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DECISION MAKING ON THE DIRECTION OF INVESTMENT IN THE DEVELOPMENT OF SEPARATE PARAMETERS OF AGRICULTURAL EQUIPMENT

Об'єктом дослідження є процес самофінансування, як провідний напрямок у системі інвестиційного забезпечення розвитку суб'єктів господарювання. Одним із найбільш проблемних місць у вирішенні цього питання є визначення пріоритетності цих вкладень.

В ході дослідження використовувалися статистичний метод для аналізу й узагальнення статистичної інформації та методи кластерного аналізу та k-середніх для класифікації основних груп показників техніко-експлуатаційних й економіко-маркетингових параметрів використання сільськогосподарської техніки. А також методи матричного аналізу та багатомірних просторів – для позиціювання підприємств і обґрунтування вибору напрямків інвестування.

В роботі запропоновані теоретико-методологічні положення та висновки, які в сукупності розв'язують важливу практичну задачу – необхідності пошуку напрямів інвестування у розвиток окремих параметрів сільськогосподарської техніки. Проведено аналіз стану та особливостей діяльності підприємств сільськогосподарського машинобудування України. Наголошується на необхідності проривного розвитку машинобудівного сектора агропромислового комплексу. Зазначається, що більша частина українських підприємств, що виробляють сільськогосподарську техніку, має застаріле обладнання, тому потребують переобладнання та значних фінансових вливань. Під час класифікації пріоритетності напрямків вкладання коштів встановлено, що сільськогосподарську техніку, яку зараз виробляють українські машинобудівні підприємства, треба змінювати повністю. Тому запропоновано перелік етапів щодо вибору напрямів удосконалення тракторної техніки. Запропонований підхід щодо визначення пріоритетності вкладення коштів передбачає класифікацію показників якості за пріоритетністю їх вдосконалення за певним алгоритмом. Проведено оцінку напрямів інвестування та встановлено, що прийняття остаточного рішення щодо інвестування у розвиток окремих параметрів сільськогосподарської техніки можна зробити за допомогою удосконалення тільки тих показників визначеної групи, які були отримані за допомогою кластеризації.

Завдяки простоті запропонованого підходу він може бути застосований не тільки для сільськогосподарського машинобудування, а і для інших підприємств господарчого комплексу України. У порівнянні з аналогічними відомими підходами його використання дозволить більш точно провести дослідження й отримати необхідні дані для цілеспрямованого інвестування за умов обмеженості коштів.

Ключові слова: *агропромисловий комплекс, сільськогосподарське машинобудування, сегменти ринку, фінансування, конкурентоспроможність продукції, показники якості.*

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1. Introduction

In modern conditions there is a problem of investment attractiveness of the enterprise. This is primarily due to a decrease in budget opportunities. Enterprises, in particular the engineering industry, rely on foreign investment, but this process is still hampered by a complex tax system and the instability of political processes. Therefore, the distribution of funds within the enterprise, that is, the financing of entrepreneurial activity at the expense of its own funds, is becoming increasingly important for Ukrainian enterprises. On the practical aspect of investment areas at industrial enterprises of Ukraine, in some cases it is conducted by enterprises insufficiently justified, without due fundamental theoretical justification. Therefore, it is relevant to study the justification of investment areas at engineering enterprises in the face of limited own financial resources.

2. The object of research and its technological audit

The object of research is the process of self-financing, as a leading direction in the system of investment support for the development of business entities. But the most problematic place in resolving this issue is determining the priority of these investments.

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3. The aim and objectives of research

The aim of research is to find the direction of investment in the development of individual parameters of agricultural machinery. To achieve this aim, it is necessary to complete the following tasks:

1. Make a classification of the priority areas of investment at the enterprises of tractor engineering.
2. Propose a methodological approach to determining the priority of investment.
3. Assess the selected direction of investment.

