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Technologies of Managing the Operating Assets

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Abstract**: *This study is based on the use of discriminant analysis techniques in order to individualize the analytical tools to assess the efficiency of managing the operating assets of economic agents. It has been determined that for the enterprises belonging to the Group of Companies, different integral indicators with different levels of discrimination are created while using identical discriminant variables, according to which the opposite conclusions can be drawn about the population belonging to a particular class with the same values for each subject. The developed empirical compartment functions prove the thesis of the erroneousness of universalization and generalization of conclusions when applying statistical methods. In other words, the need to identify problems at enterprises, their development potential, and the specifics of made managerial decisions remains an urgent task of analyzing financial and economic activities.***

Index Terms**: *operating assets, asset management performance indicators, statistical methods for conducting economic research, discriminant analysis, discriminant function.***

I. INTRODUCTION

The production process is arranged by raising various forms of capital, which consistently passes through all stages of the operating cycle during its flow. The faster the capital goes through the cycle, the more an economic agent receives and sells products with the same amount of capital for a certain period of time [1]. A slowdown of the cycle at any stage delays the capital turnover, requires additional investments, and, as a result, has a negative effect on the bottom line. This means that it is necessary to strive not only to accelerate turnover but also to maximize its return, which is expressed by an increase in the amount of profit per ruble of capital [1]. The ratio of the profit to cost of capital determines the profitability of this capital; therefore, the goal of the enterprise is to increase profitability, i.e., profitability and capital utilization efficiency. The efficiency of arranging the production process can be assessed in terms of cost – return on capital (assets) and cost-efficiency, as well as on the rate of the capital turnover – the turnover ratio.

These indicators are the parameters for assessing the quality and efficiency of managing an economic agent, assessing its ability to generate sufficient return on invested capital, and therefore, improving the method for their assessment and forecasting can be considered relevant. Perhaps there are many solutions to this issue based on the implementation of various methods of conducting economic research, but there is no unified integral indicator that allows assessing the degree of cost of use and return on capital attracted directly to the production activity of the enterprise. As such, it seems necessary to develop an integral indicator (model) for evaluating and forecasting the efficiency of managing the assets (capital) involved in the production process of the agent, which determines the purpose of this article. The implementation of the discriminant analysis technique as multidimensional and integral financial assessment models, which are best known as models assessing the probability of bankruptcy, is covered in the works of Altman, Taffler, and others [2]. It is suggested to expand the analytical tools for evaluating the efficiency of managing the operating assets of an economic agent based on the implementation of the discriminant analysis method, which allows creating not universal anonymous models but rather individual integral indicators that assess the condition of a particular economic agent.

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II. METHODS

A. Concept of the discriminant analysis

The discriminant analysis belongs to a group of statistical methods enabling the study of the differences between two or more groups of objects by several variables simultaneously [3]. The key idea of the discriminant analysis is the assumption that objects of observation are discriminated (separated) by a combination of attributes [4]. The discriminant analysis is carried out in two stages: differences among the existing classes are interpreted at the first stage, and the classification of new objects is carried out, and their belonging to a certain group is revealed at the second stage [5].

The discriminant analysis belongs to the category of methods of multivariate statistical analysis involving the description of objects by a set of attributes. Like many other multidimensional methods, the discriminant analysis is based on the construction of linear combinations of attributes – functions which each of them enters with its own coefficient (contribution) [6].

The discriminant function defines a line on the coordinate axis, which reveals two fields (below and above the chart) – as such, the set of objects under study is distributed (scattered) relative to this chart.

The objects are divided into two groups. A more complex and detailed solution allows to divide the array under study into a larger number of classes (depending on the purposes of the analysis) [7].

B. Limitations of discriminant analysis

The following limitations are applied when discriminant variables are selected:

1) any number of discriminant variables is allowed if it does not exceed the number of objects (observations) minus two: $0 < p < (n-2)$, where p is the number of discriminant variables, and n is the number of objects (observations);
2) the number of classes should be more than two: $g \geq 2$, g is the number of classes; at least two objects in each class;
3) the law of normal distribution must be satisfied for each class;
4) linear dependence of discriminant variables is not allowed, i.e., the introduction of variables whose correlation coefficient is equal to or close to 1 is unacceptable; and
5) measuring classes of variables on an interval scale [3].

