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ASSESSMENT OF THE LEVEL OF COMPETITIVENESS OF AGRICULTURAL ENTERPRISES ON THE BASIS OF NEURAL NETWORK MODELING

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The article investigates the topical issue of quantitative assessment of the competitiveness of agricultural enterprises. In the framework of this work, it was determined that the specifics of agricultural enterprises do not allow the use of existing approaches to assessing the competitiveness that can be used for enterprises of other activities. Accordingly, the aim of the research was to develop an approach to quantifying the competitiveness of agricultural enterprises that would take into account the specifics of the enterprise, and which could be adapted to assess the effectiveness of other economic systems.

Based on the developed economic literature of Ukrainian and foreign scholars, an analysis of approaches to the interpretation of the concept of «competitiveness» as an economic category.

Due to the lack of a single interpretation of the economic characteristics of the enterprise as an «indicator of competitiveness», it was determined that the it should be considered as a latent characteristic, i.e., one that manifests itself on the «surface» of a set of lower factors. At the same time, an analysis of modern approaches to quantifying the competitiveness of enterprises was carried out.

The paper analyzes the approaches to quantifying the competitiveness of agricultural enterprises.The author's neural network model of integrated assessment of competitiveness of agricultural enterprises was developed, which is based on the synthesis of principles of neural network modeling, methods of determining integrated indicators, work with latent indicators, taxonomy.

The calculations presented in this paper were performed in the environment of the author's computer program «ASCO». The model of estimation of competitiveness of the agricultural enterprises is carried out. The analysis of the enterprise on the basis of simultaneous processing of primary factors and group factors with the subsequent analysis of quality of controllability of system is carried out. This approach allows for a comprehensive analysis of the enterprise in all areas of its activities.

Key words: competitiveness, agricultural enterprises, latent characteristics, model, integrated assessment, taxonomy method, neural network.

Table: 4. Fig.: 9. Ref.: 25.

ОЦІНКА РІВНЯ КОНКУРЕНТОСПРОМОЖНОСТІ АГРАРНИХ ПІДПРИЄМСТВ НА ОСНОВІ НЕЙРОМЕРЕЖЕВОГО МОДЕЛЮВАННЯ

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У статті досліджено актуальне питання кількісної оцінки конкурентоспроможності аграрних підприємств. У межах роботи було визначено, що специфіка діяльності аграрних підприємств не дозволяє використовувати наявні підходи до оцінки конкурентоспроможності, які можна використовувати до підприємств інших видів діяльності. Відповідно до цього, метою наукової роботи була розробка підходу до кількісної оцінки конкурентоспроможності аграрних підприємств, який би врахував специфіку діяльності підприємства, і який можливо було б адаптувати до оцінки ефективності інших економічних систем.

На основі опрацьованої економічної літератури вітчизняних і зарубіжних науковців було здійснено аналіз підходів щодо трактування поняття «конкурентоспроможність» як економічної категорії.

У зв'язку з відсутністю єдиного трактування такої економічної характеристики підприємства як «показник конкурентоспроможності» було визначено, що показник «конкурентоспроможність» доцільно розглядати як латентну характеристику, тобто таку, яка проявляється на «поверхні» сукупності факторів-симптомів нижчого рівня ієрархії. Разом із цим, було здійснено аналіз сучасних підходів щодо кількісної оцінки конкурентоспроможності підприємств.

У роботі було здійснено аналіз підходів щодо кількісної оцінки конкурентоспроможності аграрних підприємств. Було розроблено авторську нейромережеву модель інтегральної оцінки конкурентоспроможності аграрних підприємств, яка ґрунтується на синтезі принципів нейромережевого моделювання, методів визначення інтегральних показників, роботи з латентними показниками, таксономії.

Розрахунки, які наведені у роботі, були виконані в середовищі авторської комп'ютерної програми «ASCO». Запропонована модель оцінки конкурентоспроможності аграрних підприємств здійснює аналіз підприємств на основі одночасної обробки первинних чинників і групових факторів із наступним аналізом якості керованості системи. Такий підхід дозволяє здійснити комплексний аналіз підприємства з усіх напрямів його діяльності.

Ключові слова: конкурентоспроможність, аграрні підприємства, латентна характеристика, модель, інтегральна оцінка, метод таксономії, нейронна мережа.

Табл.: 4. Рис.: 9. Літ.: 25.

ОЦЕНКА УРОВНЯ КОНКУРЕНТОСПОСОБНОСТИ АГРАРНЫХ ПРЕДПРИЯТИЙ НА ОСНОВЕ НЕЙРОСЕТЕВОГО МОДЕЛИРОВАНИЯ

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В научной работе исследованы актуальные вопросы количественной оценки конкурентоспособности аграрных предприятий. В рамках данной работы было определено, что специфика деятельности аграрных предприятий не позволяет использовать имеющиеся подходы к оценке конкурентоспособности, которые можно использовать к предприятиям других видов деятельности. Согласно этому, целью научной работы была разработка подхода к количественной оценке конкурентоспособности аграрных предприятий, который учел бы специфику деятельности предприятия, и который можно было бы адаптировать к оценке эффективности других экономических систем.

На основе проработанной экономической литературы отечественных и зарубежных ученых был проведен анализ подходов к трактовке понятия «конкурентоспособность» как

экономической категории.

В связи с отсутствием единой трактовки такой экономической характеристики предприятия как «показатель конкурентоспособности» было определено, что «показатель конкурентоспособности» целесообразно рассматривать как латентную характеристику, проявляющуюся на «поверхности» совокупности факторов-симптомов низшего уровня иерархии. Вместе с тем, был проведен анализ современных подходов к количественной оценке конкурентоспособности предприятий.