4. Research of existing solutions of the problem

Issues related to the investment attractiveness of industrial enterprises are given significant attention in [1, 2]. However, in these works there is no mechanism and suggestions on the choice of investment areas for agricultural engineering enterprises.

The authors of [3, 4] note that further development of agriculture will be associated with significant investments in agricultural engineering. It is also noted that farms will be the main investors. However, it is not clear to the end whether it is possible to apply the experience of foreign countries in the conditions of the Ukrainian economy.

The works [5, 6] emphasizes the need for fiscal reforms and state support for industrial enterprises, but nothing is said about the support of the agricultural engineering sector.

In [7, 8], general methodological approaches to assessing the investment attractiveness of agricultural enterprises are presented, but there are no recommendations for evaluating individual parameters of agricultural machinery.

The authors in [9] note the need to search for internal sources of financing the development of agricultural enterprises. But they do not indicate what to do when internal sources of financing are limited.

It is necessary to agree with the authors of the studies [10, 11], who note that there are a number of factors of not only economic nature that inhibit the development of agricultural engineering.

Thus, the analysis results allow to conclude that there is a significant number of works devoted to the problem under consideration. But there are no system developments for its solution.

5. Methods of research

In solving the tasks set in the work, general scientific and special methods are used, namely:

– statistical – to analyze and summarize statistical information;

– methods of cluster analysis and k-means – to classify the main groups of indicators of technical, operational and economic and marketing parameters for the use of agricultural machinery;

– methods of matrix analysis and multidimensional spaces – for the positioning of enterprises and the rationale for the choice of investment areas.

6. Research results

Modern innovative development of Ukraine is impossible without the active development of one of the leading sectors – agriculture. In a planned economy, agricultural support is expressed in various ways, including the organization of an industry such as tractor agricultural engineering. During the Soviet period, a powerful industry was created in the country, producing up to 560 thousand tractors per year, which amounted to approximately 40 % of world volumes [12]. Initially, tractor construction was built on non-market principles. There were factories that made machines of a very narrow nomenclature in mass circulation, which made it possible to deeply specialize production and make equipment cheap.

By the beginning of the 90s, significant capital and potential has been accumulated in the region. With the beginning of economic reform, it was necessary to transform the industry in accordance with market principles on which the modern economy is based. However, there are a number of reasons why this has not been fully achieved. The main one is a sharp drop (literally at times) in solvent demand from agricultural producers. Since 1991, tractor plants are not loaded or loaded at a very low percentage of their capacity. And, as a result, factories are gradually losing professional staff, rather than updating production equipment and working on new equipment more slowly than necessary. So, in [13] it is noted that «the level of provision of the majority of agricultural enterprises with material and technical means does not exceed 50 % of the normative technological needs», 35 % of enterprises are in unsatisfactory condition. Currently, about 129.3 thousand tractors and 26.8 thousand combine harvesters are used in the agricultural sector. The presence of the main types of equipment in agricultural enterprises is presented in Table 1.

As can be seen from the Table 1, throughout the study period there is a reduction in the machine-tractor fleet of agricultural enterprises. The available number of tractors and combines does not meet technological needs. So, in the absence of modern harvesting equipment, Ukrainian farmers lose 11 % of their crops annually, which is almost 7 million tons of grain.

Provision of agricultural enterprises with agricultural machinery has been getting worse over the past years. Thus, the number of tractors decreased by 2.05 %, combine harvesters – by 2.06 %, flax harvesters – by 24.2 %. Now the purchase of the main types of agricultural machinery is 3–5 % of the available, while for the normal reproduction of the machine and tractor fleet, 8–12 % must be purchased annually [15]. Therefore, the load on one unit of agricultural machinery is growing, although it must be borne in mind that most of it has worked out its life, is physically completely worn out, and morally obsolete. A high level of equipment wear requires significant funds for its repair. More than half of the tractors, almost every combine harvester, and almost all the tillage equipment need to be repaired annually.