C. Method of rejection (acceptance) of limitations

First of all, the type of scale (variational series) on which objects of a certain class are grouped should be determined: in the case of representation as a discrete series, the data should be rearranged into an interval scale. The number of groups (k) is determined according to formula (1):

$$k = 1 + 3.32 \log n \tag{1}$$

The length of the interval (h) is calculated as the difference between the maximum and minimum values of the attribute x_i to the number of groups [8]:

$$h = \frac{x_{max} - x_{min}}{k} \tag{2}$$

The hypotheses about the compliance with the law of the normal distribution in the sample forming the class of each discriminant variable should be checked at the next stage. The following two hypotheses are defined:

1) H_0 is the main hypothesis: the class (sample) g has a distribution law that is different from the normal;

2) H_1 is the alternative hypothesis: the class (sample) g has a normal distribution law [9].

The hypothesis of a normal distribution will be tested in accordance with the Pearson’s chi-squared (χ^2) test, which reveals the relevance of the divergence of empirical and theoretical frequencies (probability of an event) [10]. To do this, the observed chi-square value (χ^2_{obs}) is found as the ratio of the observed and expected frequencies, the critical point of the chi-square distribution (χ^2_{cr}) is determined for a given level of significance α and the number of degrees of freedom ν ($\nu = n - 3$) of the right-sided critical area [11].

The main hypothesis will be valid when $\chi^2_{obs} > \chi^2_{cr}$. The alternative hypothesis is accepted when $\chi^2_{obs} < \chi^2_{cr}$, i.e., the empirical and theoretical frequencies differ slightly, and the law of normal distribution remains valid [12]. Testing the hypothesis of a normal distribution is accompanied by calculations of the following indicators, since calculations are carried out over interval rows, and the frequency of occurrence of the event (f_i) is entered into the formulas:

1) selective arithmetic average:

$$\bar{x}_s = \frac{\sum x_i f_i}{\sum f_i} \tag{3}$$

2) sample standard deviation:

$$\sigma_s = \sqrt{\frac{\sum (x_i - \bar{x}_s)^2 \cdot f_i}{\sum f_i}} \tag{4}$$

3) standardized variable x_i:

$$u_i = \frac{x_i - \bar{x}_s}{\sigma_s} \tag{5}$$

4) differential normal distribution function:

$$\varphi(u) = \frac{1}{\sqrt{2\pi}} e^{-\frac{u^2}{2}} \tag{6}$$

5) observable (empirical) chi-square value χ^2:

$$\chi^2_{obs} = \sum \frac{\left(f_i - \tilde{f}_i\right)^2}{\tilde{f}_i} \tag{7}$$

where f_i is the empirical frequency, and $\tilde{f}_i$ is the theoretical frequency *[9]*.

The fulfillment of the three sigma rule $\pm 3\sigma$ also indicates the observance of the law of the normal distribution, as it says: if the random variable has normal distribution, then the modulus of its deviation from the mathematical expectation does not exceed its threefold standard deviation [13].

The relationship between the variables is defined on the basis of testing the hypothesis of linearity of the relationship according to the Pearson's correlation coefficient. The two hypotheses are defined:

1) H_0 is the main hypothesis: there is no linear relationship between the variables.

2) H_1 is an alternative hypothesis: the variables are correlated, i.e., there is a linear relationship between them [14].

A two-sided test will be conducted with two boundary points, which are determined according to the table of Student's t-distribution for a given level of significance α and the number of degrees of freedom ν ($\nu = n - 2$) of the central critical region. The observed value of t-statistics is determined using formula (8):

$$t = \sqrt{\frac{r^2(n-2)}{1-r^2}}, \tag{8}$$

where r is the Pearson's correlation coefficient *[15]*.

D. Selection of discriminant variables

The choice of discriminant variables is determined by the research of the activities of the PJSC TATNEFT subsidiaries, which have shown a reduction in their share in the formation of the Company's total profit in the last five years. TATNEFT Group has 69 subsidiaries, where PJSC TATNEFT is the founder in 19 only [16]. It can be assumed that the negative dynamics of the subsidiaries and affiliates in the Group's financial results are associated with the effect of a high base in 2014, including reaching the planned capacity of TANECO, on the one hand, and a fall in profitability of many non-mining industries since 2014, on the other hand.

A selective analysis of the profitability of the assets of subsidiaries and affiliates of the group is carried out in order to identify the trend in the efficiency of assets owned by PJSC TATNEFT. It has been decided to calculate the profitability index of operating capital, which in theory and practice of economic analysis is understood as assets directly involved in the operating activities of an enterprise, i.e., dependent on the activity of the enterprise [1]. The discriminant analysis will be conducted on three subsidiaries and affiliates, in which the Company is the sole founder (Table 1).