В работе был проведен анализ подходов к количественной оценке конкурентоспособности аграрных предприятий. Была разработана авторская нейросетевая модель интегральной оценки конкурентоспособности аграрных предприятий, основывающаяся на синтезе принципов нейросетевого моделирования, методов определения интегральных показателей, работе с латентными показателями, таксономии.

Расчеты, представленные в данной работе, были выполнены в среде авторской компьютерной программы «ASCO». Предлагаемая модель оценки конкурентоспособности аграрных предприятий осуществляет анализ предприятия на основе одновременной обработки первичных факторов и групповых факторов с последующим анализом качества управляемости системы. Данный подход позволяет осуществить комплексный анализ предприятия по всем направлениям его деятельности.

Ключевые слова: конкурентоспособность, аграрные предприятия, латентная характеристика, модель, интегральная оценка, метод таксономии, нейронная сеть.

Табл.: 4. Рис.: 9. Лит.: 25.

Formulation of the problem. The main criterion for the successful functioning of any enterprise is their ability to occupy a leading position among enterprises that produce similar goods and services, as well as attract the largest number of consumers.

The high level of competitiveness of the enterprise is a guarantee of getting stable, high profit. The level of competitiveness of the enterprise shows the existing potential of the enterprise, outlines the prospects for its further development, provides opportunities for the implementation of strategic goals and objectives.

The greatest difficulty in studying the competitiveness of enterprises, in particular agricultural ones, is that, firstly, their activities have a number of specific properties that do not allow the use of valuation methods that are usually used to enterprises of other activities; secondly, in the economic literature there is no single opinion regarding what can be considered an «indicator of competitiveness». At the same time, there is a problem of the lack of a single method for determining the same indicator, which could be considered as an «indicator of competitiveness».

Analysis of recent research and publications. The multifaceted nature of competitiveness has led to the study of this problem from different angles. In particular, the issues of conducting effective business in the agricultural sector were studied by such scientists as Kaletnik G.M. [1], Honcharuk I.V. [2], Andriychuk A.V., Mesel-Veselyak V.Ya. [3] and others.

The following scientists as Porter M.E. [11], Fatkhutdinov R.A. [4], Ermak A.V. [5], Yatsiv I.B. [6], Lozovsky Y.A. [7], Yankovyi O.G. [8], Tsober I.Yu. [9], Babiy O.N. [10] and others, studied the problem of quantitative assessment of the level of economic efficiency of agricultural enterprises.

Despite the significant amount of research on this issue, there is now a need to apply a quantitative assessment of the competitiveness of agricultural enterprises.

Formulation of the goals of the article. The purpose of the study is to develop an approach to comprehensive assessment of the competitiveness of agricultural enterprises. To solve this problem, an analysis of approaches to the interpretation of the concepts of «competitiveness» as an economic category and «competitiveness indicator» as the economic characteristics of the enterprises was carried out; analysis of approaches to assessing the competitiveness of agricultural enterprises was conducted; based on the above analysis, an approach to comprehensive assessment of the competitiveness of agricultural enterprises was developed.

Presentation of the main research material. The classic concept of defining the essence and functional features of entrepreneurship is the desire to outperform competitors [2, p. 156]. The criterion that characterizes the level of efficiency of entrepreneurial activity in relation to other players in the market – is the level of competitiveness of the enterprise.

The competitiveness of the enterprise is a complex, multi-component economic category that does not have a single approach to interpretation.

The analysis of approaches to the assertion of the competitiveness of the enterprise as an economic category should begin with the interpretation of Porter M.E. In his opinion, the competitiveness of the enterprise is a reflection of the relative level of efficiency in the use of all types of production resources available to this enterprise [11, p. 67].

Voronkova A.E. considers that the competitiveness of the enterprise is a generalized final indicator of its sustainable work, which absorbs the results of various production, support and management units, subsystems and resources involved [12, p. 134].

According to Ermak A.V. [5, p. 43], the competitiveness of the enterprise is a synthetic category that characterizes the ability of the enterprise to function and develop in accordance with the planned strategic goals.

Vasilenko V.O. [13, p. 85], argues that the competitiveness of the enterprise – is the possibility of its effective economic activity and the practical implementation of the acquired competitive advantages in a competitive market.

Levitska A.O. [14, p. 204] believes that the competitiveness of the enterprise is the ability of the enterprise to form and implement competitive advantages that allow it to develop effectively compared to other enterprises in Ukrainian and foreign markets.

Considering competitiveness from the standpoint of agricultural enterprises, Ukrainian and foreign scientists Mesel-Veselyak V.Ya. [3], Fatkhutdinov R.A. [4] Yatsiv I.B. [6] in their work, they agree that the competitiveness of an agricultural enterprise is the real and potential ability of an economic entity to produce competitive products and ensure its effective marketing. Competitive products, the authors consider, such products, which: first, in the complex of price and non-price characteristics are more attractive to consumers than competitors; secondly, it provides high profitability of production and financial stability of the enterprise and, as a result, forms the image of the enterprise and opportunities of development in the world market.

Marmul L.O., Bojko V.O. [15, p. 84] consider competitiveness as a dynamic characteristic of agricultural enterprises, which is constantly adjusted by the external environment, determined by the market share of the producer in the current market.

Thus, having considered a number of interpretations of the concept of «competitiveness of the enterprise» as an economic category, we will determine the competitiveness of agricultural enterprises as the ability to rationally use their resources in order to conduct effective entrepreneurial activity, by forming a set of competitive advantages that determine the level of efficiency of the enterprise compared to other market players.

