Assessment of the agricultural machinery company's competitiveness based on data envelopment analysis

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Abstract. The ability of enterprises to compete in a particular product market depends not only on the totality of economic methods used for conducting business, but also directly on the competitiveness of the product. The article presents ways to improve the competitiveness of agricultural machinery products, which ultimately determines the level of competitiveness of the enterprise as a whole. The article describes the properties of the data envelopment analysis (DEA) method in terms of its effectiveness in assessing the competitiveness of agricultural machinery products, and presents a model for improving competitiveness. Based on the analysis carried out, it is concluded that the DEA method should be used to assess the competitiveness of agricultural engineering enterprises.

1. Introduction
In the conditions of growth of the market of agricultural machinery, one of the remaining problems is the problem of insufficient competitiveness of Russian engineering products (the share of domestic enterprises' products are no more than 26%) [1].

This trend makes the main problem is the issue of forming an effective system for forming a program for the production of competitive products of agricultural machinery enterprises.

The ability of enterprises to compete in a particular product market depends on both the combination of business methods and the level of competitiveness of its products.

2. Opportunities and necessity of applying the DEA method for assessing the competitiveness of agricultural machinery products
Competitive advantages of the enterprise are achieved by better using the existing potential of the enterprise. The optimal use of which leads to the production of competitive products that can sell themselves.

Many researchers share the concepts of enterprise competitiveness and product competitiveness, while if product competitiveness is one of the factors of enterprise competitiveness, the influence of the manufacturer on the level of product competitiveness is often simply not taken into account [2,3]. The division of these concepts is not always legitimate because the high scientific and technical personnel potential of the manufacturer has significant impact on the success of the product on the market. It is proposed to divide the factors of competitiveness of agricultural machinery products depending on the character of the impact on the competitiveness products on the basic and industrial (figure 1).
Figure 1. Classification of factors of competitiveness of agricultural machinery products.

It is necessary to note that the number of parameters for assessing competitiveness depends primarily on external factors. The peculiarity of technically complex products is that the level of their competitiveness is influenced not only by basic factors (technical and economic factors), but also by factors that are determined by the specifics of the industry (external and internal factors).

Assessment of competitiveness is a series of actions, including the development of a method by which the assessment will be carried out [5].

The existing assessment methods have one obvious drawback is their limited application. In addition, the evaluation results are often distorted by taking into account the subjectivity factor in expert evaluations used in existing methods. This provides a basis for improving the separate aspects of the assessment process and finding new approaches to implement them in practice.

The DEA method is a method based on finding the relative efficiency of the object under study, which in market conditions is a criterion of competitiveness, allowing to be applied in the assessment [5].

This method appeared as a generalization of simple indicators of multidimensional systems, i.e. when the efficiency of a complex object, which includes agricultural machinery products, is described by a set of input parameters ($X_1, ..., X_m$) and output parameters ($Y_1, ..., Y_m$).

Efficiency (in this case, we mean competitiveness) refers to the ratio of utility functions that are built on the values of input parameters and on the values of output parameters of the studied objects.

Thus, according to this approach, the most competitive products are those in the agricultural machinery industry that either increase output parameters (sales volume) with a constant volume of input resources (material, labor, technical) or reduce input resources (maximize the use of economic resources) with a constant volume of output parameters.
In addition, in the DEA method, inputs and outputs can be measured in different scales, which is not possible in existing estimation methods. This allows to evaluate the competitiveness not only with a different set of resources but also to rank objects by levels of competitiveness.

Thus, this approach allows us to comprehensively assess the level of product competitiveness while obtaining its quantitative value.

3. The procedure for assessing the competitiveness of agricultural machinery products

As noted above, competitiveness is characterized by the ability of a product to be purchased first. The consumer evaluates not only the attractiveness of the purchased product and the possible degree of satisfaction of their specific needs, but also their readiness to bear the costs associated with its purchase and use. This suggests that competitiveness is determined by both qualitative and cost factors, which can be fully characterized using the system of indicators (figure 2).

The choice of the competitiveness criterion is the central issue of developing a methodology for evaluating the competitiveness of products. It is important to understand that an incorrect choice of criteria can distort the results of the evaluation.

The competitiveness criterion is a quantitative or qualitative characteristic of a product used to assess its competitiveness [6,7].

Based on the definition of the product's competitiveness, it can be judged that the main criterion for its evaluation is the volume of sales of the product being evaluated.

Factors (indicators) are the input characteristics when evaluating competitiveness using the DEA method, whereas the actual criterion is the output characteristic (effect). Input parameters of agricultural machinery form indicators that determine the level of its competitiveness.

Figure 2. System of indicators of competitiveness of agricultural machinery products.
To determine the level of competitiveness of technically complex products, which include agricultural machinery products, it is recommended to use the following basic input parameters: purchase price, service price, versatility of agricultural machinery, productivity and maintainability.