Table 1. Classification of the assets of the affiliates and affiliates of the TATNEFT Group as operating

Name of subsidiaries and affiliates	Assets that can be attributed to operating
TANECO JSC (production of petroleum products)	*Fixed assets*
LLC TATNEFT Samara (geological exploration)	*Fixed assets*
LLC TATNEFT-AZS Center (wholesale trade in motor fuel)	*Fixed assets*
	Reserves
	Receivables

The indicators of the management efficiency in operating assets and costs of enterprises are defined as discriminant variables [1]. The profitability indicators will be found using the profit before tax, since it includes not only the result of the main activities of the subsidiaries and affiliates, but also the balance of other income and expenses, the formation of which is influenced by the Company. The profitability of the operating capital is found using the ratio of profit before tax to the value of assets related to the operating capital; the turnover ratio of operating capital (the ratio of revenue to the value of operating assets) is an indicator of not only efficiency, but also business activity, while the profitability of the total cost of an enterprise is the ratio of profit before tax to the total costs generated by all activities.

III. RESULTS

A. Calculation of discriminant variables, rejection (acceptance) of discriminant analysis constraints (for the first object of study)

The first object of the study is TANECO JSC. The classes of discriminant variables of subsidiaries and affiliates are presented in Table 2.

Table 2. Value of classes of discriminant variables (TANECO JSC) *[17]*

Year/ interval	Return on the operating capital, %	Turnover ratio of operating capital	Cost-effectiveness, %
Discrete series			
2010	0.2617	0.0195	7.1740
2011	0.1556	0.0300	1.9934
2012	0.9995	0.1033	6.6326
2013	0.6259	0.1397	3.1383
2014	0.9603	0.2118	4.4347
2015	0.1783	0.2311	0.7244
2016	0.3074	0.2235	1.2791
2017	0.1371	0.2363	0.4918
Interval series			
1	0.1371 – 0.3527	0.0195 – 0.0737	0.4918 – 2.1624
2	0.3527 – 0.5683	0.0737 – 0.1279	2.1624 – 3.8329
3	0.5683 – 0.7839	0.1279 – 0.1821	3.8329 – 5.5035
4	0.7839 – 0.9995	0.1821 – 0.2363	5.5035 – 7.1740

Group 1
Group 2

The study of the data of discrete variational series in terms of the normal distribution implies their representation as interval scales. The number of groups (k) is determined as four, using formula (1). The length of the interval (h) is found using formula (2): 0.2156 for the return on the operating capital, 0.0542 for the turnover ratio, and 1.6706 for the cost-effectiveness.

The following values are given for the calculations: the significance level $\alpha = 0.05$, the number of degrees of freedom ν (ν = 8 - 3 = 5). The results of calculations and testing of the hypothesis on the normal distribution of classes of discriminant variables are presented in Table 3.

Table 3. Testing the hypothesis on the normal distribution of classes of discriminant variables (TANECO JSC) – by interval series

Estimation parameters for normal distribution	Return on the operating capital, %	Turnover ratio of operating capital	Cost-effectiveness, %
Sample standard deviation	0.3049	0.0735	2.2656
Observed (empirical) chi-square value	10.213	5.789	5.886
Theoretical chi-square value	11.070	11.070	11.070
Hypothesis selection	10.213< 11.070 H_1	5.789 < 11.070 H_1	5.886< 11.070 H_1
Compliance with the three sigma rule	[-0.4542… 1.3752] values are in the range of deviations from the average	[-0.0723… 0.3687] values are in the range of deviations from the average	[-3.5904… 10.0034] values are in the range of deviations from the average
Compliance with the normal distribution law	True	True	True

The law of normal distribution is observed for all discriminant variables, since the observed chi-square value is less than the critical one; therefore, an alternative hypothesis is accepted, and the three sigma rule is also complied with – deviations from the mathematical expectation do not exceed its threefold standard deviation.

Let us find and verify the linearity of the relationship between the discriminant variables. The results are presented in Table 4.

Table 4. Testing the hypothesis of linear dependence of discriminant variables (TANECO JSC)

Pair of discriminant variables	Evaluation parameters for linearity of the relationship				
	Correlation coefficient	Observable t-statistics	Theoretical t-statistics	Hypothesis selection	Linearity of the relationship
Pair 1: return on the operating capital / turnover ratio	0.0195	0.0477	2.447	-2.447 < 0.0477 < 2.447 H_0	No
Pair 2: return on the operating capital / cost-effectiveness	0.5936	1.8066	2.447	-2.447 < 1.8066 < 2.447 H_0	No
Pair 3: turnover ratio / cost-effectiveness	-0.6266	1.9695	2.447	-2.447 < 1.9695 < 2.447 H_0	No

The main hypothesis is accepted for all pairs since the value of the observed t-statistics is in the critical region; therefore, there is no linear relationship between the discriminant variables.