Most scientists who have been engaged in the study of quantitative assessment of competitiveness, agree that «competitiveness» should be considered as a latent (hidden) characteristic of an enterprise that does not have a single meter [16, p. 133].

The peculiarity of constructing models with latent indicators is that the model is based on the hypothesis that some initial latent indicator is l_i is an aggregated indicator of a set of partial indicators $\{x_1, x_2, \dots, x_n\}$ i.e., $l_i = \{x_1, x_2, \dots, x_n\}$.

Latent or hidden signs appear on the «surface» of economic phenomena in the form of a set of symptoms factors – individual group indicators and /or partial indicators that reflect different sides of complex economic systems [17, p. 15-16]. Thus, a certain unknown criterion, which is a general indicator of the set of factors-symptoms of the previous level of hierarchy, can be considered as a latent characteristic of a higher level.

Taking into account the above, we propose a conceptual scheme of the model of competitiveness of agricultural enterprises (Fig. 1).

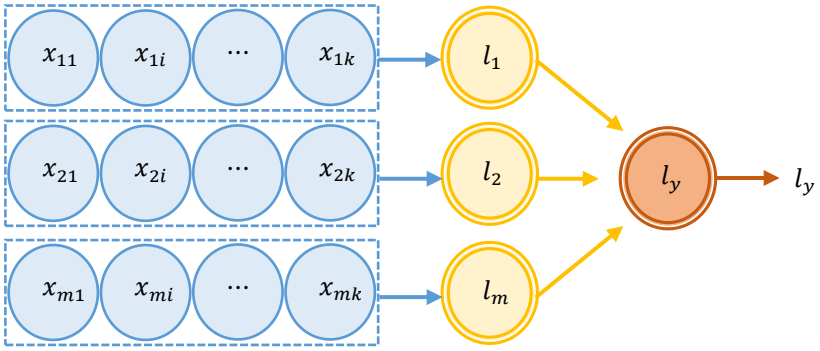

Fig. 1. **Structure of the relationship between factor indicators and latent resulting**

Note: $x_{11}, \dots, x_{mk}$ – grouped partial indicators; l_1, l_2, l_m – latent group indicators; l_y – resulting latent indicator of competitiveness.

Source: built by the author

Thus, we propose to use an approach that is based on the simultaneous processing of primary factors and group factors. The complexity of this approach is the need to determine the weights of latent group indicators. The presence of weights automatically creates a problem of subjectivity, as weights are usually determined by experts. To avoid the factor of subjectivity, we propose to use statistical methods to determine the weights of indicators.

The next problem, we can say, the most difficult, is related to the formation of a system of partial indicators. The problem is to form the optimal number of partial

indicators that would most fully characterize the subject area. The question of the number of partial indicators is quite acute, because it is clear that the presence of a large number of indicators automatically complicates the calculation, at the same time there is the opposite problem – a small set of data will not fully characterize the effectiveness of the economic system – both in fact, the informativeness of the results will be tentative. One of the ways to solve this problem is to group indicators by a specific characteristic, but even in this case, between the indicators within each group should be quite close correlations.

However, researching the assessment of the competitiveness of the enterprise, scientists agree that the analysis of the competitiveness of the enterprise should be carried out by calculating the financial and economic indicators [18, p. 155; 19, p. 231-232; 20]. Honcharuk, I.V., Starosud, V.I., Mulyk, T.O. [21, p. 19] share this position and argue that «financial results for agricultural enterprises are the key to their successful operation. They are the defining economic category and the main measure of the efficiency of the enterprise».

In our opinion, the analysis of the competitiveness of agricultural enterprises should be carried out on the basis of public financial statements. The existence of indicators that can only be obtained by experts calls into question the validity of the resulting indicator, as there is a factor of subjectivity.

Thus, as part of our study, the information base for building a model for assessing the competitiveness of the enterprise selected financial statements of economic entities, namely form № 1 «Balance Sheet» (Statement of financial position) and form № 2 «Statement of financial performance» (Report on total income).

The main purpose of the financial statements of the enterprise is to obtain information that provides a reliable and complete picture of the property and financial condition of the enterprise [17, p. 56].

As noted, scientists don't have common opinion on a single, unified method for assessing the competitiveness of agricultural enterprises, so we believe that the methods of quantitative assessment are the most economically justified, because a specific numerical indicator is formed at the output, and not an at attribute characteristics, unlike qualitative methods.

The most widespread in assessing the competitiveness of enterprises are the methods of the index group, among which are often used integrated valuation methods.

According to the definition given by the authors [22, p. 35], an integral indicator can be called a numerical measure of the latent quality of the studied phenomenon.

Kvasha T.K. and Voloshchuk R.V. in their work [23, p. 32] argue that integrated indicators are complex indices of individual indicators, which are widely used due to their ability to aggregate large amounts of information into easily understandable formats.

In connection with the above material, the paper proposes two models for assessing the competitiveness of the enterprise: the first model is based on the calculation of group integrated indicators of enterprise competitiveness (GIIEC); the

second model – on the functional convolution of the GIIEC and the formation of the overall integrated indicator of enterprise competitiveness (OIIEC).

According to the author's opinion, OIIEC is a complex indicator, which is based on a summary of group integrated indicators of the previous level of the hierarchy with their weights; GIIEC means an aggregate indicator, which is calculated by synthesizing pre-normalized partial indicators that characterize the efficiency of entrepreneurial activity.

The neural network model of integrated assessment of the competitiveness of agricultural enterprises is based on the tools of neural network modeling, synthesis of methods for determining integrated indicators, work with latent indicators, taxonomy.