Now it is possible to observe some updating of agricultural machinery. So, for the first half of 2016, farmers bought 4.9 thousand units of equipment for 188 million dollars, which is 35 % more compared to the same period of 2015. Agricultural producers spent more than half of this amount on tractors and combines (more than 100 million USD). In total, 9995 units worth 58 million USD were purchased in 2016, and in January 2017 the market continued to grow – farmers purchased 341 pieces of equipment worth about 13 million USD. In total, over 4 months of 2017, farmers purchased 3218 units of equipment worth about 141 million USD [16].

Table 1

The presence of tractors and combines in agricultural enterprises of Ukraine, thousand pcs in 2012–2017 [14]

Type of equipment	Years						2017 in % to 2016
	2012	2013	2014	2015	2016	2017	
Tractors of all brands – total	150740	146004	130811	127852	132686	129272	–2.05
Harvesters:							
grain harvesting	31997	30061	27196	26735	27366	26801	–2.06
corn harvesting	2131	2009	1784	1634	1534	1523	–0.72
forage harvesting	6731	6098	5274	4982	4861	4559	–6.21
flax harvesting	298	259	209	187	190	144	–24.2
potato harvesting	1632	1483	1276	1215	1239	1090	–
plows	51981	51349	47933	47336	49306	49072	–
cultivators	76709	75695	69452	69474	71659	70100	–
harrows	227505	218290	200017	193950	192029	181386	–
mowing machines	11522	11571	10920	10733	11283	10929	–
roller headers	14721	14545	13485	13595	14477	15389	–

This is due to the following factors:

1) the critical deterioration of equipment that works in agricultural enterprises;

2) during 2014–2016 farmers, thanks to the high yield, had significant profits;

3) dissatisfaction with the demand of previous years, the presence of a state program to support farmers – compensation for the purchase of Ukrainian agricultural equipment is paid – 20 %.

The need for breakthrough development in the machine-building sector of the agro-industrial complex (agro-industrial complex) is also caused by the increased expansion of foreign equipment in the Ukrainian market. The analysis shows that in 2016, the import of agricultural machinery in Ukraine increased significantly, foreign companies open dealerships [16]. Every year, the import of used equipment is growing. Although in general its share in the sales structure remained small. A 10 percent duty limits the demand for used cars [17]. In this case, the equipment used is: tractors – more than 6 %, combine harvesters – about a third.

Due to the decline in sales of their products in traditional importing countries, Western firms are actively seeking new ways to further consolidate themselves in the capacious and promising Ukrainian market, which does not coincide with the strategic interests of Ukraine. The adoption by the Verkhovna Rada of Ukraine of draft law No. 4024 regarding amendments to the Law of Ukraine «On Stimulating the Development of Domestic Engineering for the Agro-Industrial Complex» will enable farmers to buy cheaper (20–30 %) and modernized agricultural equipment.

The share of the presence of foreign firms in the Ukrainian market is economically justified – 10–15 % of sales. Orientation to the mass use of imported equipment is also not realistic, since, according to expert estimates, enormous financial expenses will be required – more than 20 billion USD annually, which will cause a sharp rise in price of agricultural products. The consequence of this will be a decrease in the purchasing power of rural producers, which will immediately negatively affect the engineering sector of the agro-industrial complex.

The market of tractors was filled with 11552 units of imported equipment worth 418 million USD. However, 1282 units were imported of used tractors in the amount of 36.2 million USD, that is, the share of used cars amounted to 8 % of the Ukrainian market.

It should be noted that in the total quantitative composition of imported in 2016, 72 % of the supply of new tractors was made up of Belarusian products. In terms of value, the situation looks a little different; Belarusian tractors were imported in the amount of 110.5 million USD, or 29 % of all imports. Along with them were deliveries of CnH Corporation (Italy) with the New Holland and Case brands, the third place was held by John Deere (USA) with a market share of 22 % [17].