The discriminant analysis implies the rejection of all its constraints; each class of variables must be divided into groups at the next stage. The classes of discriminant variables are divided into two groups: the periods when the performance indicators in the aggregate took the highest values in the sample are assigned to the first group, while the minimum values are assigned to the second group.

B. Calculation of the discriminant function and discrimination of indicators of operating assets management efficiency (for the first object of study)

Let us create matrices X_1 and X_2 – to do this, the values of the initial variables for each group are written down, i.e., group 1 of performance indicators of TANECO JSC forms matrix X_1, while group 2 forms matrix X_2.

$$X_1 = \begin{pmatrix} 0.2617 & 0.0195 & 7.1740 \\ 0.9995 & 0.1033 & 6.6326 \\ 0.6259 & 0.1397 & 3.1383 \\ 0.9603 & 0.2118 & 4.4347 \end{pmatrix} \quad X_2 = \begin{pmatrix} 0.1556 & 0.0300 & 1.9934 \\ 0.1783 & 0.2311 & 0.7244 \\ 0.3074 & 0.2235 & 1.2791 \\ 0.1371 & 0.2363 & 0.4918 \end{pmatrix}$$

Let us find the arithmetic average values for each group of variables, thus determining the position of the centers in these groups:

Group 1: $x_{11} = 0.7119$, $x_{21} = 0.1186$, $x_{31} = 5.3449$.

Group 2: $x_{12} = 0.1946$, $x_{22} = 0.1802$, $x_{32} = 1.1222$.

Since three discriminant variables are taken into account, and the construction of a multiple linear regression equation is required, the discriminant function f(x) will be as follows (9):

$$f(x) = a_1x_1 + a_2x_2 + a_3x_3 \tag{9}$$

Coefficients a_1, a_2, a_3 are found using formula (10):

$$A = S_*^{-1}(\overline{X_1} - \overline{X_2}) \quad (10)$$

where X_1, X_2 are the vectors of averages in the first and second groups of coefficients,

A is the vector of coefficients, and

S_* is the inverse matrix of the joint covariance matrix [18].

Matrices S_1 and S_2 should be found to determine the joint covariance matrix S_*; the algorithm for the formation of the former is presented in Table 5. The matrix is square symmetric, i.e., its elements are symmetric with respect to the main diagonal. Each element of these matrices represents the difference between the corresponding values of the initial variable x_{ij} and the mean value of this variable in the given group x_{ik} (k is the group number) [4].

Table 5. Algorithm of forming covariance matrices S_1 and S_2*[19]*

$M(x_1^2) = \sum(x_{i1} - \overline{x_{1k}})^2$	$M(x_1x_2) = \sum(x_{i1} - \overline{x_{1k}})(x_{i2} - \overline{x_{2k}})$	$M(x_1x_3) = \sum(x_{i1} - \overline{x_{1k}})(x_{i3} - \overline{x_{3k}})$
$M(x_2x_1) = \sum(x_{i2} - \overline{x_{2k}})(x_{i1} - \overline{x_{1k}})$	$M(x_2^2) = \sum(x_{i2} - \overline{x_{2k}})^2$	$M(x_2x_3) = \sum(x_{i2} - \overline{x_{2k}})(x_{i3} - \overline{x_{3k}})$
$M(x_3x_1) = \sum(x_{i3} - \overline{x_{3k}})(x_{i1} - \overline{x_{1k}})$	$M(x_3x_2) = \sum(x_{i3} - \overline{x_{3k}})(x_{i2} - \overline{x_{2k}})$	$M(x_3^2) = \sum(x_{i3} - \overline{x_{3k}})^2$

The elements of the covariance matrices S_1 and S_2 are defined using the algorithm.

$$S_1 = \begin{pmatrix} 0.3545 & 0.0616 & -0.4894 \\ 0.0616 & 0.0192 & -0.3324 \\ -0.4894 & -0.3324 & 10.7013 \end{pmatrix} S_2 = \begin{pmatrix} 0.0178 & 0.0067 & 0.0265 \\ 0.0067 & 0.0302 & -0.1797 \\ 0.0265 & -0.1797 & 1.3393 \end{pmatrix}$$

The joint covariance matrix is defined using formula (11):

$$S_* = \frac{1}{n_1 + n_2 - 2}(S_1 + S_2) \quad (11)$$

where n_1, n_2 are the numbers of objects in groups 1 and 2.

$$S_* = \frac{1}{6}\begin{pmatrix} 0.3723 & 0.0682 & -0.4630 \\ 0.0682 & 0.0494 & -0.5120 \\ -0.4630 & -0.5120 & 12.0406 \end{pmatrix} = \begin{pmatrix} 0.0621 & 0.0114 & -0.0772 \\ 0.0114 & 0.0082 & -0.0853 \\ -0.0772 & -0.0853 & 2.0068 \end{pmatrix}$$