The offered model allows to estimate a condition of the enterprise taking into account all directions of its activity with the subsequent analysis of level of controllability of system.

To assess the competitiveness of the enterprise, it is proposed to choose the following groups of indicators: K_{PS} – group integrated indicator of property status, K_L – group integrated indicator of liquidity, K_{FS} – group integrated indicator of financial stability, K_{BA} – group integrated indicator of business activity, K_P – group integrated indicator of profitability. Each of the above groups of indicators can be formed from a system of partial indicators of the corresponding nature. It should be noted that the above list of GIIEC is not unambiguous, and may be changed due to the tasks facing the researcher. In this paper, the main focus is on the description of the structure and mathematical apparatus of the proposed model.

Based on the above, we present model in the form of a hierarchical tree of logical inference (Fig. 2).

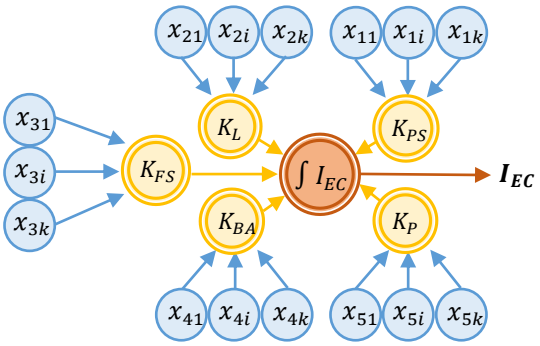

Fig. 2. **Hierarchical structural model for assessing the competitiveness of agricultural enterprises**

Source: built by the author

Analytical record of the model for assessing the competitiveness of agricultural enterprises will look like (1):

$$\begin{cases} K_{PS} = f_{K_{PS}}(x_{11}, \dots, x_{1k}) \\ K_L = f_{K_L}(x_{21}, \dots, x_{2k}) \\ K_{FS} = f_{K_{FS}}(\dots) \\ K_{BA} = f_{K_{BA}}(\dots) \\ K_P = f_{K_P}(x_{m1}, \dots, x_{mk}) \\ I_{ec} = f_{I_{ec}}(K_{PS}, K_L, K_{FS}, K_{BA}, K_P), \end{cases} \quad (1)$$

where $К_i$ – group integrated indicator of enterprise competitiveness; x_{mk} – partial indicators of enterprise competitiveness of k group; f_{X_i} – convolution function of partial competitiveness criteria x_{mk}; I_{ec} – overall integrated indicator of enterprise competitiveness.

This model was the basis of the author's computer program Comprehensive assessment of the competitiveness of the company «ASCO» [24], in the environment of which the following calculations were performed.

Based on the fact that the aim of the work is to develop an approach to comprehensive assessment of the competitiveness of agricultural enterprises, the object of study was selected agricultural enterprise. The calculations of the relevant indicators of competitiveness were made on the basis of the financial statements of Private JSC «Dashkivtsi». The main economic activity of the company according to Classification of economic activities 01.11 – cultivation of cereals (except rice), legumes and oilseeds.

At the first stage of calculation of the integrated indicator it is necessary to provide information homogeneity of dimensionality of data when working with large arrays of indicators.

When forming a system of partial indicators, it is possible that the indicators are heterogeneous in units of measurement, in which case it is necessary to normalize the indicators.

If x_i is the indicator-stimulator, i.e., its growth leads to an improvement in the state of the system, then its normalized value x_i^{norm} is determined by $min - max$ method (2):

$$x_i^{norm} = \frac{x_i - x_{\min}}{x_{max} - x_{\min}}, \quad (2)$$

where x_i^{norm} – normalized value, x_i – initial input value, x_{min} – the minimum value of the indicator, x_{max} – the maximum value of the indicator.

If x_i is indicator-disincentives, i.e., its growth leads to the deterioration of the system, then its normalized value, then its normalized value x_i^{norm} is determined by the inverse $min - max$ method (3):

$$x_i^{norm} = \frac{x_{max} - x_i}{x_{max} - x_{min}}. \quad (3)$$

It should be noted that the mathematical apparatus of normalization of indicators converts the initial values into a dimensionless form in the range [0; 1]. The presence of zero values can cause an error in the following calculations. To avoid this case, we propose to modify the normalization formulas so that the normalized values were in the range $x_i^{norm} \in [1;\ 2]$ (4), (5).

$$x_i^{norm} = \frac{x_i - x_{\min}}{x_{max} - x_{\min}} + 1. \quad (4)$$

$$x_i^{norm} = \frac{x_{max} - x_i}{x_{max} - x_{min}} + 1. \quad (5)$$

This modification of the calculation formulas rejects the probability of zero values.

The results of the calculations are given on the example of partial indicators of the group of integrated indicators of property status (Table 1).

Table 1

Normalized indicators of partial criteria of Private JSC «Dashkivtsi» in 2015-2020

Indicators	Years					
	2015	2016	2017	2018	2019	2020
x_{11}	1.000	1.223	1.012	1.492	1.997	2.000
x_{12}	1.000	1.304	1.018	1.596	1.998	2.000
x_{13}	1.778	1.621	2.000	1.212	1.000	1.408
x_{14}	1.000	1.112	1.098	1.578	1.917	2.000
x_{15}	2.000	1.888	1.900	1.422	1.083	1.000

Source: calculated by the author

Having determined the normalized indicators, we calculate the group integrated indicators of competitiveness. The GIIEC calculation model is shown in Fig. 3.