Today in the field of agricultural engineering in Ukraine there are more than 120 specialized enterprises, among which are:

– Private Joint-Stock Company «Kharkiv Tractor Plant», Kharkiv;
– State Enterprise «Production Association Southern Machine-Building Plant named after A. M. Makarov», Dnipro;
– Limited Liability Company Scientific-Production Enterprise «BilotserkivMAZ», Bila Tserkva;
– Private Joint-Stock Company «Berdiansk reapers», Berdiansk;
– Limited Liability Company «Orikhivsilmash», Orikhiv;
– Limited Liability Company «Soyuz-Objects», Yuvileine, Dnipropetrovsk Region.

Today, machine-building enterprises for the agro-industrial complex produce mainly by orders and contracts. The production capacities of the tractor and combine-building plants are only one-third full, and some of them are generally idle. The annual losses in the agricultural machinery industry are about 8 million USD. And more than a quarter of the equipment produced remains in stock. Complex agricultural machinery due to its insufficient quality and reliability, limited functionality and high price does not fully comply with the requirements of agricultural production.

However, departmental fragmentation of enterprises does not allow for a unified technical policy and ensuring a systematic approach to the creation and testing, production and operation, repair and maintenance of equipment, market monitoring, and the provision of necessary services to peasants. The production base of a significant part of industrial enterprises in agricultural engineering, primarily

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for the production of tractors, currently has outdated equipment. Therefore, the top-priority strategic priority at the present stage is technological re-equipment, deep reconstruction and raising the technical level of engineering plants aimed at ensuring the development of new types of competitive equipment that meets international standards.

In recent years, Ukrainian enterprises have been able to slightly improve the quality of their products. However, due to limited volumes of production and lack of profit, the rate of renewal of production is insufficient, because enterprises do not have the necessary funds for this. However, there is confidence that, thanks to the new investment policy of the government, new approaches to lending to consumers and manufacturers of equipment, including for setting up production of modern technical equipment and updating technologies for their manufacture, Ukrainian equipment will become competitive not only in the domestic, but also in the foreign markets. In recent years, the Ukrainian government has been to adopt regulations to support the development of the agricultural machinery industry. In particular, compensation for purchased agricultural equipment of Ukrainian production should help increase the purchasing power of farmers, which will allow updating the technical park of agricultural enterprises. The Budget Code provides funds for state support of producers in the amount of at least 1 % of agricultural output. In 2017, this amount was 42 million USD. The Ministry of Agrarian Policy is forecasting an increase in this figure to 62.5 million USD [18].

It can be stated that the Ukrainian machine-building industry for the agro-industrial complex, subject to the provisions of the Law of Ukraine «On Stimulating the Development of Domestic Machine-Building for the Agro-Industrial Complex», can eliminate the threat of agricultural enterprises becoming dependent on supplies of imported equipment. And also, to gradually meet the needs of the agro-industrial complex in high-quality and high-performance domestic equipment at lower prices than that offered by foreign firms. But it should be noted that the agricultural machinery market has special requirements for the enterprises that work on it. First of all, this is a very unstable market: depending on the season, demand varies significantly, and it is also strongly affected by climatic conditions and natural disasters, which inevitably affect the purchase of equipment. Also, approaches to the selection of equipment have changed. In the struggle for a 2–4 % increase in productivity, farmers are forced to take into account a number of factors, including regional climatic features of soils and changes in technology in crop production. When choosing agricultural equipment, they focus primarily on productivity and reliability, technical specifications, operational properties and ease of setup, warranty periods and, of course, prices and payment terms [15]. That is, agricultural machinery, which is now produced by Ukrainian machine-building enterprises, needs to be radically changed.

In this regard, the choice of areas for improving tractor equipment should have the following steps:

– analysis of the market for tractor equipment indicating the needs of consumers;
– analysis of the range of products that are presented on the market with the definition of competitiveness indicators;
– development of areas for improving tractor equipment.