The inverse matrix S_*^{-1} is found:

$$S_*^{-1} = \begin{pmatrix} 22,2997 & -39,2465 & -0,8115 \\ -39,2465 & 286,5810 & 10,6778 \\ -0,8115 & 10,6778 & 0,9212 \end{pmatrix}$$

Let us calculate the vector of the coefficients of the discriminant function using formula (10):

$$A = \begin{pmatrix} 22.2997 & -39.2465 & -0.8115 \\ -39.2465 & 286.5810 & 10.6778 \\ -0.8115 & 10.6778 & 0.9212 \end{pmatrix} \cdot \begin{pmatrix} 0.5173 \\ -0.0617 \\ 4.2222 \end{pmatrix} = \begin{pmatrix} 10.5273 \\ 7.1215 \\ 2.8119 \end{pmatrix},$$

i.e., the coefficients of the function are the following: $a_1 = 10.5273$, $a_2 = 7.1215$, $a_3 = 2.8119$.

The discriminant function (integral indicator describing the management efficiency for operating assets of TANECO JSC) is as follows:

$$f(x) = 10.5273K + 7.1215K_2 + 2.8119K_3, \quad (12)$$

where K_1 is the return on operating assets,

K_2 is the turnover ratio of operating assets, and

K_3 is the cost-effectiveness.

Let us calculate the integral asset management efficiency indicator for each point in time (year) for the first group of indicators of TANECO JSC:

$$f_{11(2010)} = 10.5273 \cdot 0.2617 + 7.1215 \cdot 0.0195 + 2.8119 \cdot 7.174 = 23.0664$$

$$f_{12(2012)} = 10.5273 \cdot 0.9995 + 7.1215 \cdot 0.1033 + 2.8119 \cdot 6.6326 = 29.9079$$

$$f_{13(2013)} = 10.5273 \cdot 0.6259 + 7.1215 \cdot 0.1397 + 2.8119 \cdot 3.1383 = 16.4085$$

$$f_{14(2014)} = 10.5273 \cdot 0.9603 + 7.1215 \cdot 0.2118 + 2.8119 \cdot 4.4347 = 24.0877$$

The values of the discriminant function for each point in time (year) for the second group of coefficients of TANECO JSC are also found:

$$f_{21(2011)} = 10.5273 \cdot 0.1556 + 7.1215 \cdot 0.03 + 2.8119 \cdot 1.9934 = 7.4569$$

$$f_{22(2015)} = 10.5273 \cdot 0.1783 + 7.1215 \cdot 0.2311 + 2.8119 \cdot 0.7244 = 5.5597$$

$$f_{23(2016)} = 10.5273 \cdot 0.3074 + 7.1215 \cdot 0.2235 + 2.8119 \cdot 1.2791 = 8.4245$$

$$f_{23(2016)} = 10.5273 \cdot 0.1371 + 7.1215 \cdot 0.2363 + 2.8119 \cdot 0.4918 = 4.5090$$

The average value of the integral indicator in the first group is $\overline{f_1} = 23,3676$ and in the second group – $\overline{f_2} = 6,4875$. Let us define the discrimination constant using formula (13):

$$C = 1/2 \cdot (\overline{f_1} + \overline{f_2}) \quad (13)$$

$$C = 1/2 \cdot (23.3676 + 6.4875) = 14.9276$$

The discrimination constant is the boundary between the first and the second groups. If the value of the integral indicator (discriminant function) is more than 14.9276, then the indicators of cost and operating assets management in this period have values higher than the average for the analyzed period; if a function value is less than the discrimination constant, then the efficiency indicators under study take their lowest values.

The resulting discriminant function indicates that the largest contribution to its value is made by variable X_1 (K_1), i.e., the return on operating assets. Let us calculate the values of the standardized coefficients of all variables (a'), having previously calculated their standard deviations (σ_x) as a root of the square of the difference between the actual value of the coefficient and its average value *[20]*.

$$a'_1 = a_1 \cdot \frac{\sigma_{x_1}}{\sigma_y} = 10.5273 \cdot \frac{0.3600}{9.7918} = 0.3871$$

$$a'_2 = a_2 \cdot \frac{\sigma_{x_2}}{\sigma_y} = 7.1215 \cdot 0.0902 = 0.0656$$

$$a'_3 = a_3 \cdot \frac{\sigma_{x_3}}{\sigma_y} = 2.8119 \cdot \frac{0.0261}{9.7918} = 0.0075$$

The discriminant function with standardized coefficients (z) is as follows (14):

$$f' = 0.3871z_1 + 0.0656z_2 + 0.0075z_3 \quad (14)$$

The standardized discriminant function coefficients also indicate the determining influence of the profitability of the operating assets of TANECO JSC on the value of the integral indicator.