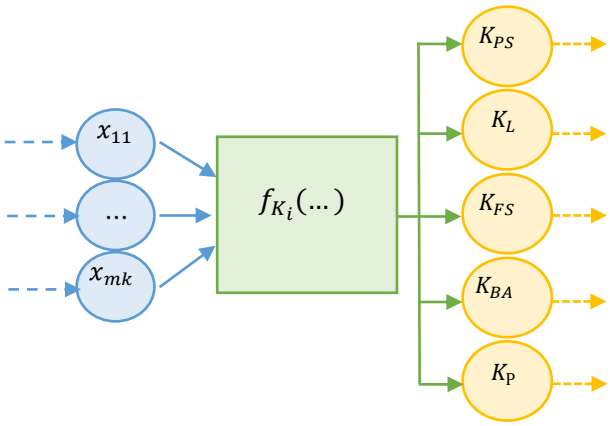

Fig. 3. **Neural network model of GIIEC calculation**

Source: author's development

The model contains three layers: the first – a layer of input partial indicators, in this case normalized indicators; the second – a layer of functional processing of normalized indicators; the third – a layer of initial indicators, in our case GIIEC.

In this research, the calculation of the GIIEC is proposed to be carried out according to a modified formula of the geometric mean of the normalized partial values (6):

$$I_{ec} = \sqrt[n]{\prod_{i=1}^{n} x_i^{norm}} - 1, i = \overline{1,n};\ x_i > 0;\ I_{ec} \in [0;1]. \quad (6)$$

The results of GIIEC calculations are given in Table 2.

Table 2

Group integrated indicators of enterprise competitiveness of Private JSC «Dashkivtsi» in 2015-2020 years

GIIEC	Years					
	2015	2016	2017	2018	2019	2020
K_{PS}	0.289	0.403	0.339	0.453	0.526	0.623
K_L	0.496	0.208	0.146	0.206	0.452	0.456
K_{FS}	0.573	0.134	0.186	0.445	0.546	0.402
K_{BA}	0.851	0.362	0.760	0.495	0.367	0.214
K_P	1.000	0.110	0.496	0.334	0.318	0.085

Source: calculated by the author on the basis of financial statements of the enterprise

According to the calculated average annual growth rate for 2015-2020, you can see the growth of only the property status, which amounted to 16.6%, for other indicators there is a negative situation: the decline in liquidity was 1.7%; financial stability – 6.8%; business activity – 24.1%; profitability – 38.9% (Fig. 4).

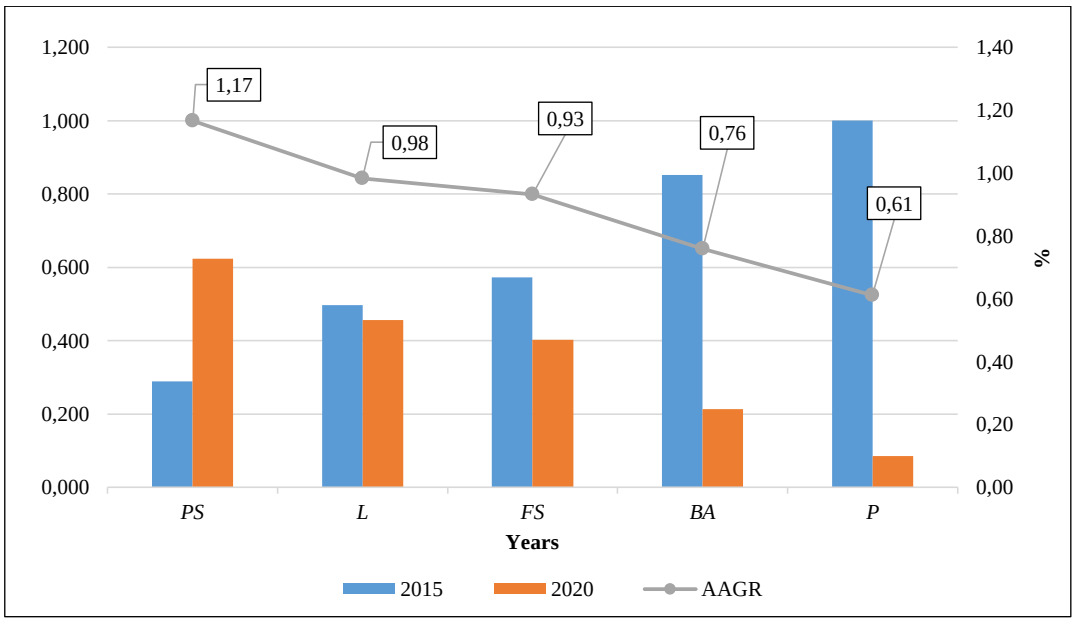

Fig. 4. **GIIEC of Private JSC «Dashkivtsi» in 2015 and 2020 years**
Source: built by the author

Having determined the GIIEC, we will calculate the OIIEC of Private JSC «Dashkivtsi» according to the model of functional convolution (Fig. 5).