The main document for assessing the technical level and quality of Ukrainian agricultural machinery is a map of the technical level and quality (ML), which is compiled and updated during the development and approval of design documentation, product certification, modernization, and decommissioning.

All quality indicators when compiling a ML, according to GOST 4.40-84 [19], consist of the following main groups:

– indicators of appointment (30 positions);
– reliability indicators (8 positions);
– indicators of manufacturability (5 positions);
– indicators of transportability (1 position);
– ergonomic indicators (4 positions) – GOST 12.2019-76;
– safety indicators (5 positions) – GOST 12.2019-76;
– patent legal indicators (2 positions);
– indicators of standardization and unification (3 positions) – GOST 23945-80;
– aesthetic indicators (4 positions).

The list of quality indicators of industrial tractors according to GOST 4.373-85 [20] contains the following indicators:

– bearing capacity in percentage of the operating weight of the tractor without technological equipment: when hanging in front, when hanging from the back;
– specific structural weight, kg/kW;
– maximum design power of the hydraulic system pumps, which is intended for selection for external consumers as a percentage of the operational power of the engine mounted on the tractor;
– maximum fluid pressure in the hydraulic control system of the working (technological) equipment, MPa;
– gamma-percent and (or) the resource is set before the first overhaul of the tractor, motorcycle hours;
– MTBF of II, III complexity groups (complex failure), motor-hours;
– established uptime running hours;
– specific total operational complexity of maintenance, man-hours/1000 moto-hours;
– specific total operational complexity of eliminating failures, man-hours/1000 moto-hours.

As it is possible to see, there are a fairly large number of quality indicators for industrial tracts [19–21]. All this makes it difficult to choose the priority of investment. Therefore, there is a need to classify quality indicators according to the priority of their improvement.

This can be done by clustering using the following algorithm:

1) the choice of the number of clusters into which the population should be divided, the task of initially breaking up the objects and determining the centers of gravity of the clusters;

2) in accordance with the selected measures of similarity, determining the new composition of each cluster;

3) after full viewing of all objects and their distribution among clusters, the centers of gravity of the clusters are listed;

4) procedures 2 and 3 are repeated until the next iteration yields the same cluster composition as the previous one.

Next, the average values of economic and statistical characteristics, the size and composition of the resulting clusters are determined by the results of the clustering process, and the results are shown both on the graph and in the tables (clustering calculations were performed using the Statistika package [22].

As the results of the clustering show, all the technical and economic indicators were divided into four clusters. The technical and operational indicators such as productivity (working width of aggregated trailed machines) came to the first cluster (Table 2).

Table 2

Objects of research included in the first cluster of technical and operational indicators

Technical and operational indicators	The validity of including an object in a cluster		
	The average value of the indicator	Deviation of indicators from the standard average value	
		absolute	relative, %
Performance	2408	0.02408	0.001
Speed	4.283	3.71635	86.77
Dynamism	18.67	22.4227	120.1
Tractor patency	18.58	18.0709	97.26
Maintainability	1.00	1.1013	110.13
Convenience of service	1.00	1.1013	110.13
Work safety	1.00	1.1013	110.13

Note: if the deviations of the values of technical-operational and economic-marketing indicators are in the range from 0.0 % to ±5.0 % – the objects are of the highest priority for inclusion in the cluster; if in the range from ±6.0 % to ±10.0 % – priority for inclusion in the cluster; if in the range from ±11.0 % to ±20.0 % – inclusion in the cluster is possible

The second cluster (Table 3), which includes indicators of efficiency (fuel consumption during operation), tractor patency: specific pressure on the ground and agricultural or ground clearance, reliability (MTBF).