C. Calculation of discriminant variables, rejection (acceptance) of discriminant analysis constraints (for the second object of study)

Let us calculate the integral indicator describing the efficiency of managing the operating assets and expenses of LLC TATNEFT Samara. The solution algorithm is similar, therefore only the results of the calculations are provided in the article.

Table 6. Value of classes of discriminant variables (LLC TATNEFT Samara) [21]

Year / interval	Return on the operating capital, %	Turnover ratio of operating capital	Cost-effectiveness, %
Discrete series			
2010	13.3635	1.1666	8.8622
2011	4.0547	0.5278	8.1271
2012	10.8754	0.5594	20.9762
2013	4.6975	0.5309	8.0878
2014	5.9704	0.4094	13.5489
2015	6.0545	0.6017	10.7257
2016	22.2749	0.8249	36.4332
2017	27.2010	1.0101	36.6200
Interval series			
1	4.0547 – 9.8413	0.4094 – 0.5987	8.0878 – 15.2208
2	9.8413 – 15.6279	0.5987 – 0.7880	15.2208 – 22.3539
3	15.6279 – 21.4144	0.7880 – 0.9773	22.3539 – 29.4869
4	21.4144 – 27.2010	0.9773 – 1.1666	29.4869 – 36.6200
Group 1			
Group 2			

Let us divide the classes of discriminant variables into two groups: the periods when the performance indicators in the aggregate took the highest values in the sample are assigned to the first group, while the minimum values are assigned to the second group. The results are presented in Table 6.

Table 7. Testing the hypothesis on the normal distribution of classes of discriminant variables (LLC TATNEFT Samara) by interval series

Estimation parameters for normal distribution	Return on the operating capital, %	Turnover ratio of operating capital	Cost-effectiveness, %
Sample standard deviation	7.5764	0.3396	9.6739
Observed (empirical) chi-square value	4.7179	5.8730	8.2532
Theoretical chi-square value	11.070	11.070	11.070
Hypothesis selection	4.7179 < 11.070 H_1	5.8730 < 11.070 H_1	8.2532 < 11.070 H_1
Compliance with the three sigma rule	[-9.9946 …35.4638] values are in the range of deviations from the average	[-0.3019 …1.7359] values are in the range of deviations from the average	[-11.1258…46.9173] values are in the range of deviations from the average
Compliance with the normal distribution law	True	True	True

According to Table 7, the law of normal distribution is observed for all discriminant variables of LLC TATNEFT Samara, since the observed chi-square value is less than the theoretical one; therefore, an alternative hypothesis is accepted, and the three sigma rule is also complied with – deviations from the mathematical expectation do not exceed its threefold standard deviation.

Table 8. Testing the hypothesis of linear dependence of discriminant variables (LLC TATNEFT Samara)

Pair of discriminant variables	Evaluation parameters for linearity of the relationship				
	Correlation coefficient	Observable t-statistics	Theoretical t-statistics	Hypothesis selection	Linearity of the relationship
Pair 1: return on the operating capital / turnover ratio	0.6822	2.2854	2.447	-2.447 < 2.2854< 2.447 H_0	No
Pair 2: return on the operating capital / cost-effectiveness	0.7025	2.4179	2.447	-2.447 < 2.4179 < 2.447 H_0	No
Pair 3: turnover ratio / cost-effectiveness	0.3831	1.0160	2.447	-2.447 < 1.0160< 2.447 H_0	No

The data from Table 8 allow making a conclusion that the main hypothesis is accepted for all pairs of discriminant variables since the value of the observed t-statistics is in the critical region; therefore, there is no linear relationship between the predictors.

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D. Calculation of the discriminant function, discrimination of indicators of operating assets management efficiency (for the second object of study)

All the limitations for the calculation of the integral indicator of managing the efficiency of operating capital and expenses of LLC TATNEFT Samara are rejected. The discriminant function is as follows:

$$f(x) = 2.1004K_1 + 45.2778K_2 + 1.3885K_3, \quad (15)$$

where K_1 is the return on operating assets,

K_2 is the turnover ratio of operating assets, and

K_3 is the cost-effectiveness.