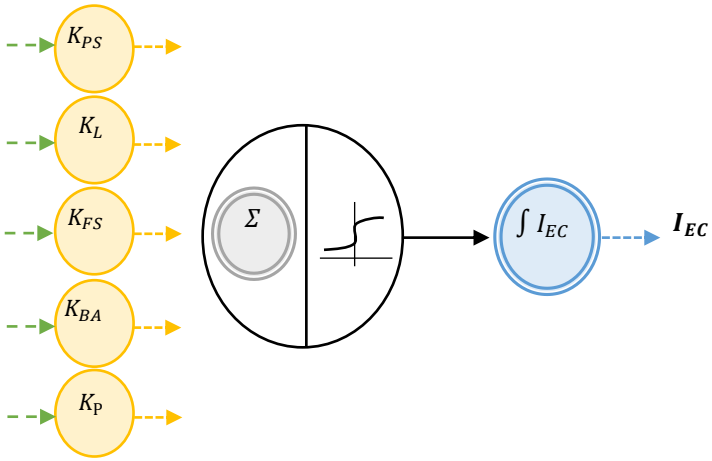

Fig. 5. **Neural network model for calculating OIIEC**
Source: author's development

As described above, the prerequisite for calculating OIIEC is to determine the level of significance (weight) of individual GIIEC. Assessment of complex systems is based on the formation of a generalized indicator from a system of a significant number of partial indicators. However, it is clear that partial indicators may not always have the same level of impact on the resulting indicator, in which case there is a problem of determining their weights. The presence of weights will give the model «understand» how to calculate all group indicators.

It is proposed to determine the weights by the Fishburne method, the algorithm of which is shown in Fig. 6.

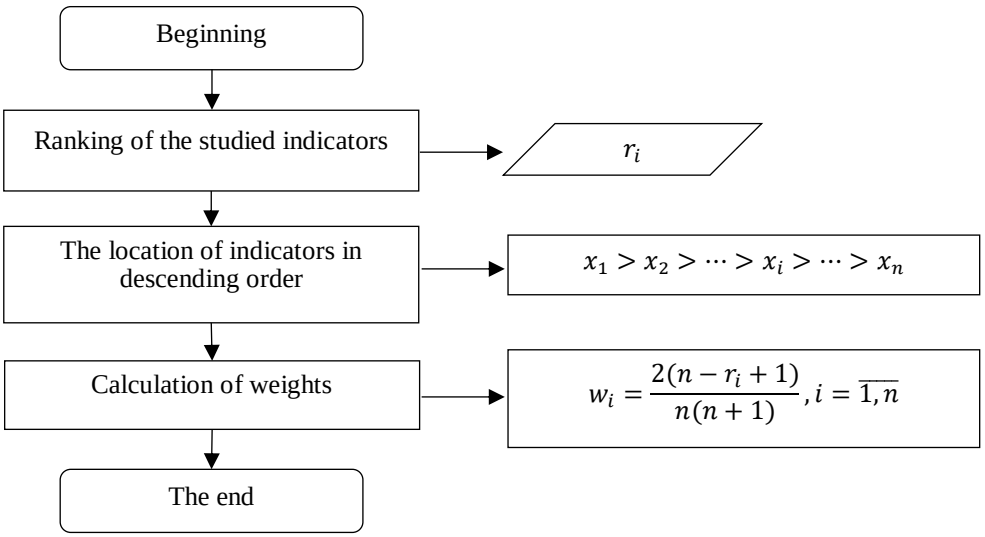

Fig. 6. **Algorithm for determining weights by the Fishburne method**
Source: developed by the author by the method of Fishburne [25]

Thus, the calculated weights of GIIEC are given in Table 3.

Table 3

Weighting factors of GIIEC of Private JSC «Dashkivtsi» in 2015-2020 years

GIIEC	Years					
	2015	2016	2017	2018	2019	2020
	w_i					
K_{PS}	0.067	**0.333**	0.200	**0.267**	**0.267**	**0.333**
K_L	0.133	0.200	0.067	0.067	0.200	**0.267**
K_{FS}	0.200	0.133	0.133	0.200	**0.333**	0.200
K_{BA}	**0.267**	**0.267**	**0.333**	**0.333**	0.133	0.133
K_P	**0.333**	0.067	**0.267**	0.133	0.067	0.067

Source: calculated by the author according to the financial statements of the enterprise

According to the proposed methodological approach, the obtained weights form the relationship (synapses) between the model of functional convolution and the transformation model. With the help of weight coefficients, we can indicate the model, what degree of influence the GIIEC has on the resulting indicator, and thus determine the overall integral indicator of the competitiveness of agricultural enterprises.

The transformation of the obtained results is given on the example of the OIIEC for 2020 year. The analytical record will look like:

$$I_{ec}^{2020} = \psi\left(\sum_{i=1}^{n} K_i w_i\right) = \left[\overbrace{(0.623 * 0.333)}^{0.208_{K_{PS}}} + \overbrace{(0.456 * 0.267)}^{0.122_{K_L}} + \overbrace{(0.402 * 0.200)}^{0.080_{K_{FS}}} + \overbrace{(0.214 * 0.133)}^{0.029_{K_{BA}}} + \overbrace{(0{,}085 * 0.067)}^{0.006_{K_P}}\right] = \mathbf{0.444}.$$

According to a similar principle, OIIEC of Private JSC «Dashkivtsi» for other years are calculated: $I_{ec}^{2016} = 0.298; I_{ec}^{2017} = 0.488;\ I_{ec}^{2018} = 0.433; I_{ec}^{2019} = 0.483;\ I_{ec}^{2020} = 0.444$.

The sequence of stages of calculations of the neural network model in the environment of the computer program «ASCO» is shown in Fig. 7.

