of natural resources, etc.
4. Evaluation of the effectiveness of the future activity of 19 agricultural enterprises by the Data Envelopment Analysis method shows that the best are enterprises B1, B2, B4 and B7.
5. The Data Envelopment Analysis method is suitable for practical purposes while evaluating the future effectiveness of agricultural enterprises, as it allows inclusion of various combinations of indexes that describe inputs and outputs of enterprises and can be expressed in various measure units. The results of evaluation are expressed as a relation, and this fact allows an easy and open comparison of the effectiveness of enterprises.
6. The successful use of the Data Envelopment Analysis method depends mostly on three main factors: the quality of data, a suitable list of criteria and indexes used for evaluation, and the precise weight of their importance.

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DUOMENŲ GAUBTINĖS ANALIZĖS METODO TAIKYMAS PASIRINKTI INVESTICIJŲ OBJEKTĄ

D. Rimkuvienė

S a n t r a u k a

Valstybės parama dėl ribotų išteklių gali būti teikiama tik daliai įmonių. Todėl remiant žemės ūkio įmonių investicijų projektus būtina atsivelti ne tik į įmonės finansinės veiklos rezultatus, bet ir į jos pasirengimą efektyviai dirbti ateityje. Analizuojant įmonių veiklą įvairiais aspektais yra susiduriama su palyginimo tarpusavyje problemomis dėl veiklos rodiklių įvairovės. Duomenų gaubtinės analizės metodas teikia galimybę surikiuoti lyginamus objektus naudojant daugelį krite-

rijų, išreikštų įvairiais matavimo vienetais ir pasirinkta išteklius ir rezultatus apibūdinančių rodiklių skaičių. Straipsnyje analizuojami įmonių būsimo veiklos vertinimo aspektai, pateikiami žemės ūkio bendrovių veiklos efektyvumo vertinimo duomenų gaubtinės analizės metodo rezultatai, aptariamos metodo taikymo galimybės.

Pagrindiniai žodžiai: duomenų gaubtinė analizė, žemės ūkis, veiklos efektyvumas.

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