Table 3

Objects of research included in the second cluster of economic indicators

Technical and operational indicators	The validity of including an object in a cluster		
	The average value of the indicator	Deviation of indicators from the standard average value	
		absolute	relative, %
Profitability	235.125	6.0262	2.563
Clearance	400.375	23.1697	5.787
Reliability	418.500	4.4151	1.055
Price	1032.112	1172.066	113.56
Brand work	0.750	1.3418	178.91
Trademark prevalence in the target tractor segment	0.500	0.7782	155.64

The third cluster included indicators such as speed, dynamism (traction), maneuverability, maintainability, ease of maintenance and operational safety (Table 4).

The fourth cluster includes economic and marketing characteristics, such as price, awareness and brand awareness, brand distribution in a specific target segment of the sales market (Table 5).

Further, comparing tractor models competing in a particular market segment, let's determine a group of indicators that need improvement, that is, the proposed classifier determines the direction of investment by building a dendrogram. With each of the selected subsystems of technical and economic indicators, using the construction of the dendrogram, it is necessary to select a representative using the following methodology.

Table 4

Objects of research included in the third cluster of technical and operational indicators

Technical and operational indicators	The validity of including an object in a cluster		
	The average value of the indicator	Deviation of indicators from the standard average value	
		absolute	relative, %
Performance	2408	2835.66	117.76
Speed	4.283	0.15316	3.576
Dynamism	18.67	3.89829	20.88
Tractor patency	18.58	4.16749	22.43
Maintainability	1.00	0.05111	5.389
Convenience of service	1.00	0.05111	5.389
Work safety	1.00	0.05111	5.389

Table 5

Objects of research included in the fourth cluster of economic and marketing indicators

Technical and operational indicators	The validity of including an object in a cluster		
	The average value of the indicator	Deviation of indicators from the standard average value	
		absolute	relative, %
Profitability	235.125	–	132.5664
Clearance	400.375	303.441	75.78928
Reliability	418.500	339.216	81.05537
Price	1032.112	55.6259	5.389523
Brand work	0.750	0.04252	5.669731
Trademark prevalence in the target tractor segment	0.500	0.02883	5.76649

Since all indicators are qualitatively incomparable, that is, they have different units, it is necessary to carry out their conversion. From the beginning, let's calculate the arithmetic mean value of the indicators, for this let's divide the indicators of each row of the original matrix into the arithmetic mean value of the indicator, and build the transformed matrix.

Based on this matrix, let's form a matrix of multidimensional distances between all pairs of factors and calculate the Euclidean distance between the first and second factors by the formula:

$$d_{io} = \sqrt{\sum_{j=1} \left(z_{ij} - z_{oj}\right)^2}, \quad (1)$$

where d_{io} – Euclidean distance; z_{ij}, z_{oj} – serial number of the qualitative characteristics of the studied parameter.

As a result of all calculations, let's obtain a transformed matrix of multidimensional distances.

Fig. 1 shows an example of constructing a dendrogram to determine the most developed type representative of six factors.