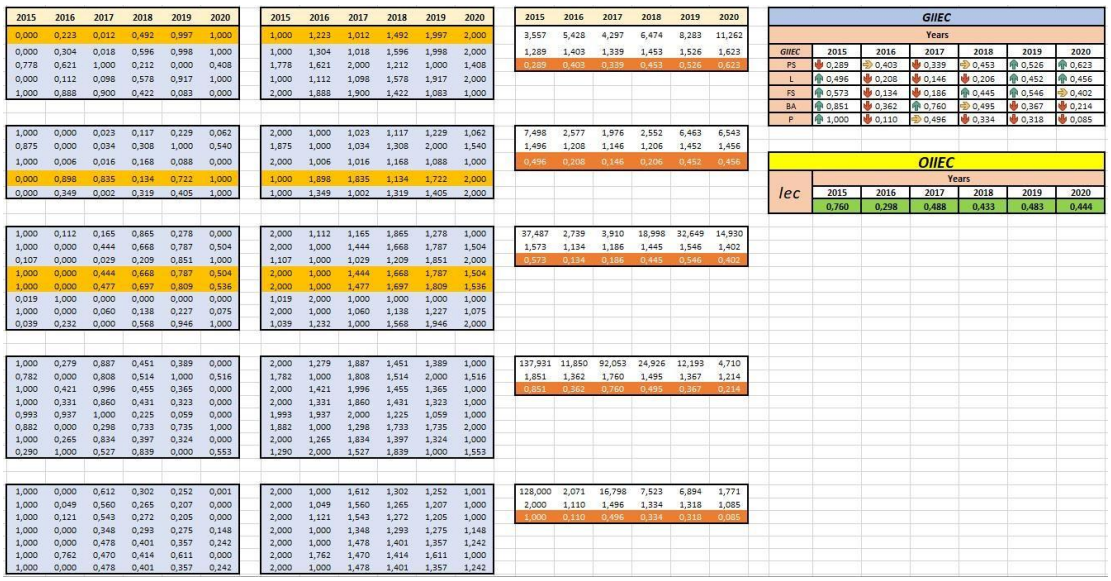

Fig. 7. **Author's computer program ASCO window**

Source: developed by the author

Analyzing the dynamics of the competitiveness of Private JSC «Dashkivtsi» (Fig. 8), we can observe the highest value of the indicator in 2015, however, the lowest value – in 2016 (0.760 and 0.298, respectively).

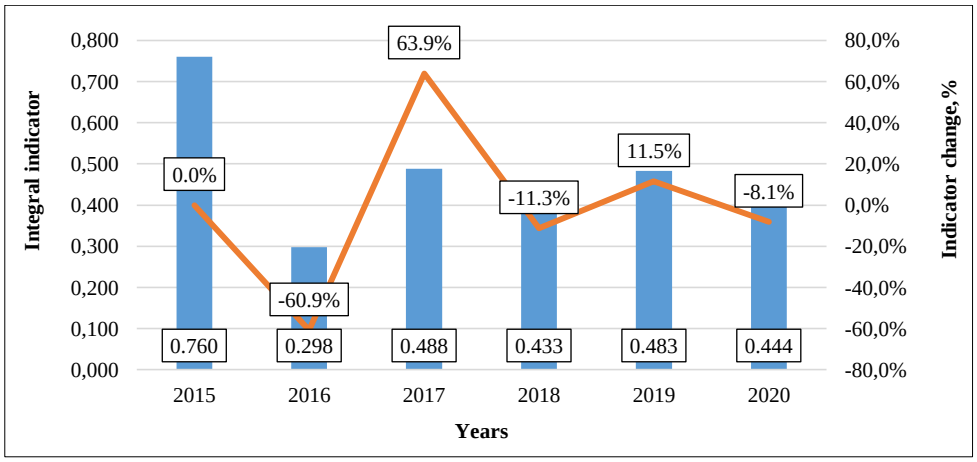

Fig. 8. **Dynamics of change of GIIEC of Private JSC «Dashkivtsi» in 2015-2020**

Source: built by the author

The chain change of the indicator between 2015 and 2016 was critical -60.9%, which indicates significant problems of functioning at the enterprise. At the same time, in 2017 there is an increase in the indicator of OIIEC by 63.9% compared to the previous period. During 2017-2020, we can see a stable dynamic of indicators, the change of which is in the range from -11.3 to 11.5% for the entire study period.

If we consider the dynamics of OIIEC in terms of GIIEC, we can see the corresponding fluctuations between the generalized indicator and the indicators of the lower hierarchy. In 2016, the lowest indicators for the entire study period were observed, which, accordingly, reflects the OIIEC. For 2017-2020, the stabilization of

the financial and economic condition of Private JSC «Dashkivtsi» is noticeable, which is confirmed by the values of OIIEC.

In order to identify the causes of a sharp rise or fall in performance, we propose to investigate the level of quality of system control. The level of quality of system control can be determined by analyzing the fluctuations of the calculated indicators.

The most convenient and informative statistical tool for the analysis of the quality of controllability of the system are the control charts of Schuhart (CCS).

CCS is a graphical diagnostic tool that allows you to investigate the variability of values of indicators, and depending on the positioning of values on the graph, you can determine the level of controllability of the system.

The use of CCS is due to the need to detect unnatural changes in the dynamics of data sampling. Thus, it is possible to confirm or deny the existence of statistical controllability of the process. The process is considered controllable if the change in dynamics was caused only by accidental causes. If the change was greater than optimal, it is the result of special causes that need to be identified.

In this study, the boundaries of CCS zones are determined on the basis of a modified approach based on the «three sigmas» rule. According to this rule, the control limits will be at a distance of $[-3\sigma; +3\sigma]$ from the center line. This approach indicates that about 99.7% of observations will be in a statistically controlled state. The remaining 0.3% of observations are likely to go beyond the controllability of the system, which may indicate a non-statistical probability of the case.

It should be noted that CCS, in this study, will be based on individual sample values. This is explained by the fact that the process of data collection does not always involve the grouping of indicators by certain categories, in such situations it is advisable to study the management process based on individual, independent values of the system.