The average value of the integral indicator in group 1 is $\overline{f_1} = 114.731$, and in group 2 – $\overline{f_2} = 48.3934$. Let us define the discrimination constant using formula (13):

$$C = 1/2 \cdot (114.731 + 48.3934) = 81.5622$$

If the value of the discriminant function is more than 81.5622, then the indicators of cost and operating assets management in this period have values higher than the average for the analyzed period; if the function value is less than 81.5622, the performance indicators under study take their lowest values.

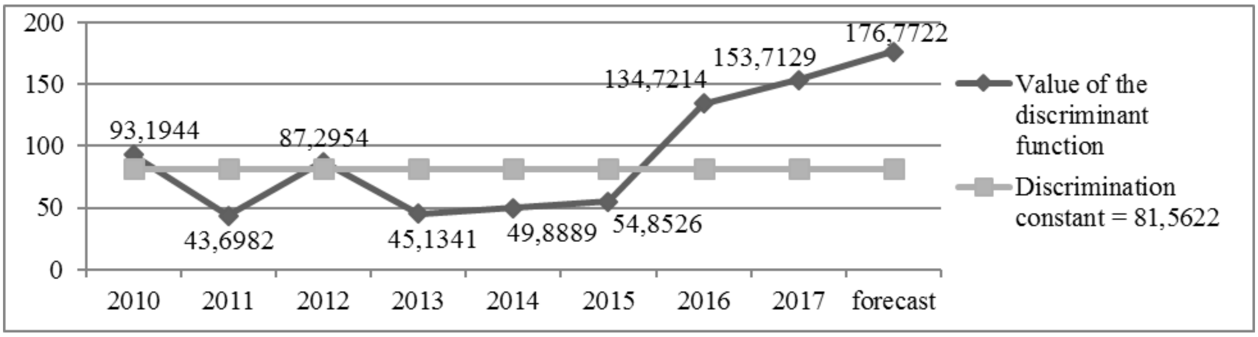

Fig. 1: Distribution of the values of the discriminant function relative to the discrimination constant (LLC TATNEFT Samara)

The visualization of the discriminant analysis results (Figure 1) allows making a conclusion that the values of the function that are above the critical boundary describe the state of high efficiency in the management of operating assets and expenses of LLC TATNEFT Samara, and the values located below the boundary describe low efficiency.

The discriminant function with standardized coefficients (z) is as follows (16):

$$f' = 0.0429z_1 + 0.2849z_2 + 0.0399z_3 \quad (16)$$

The standardized coefficients also revealed the determining influence of the turnover ratio of the operating assets of LLC TATNEFT Samara on the value of the integral indicator.

E. Calculation of discriminant variables, rejection (acceptance) of discriminant analysis constraints (for the second object of study)

The integral indicator describing the efficiency of managing operating assets and expenses of LLC TATNEFT-AZS Center are found using a similar algorithm.

Table 9. Study of classes of discriminant variables (LLC TATNEFT-AZS Center) *[22]*

Year / interval	Return on the operating capital, %	Turnover ratio of operating capital	Cost-effectiveness, %
Discrete series			
2010	3.5101	1.3013	2.7554
2011	2.4504	2.1227	1.1243
2012	2.8788	2.2916	1.2481
2013	2.4018	2.3656	1.0001
2014	1.8795	2.1581	0.8731
2015	4.0095	2.4337	1.6682
2016	6.6830	2.5775	2.6484
2017	3.0007	2.2218	1.3662
Interval series			
1	1.8795 – 3.0804	1.3013 – 1.6203	0.8731 – 1.3437
2	3.0804 – 4.2812	1.6203 – 1.9394	1.3437 – 1.8143
3	4.2812 – 5.4821	1.9394 – 2.2584	1.8143 – 2.2848
4	5.4821 – 6.6830	2.2584 – 2.5775	2.2848 – 2.7554
Group 1			
Group 2			

Let us divide the classes of discriminant variables into two groups: indicators, the values of which take the highest values in the sample, will form the first group, while the minimum values will form the second group, which is presented in Table 9.

Table 10. Testing the hypothesis on the normal distribution of classes of discriminant variables (LLC TATNEFT-AZS Center) by interval series

Estimation parameters for normal distribution	Return on the operating capital, %	Turnover ratio of operating capital	Cost-effectiveness, %
Sample standard deviation	01.3402	0.3302	0.6257
Observed (empirical) chi-square value	2.5106	5.9361	4.6457
Theoretical chi-square value	11.070	11.070	11.070
Hypothesis selection	2.5106 < 11.070 H_1	5.9361 < 11.070 H_1	4.6457 < 11.070 H_1
Compliance with the three sigma rule	[-0.4148…7.6264] values are in the range of deviations from the average	[1.1880…3.1694] values are in the range of deviations from the average	[-0.2393…3.5149] values are in the range of deviations from the average
Compliance with the normal distribution law	True	True	True

According to Table 10, the normal distribution law is observed for all the samples of discriminant variables of LLC TATNEFT-AZS Center: an alternative hypothesis has been accepted since the observed chi-square is less than the theoretical one. Compliance with the three sigma rule also predetermines the normal distribution in the classes of variables.