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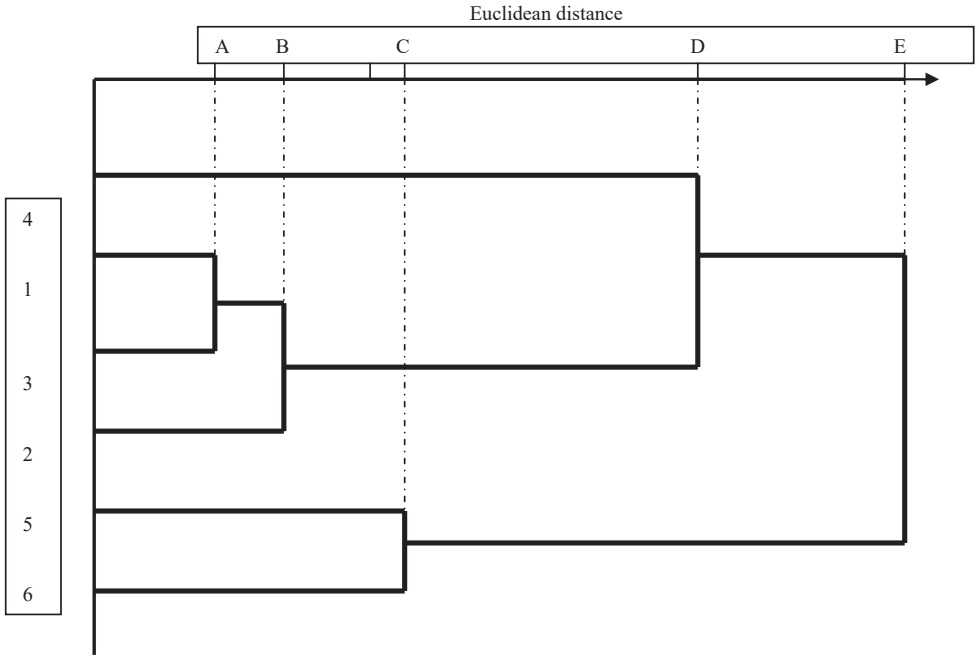

Fig. 1. Dendrogram of ordering factors

That is, it is necessary to select the minimum element in the matrix, to which the distance between 1 and 3 factors can be attributed.

Let's combine 1 and 3 into groups and provide the number 1. Let's calculate the distance of each factor to the newly formed group. Let's build a new transformed matrix. Let's combine the 1st and 2nd groups, provide the new group with a number and calculate the distance of the new factor to the others. Next, let's repeat the operations until only the 2 most significant elements remain in the transformed matrix.

Based on the results of the compilation, let's construct graphically the dendrogram, where the Euclidean distance between the model factors is plotted on top of the *OX* axis, and the numbers of factors that are combined along the *OA* axis are plotted.

To distinguish groups and their typical representatives, it is necessary to divide the dendrogram into classes. In this example, two groups of objects can be distinguished: the first – consists of four objects 4, 1, 3, 2, the second contains 5 and 6.

It has been established that the final decision on the direction of investment in the development of certain parameters of agricultural machinery of the manufacturing enterprise can be done by improving only those indicators of a certain group that were obtained using clustering. In particular, it is more efficient to invest and get positive results in improving the competitiveness of products in a shorter period of time.

Thus, the proposed methodology will identify the priority of investing in the development of commodity units. And also, it will allow them to more correctly position them on the market and will allow the company to allocate funds to improve product quality in difficult competitive conditions.

7. SWOT analysis of research results

Strengths. The theoretical and methodological approach to substantiating the directions of financing the development of agricultural engineering enterprises is substantiated and developed.

Using this approach will allow more accurate research and obtain the necessary data for targeted investment in the face of limited funds.

Weaknesses. The range of quality indicators, based on the analysis of factors of the external and internal environment, needs to be clarified. And also, using complex and systemic methods of cluster analysis, taking into account the relevant specifics of agricultural machinery manufacturers and can be used in the analysis by Ukrainian manufacturing plants.

Opportunities. A methodological approach has been developed that can be applied not only to agricultural engineering, but also to other enterprises of the economic complex of Ukraine.

Threats. For conditions with limited resources characteristic of the present, it is necessary to carefully check the appropriateness of including in this system a range of indicators that take into account the specifics of manufacturers, and this causes certain difficulties.

8. Conclusions

1. When classifying the priority areas of investment, it is found that agricultural machinery, which is now produced by Ukrainian machine-building enterprises, must be completely changed. Therefore, a list of stages for the selection of areas for improving tractor equipment is proposed.

2. An approach to determining the priority of investing is proposed, which provides for the classification of quality indicators according to the priority of their improvement according to a certain algorithm.

3. The investment areas are evaluated and it is established that the final decision on investing in the development of certain parameters of agricultural machinery can be made by improving only those indicators of a certain group that are obtained using clustering.

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