The calculation of the system of indicators for the construction of zones CCS for the analysis of OIIEC is given in Table 4.

Table 4

System of indicators for construction of CCS

Legend	Description of CCS' zones	Analytical view	Borders of CCS' zones
LCL_1	the lower limit of the optimal zone	$\bar{x} - 1\sigma$	0,322
UCL_1	the upper limit of the optimal zone	$\bar{x} + 1\sigma$	0,628
LCL_2	the lower limit of the warning zone	$\bar{x} - 2\sigma$	0,170
UCL_2	the upper limit of the warning zone	$\bar{x} + 2\sigma$	0,781
LCL_3	the lower limit of the control zone	$\bar{x} - 3\sigma$	0,017
UCL_3	the upper limit of the control zone	$\bar{x} + 3\sigma$	0,934

Source: generated by the author

The graph of the analysis of the level of controllability of the system of the general integrated indicator of competitiveness of the enterprise on CCS is given in Fig. 9.

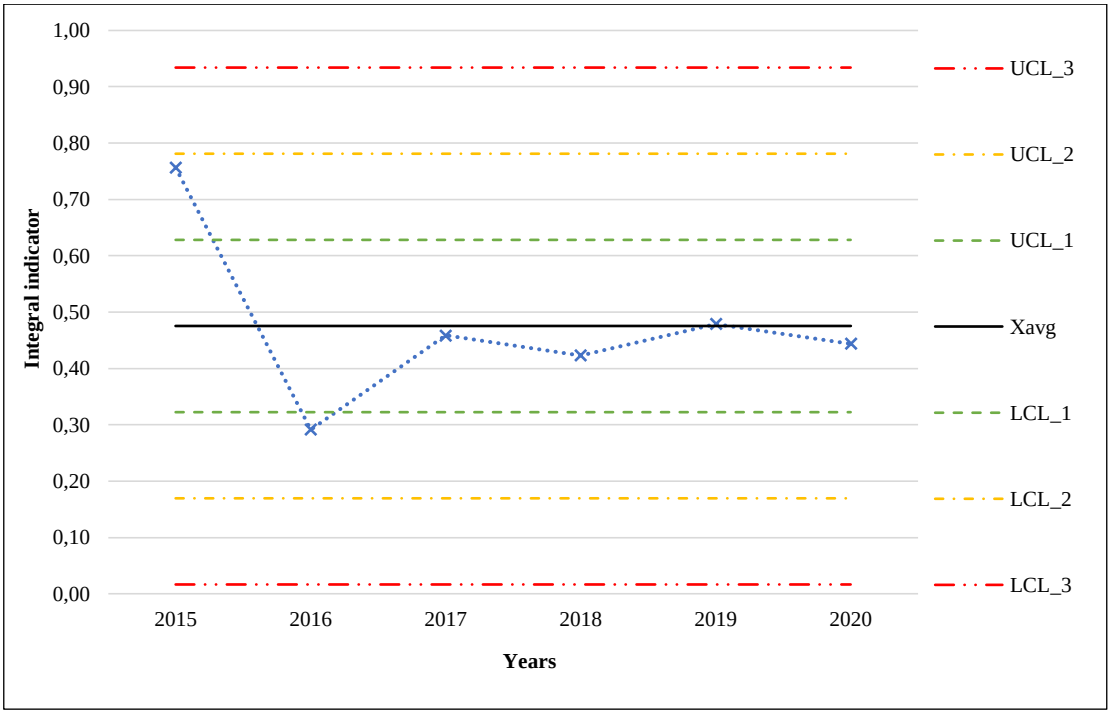

Fig. 9. **CCS' dynamics OIIEC of Private JSC «Dashkivtsi» in 2015-2020 years**
Source: built by the author

As can be seen from the figure, the values of the indicator OIIEC during 2017-2020 are within the zone $\bar{x} \pm 1\sigma$. This situation indicates a state characterized by a stable level of controllability of the system. In 2015, we can see a sharp increase in the indicator, as well as going beyond the optimal zone. This indicates possible changes in resource management. This growth is certainly positive for the company, but in 2016 there is a positioning of OIIEC below the limit of the warning zone – $\bar{x} \pm 2\sigma$ – which indicates the irrational use of the obtained competitive advantages, as evidenced by the decline.

Considering CCS as a forecasting tool, it can be argued with high probability that in 2021 the company's activities will be within $[\bar{x} - 1\sigma; \bar{x} + 1\sigma]$, which corresponds to the area close to absolute control.

Conclusions. Thus, to solve the problem of quantifying the assessment of the competitiveness of agricultural enterprises requires a careful study of the issue for all its components. The process of analyzing the competitiveness of agricultural enterprises is a complex and multi-criteria task that is based on the processing and compilation of a significant number of indicators of the enterprise.

The presented non-classical approach to assessing the competitiveness of agricultural enterprises, based on the synthesis of the principles of neural network modeling, work with latent indicators, taxonomy methods allow to obtain an economically sound quantitative indicator that can be interpreted as an indicator of competitiveness.

The principle of the modularity of the model allows the researcher to easily change the structure of the model by increasing or decreasing the calculated blocks, thus adapting the model to the assessment of other economic systems. The flexibility of the model provides an opportunity to change the set of groups of indicators that

shape the efficiency of economic activity of the enterprise, thereby increasing the variability of the model.

In our opinion, the prospects for further development are seen in the development of a unified scale for the linguistic interpretation of OIIEC by synthesizing the desirability function and Harrington's psychophysical scale.

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