Output parameters represent the level of competitiveness of the studied objects. As noted above, competitiveness characterizes the ability of a product to be purchased among the first on the market among competing products. Based on this, it is advisable to consider the sales volume as an output parameter.

It is necessary to determine how effectively each of the input parameters is used to get the achieved sales volume (table 1) [8].

The manufacturing company strives to increase the sales volume of each of the analyzed models. In the framework of the DEA analysis, to achieve this goal, it is necessary to determine the level of competitiveness of agricultural machinery models relative to each other. At the same time, it is important to determine which of the models produced by the company is more competitive, and which is less, and by what parameters

Table 1. Initial values of parameters of the studied objects.

| The competing agricultural machinery models / Object of DEA of model | Purchase price | Service price | Versatility | Average productivity per hour of main time | Maintain ability | Sales volume | Level of competitiveness |
|---|---|---|---|---|---|---|---|
| Variable type Designation of the variable | Entrance | Entrance | Entrance | Entrance | Exit | Exit | |
| Model 1 | X₁ | X₂ | X₃ | X₄ | X₅ | Y₁ | 0 |
| Model 2 | X₁₁ | X₁₂ | X₁₃ | X₁₄ | X₁₅ | Y₁₁ | Θ₁ |
| Model n | Xₙ₁ | Xₙ₂ | Xₙ₃ | Xₙ₄ | Xₙ₅ | Yₙ₂ | Θₙ |

4. Technology for improving agricultural machinery production

The technology for improving product competitiveness based on the interaction of DEA analysis stages is shown on figure 3.

Let’s look at the main procedures for studying the competitiveness of an item.

For agricultural machinery models with output volume < 1, set the goal to reduce their input indicators proportionally while maintaining output at the same level. For models with a level of output sales > 1 a proportional increase in their output indicators, provided that the output indicators remain at the same level.

Calculation of competitive strength of analyzed goods. At this stage, the agricultural machinery model under analysis is subject to DEA to determine its level of competitiveness.

Identification of model players and models of outsiders.

After evaluation of competitiveness, all models are divided into models of outsiders and models for further analysis. As a modeler, according to the definition of the competitiveness of the product, we refer to those models whose volume of realization is 1.

As a formula, this can be reflected as follows:

- \( V_{\text{real}} = \frac{\text{Number of produced agricultural machinery models}}{\text{Number of sold models}} = 1 \)
- An outsider is a model whose implementation volume is less than 1.
Figure 3. Technology to improve the competitiveness of the goods.

5. Conclusion
The use of the DEA method in assessing competitiveness avoids the limitations of existing methods. Thus, using the DEA method, you can simultaneously process many input and output parameters, each of which can be measured in different units of measurement. In addition, this method does not require specifying weights for variables corresponding to input and output indicators, which minimizes the influence of experts on the assessment of competitiveness.

References
[1] Ruiga I R, Rogozinskiy E V, Yamschikov A S, Kovzunova E S and Teterin Yu A 2019 Methodological aspects of machine-building complex economic security from the position of innovative and investment sustainability: macroeconomic cross-section J. Phys.: Conf. Ser. 1399 033088
[2] Antamoshkina O I, Kamenskaya N V and Olentsova J A 2020 The problem of choosing a consumer segment in the agro-industrial complex IOP Conference Series: Earth and Environmental Science 421 022056
[3] Sandrakova I, Spryzhkova A, Shmeleva Zh, Stupina A and Yushkova L 2019 The competitiveness of the enterprise as a factor of its market superiority IOP Conference Series: Earth and Environmental Science 315 022063
[4] Ruiga I R, Stupina A A, Kovzunova E S, Chayka A A and Shkradyuk I A 2019 Practical implementation of Data Envelopment Analysis technology to assess the innovative sustainability of resource-type regions J. Phys.: Conf. Ser. 1399 033118
[5] Ruiga I R, Kovzunova E S, Stupina A A, Kashina E V and Burmenko T A 2020 Improvement of
the methodological approaches to the evaluation of the agro-industrial clusters development potential in the regional economy *IOP Conf. Ser.: Earth Environ. Sci.* **421** 032053

[6] Kuimov V V, Yushkova L V, Shcherbenko E V and Yamskikh T N 2018 The role of cooperative-network interactions in maintaining competition in the local food market *Scanges in Social and Business Environment (SISABE, 2018)* pp 39-44

[7] Antamoshkina O I and Zinina O V 2019 A methodology for assessing the prospects of modifying business strategy of an enterprise in the external environment *IOP Conference Series: Materials Science and Engineering* **537** 42023

[8] Kosterin A 2005 *Improving the competitiveness of stores based on DEA analysis* (Moscow) pp 30-44