Table 11. Testing the hypothesis on linear dependence of discriminant variables (Tatneft-AZS Center LLC)

Pair of discriminant variables	Evaluation parameters for linearity of the relationship				
	Correlation coefficient	Observable t-statistics	Theoretical t-statistics	Hypothesis selection	Linearity of the relationship
Pair 1: return on the operating capital / turnover ratio	0.2932	0.7513	2.447	-2.447 < 0.7513 < 2.447 H_0	No
Pair 2: return on the operating capital / cost-effectiveness	0.7021	2.4152	2.447	-2.447 < 2.4152< 2.447 H_0	No
Pair 3: turnover ratio / cost-effectiveness	0.3532	0.9248	2.447	-2.447 < 0.9248 < 2.447 H_0	No

According to Table 11, the main hypothesis for all pairs is accepted, i.e., they are not correlated with each other and there is no linear connection.

F. Calculation of the discriminant function, discrimination of indicators of operating assets management efficiency (for the third object of study)

The limitations of the discriminant analysis of variables for LLC TATNEFT-AZS Center have been verified; as a result, the calculations are made for determining the integral indicator evaluating the efficiency of managing the operating capital and costs of the enterprise.

The discriminant function is as follows:

$$f(x) = 2.3564K + 9.4559K_2 + 7.9165K_3, \qquad (17)$$

the discriminant variables are the same as for the previous objects of study.

The average value of the integral indicator in group 1 is $\overline{f_1} = 47.7596$, and in group 2 – $\overline{f_2} = 35.1934$, the discrimination constant is C = 41.4765.

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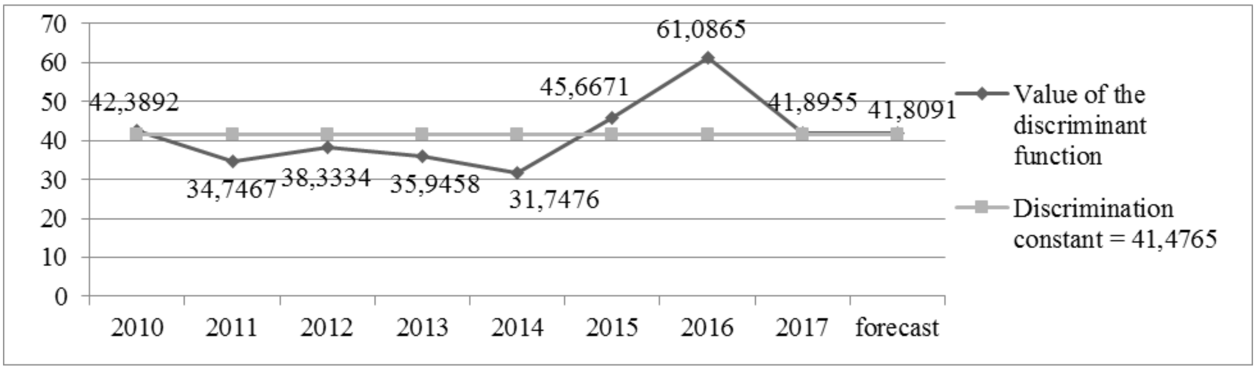

Fig. 2: Distribution of the values of the discriminant function relative to the discrimination constant (LLC TATNEFT-AZS Center)

It can be seen from Figure 2 that the points in time when the discriminant function value is more than 41.4765 are described by the state of high efficiency of operating assets and costs management LLC TATNEFT-AZS Center, and the values below the boundary describe low efficiency.

IV. DISCUSSION (FORECAST OF THE INTEGRAL ASSET MANAGEMENT EFFICIENCY INDICATOR)

The discrimination constant allows verifying the correctness of the distribution of objects in the existing groups, as well as classifying new objects and using them for forecasting purposes [4].

The forecast values of the initial financial results involved in the calculation of discriminant variables are found using the extrapolation method [9], and thereby calculating their forecast values. The following forecast values were obtained (the average growth rate is shown in parentheses): revenue from sales was 41,470,349 thous. rub. (+7.9 %); total costs were 52,056,839 thous. rub. (+14.7 %); profit before tax was 212,750 thous. rub. (-4.6 %); the value of operating assets was 164,801,569 thous. rub. (+1.3 %); return on operating assets was 0.12291 %; turnover ratio of operating assets was 0.2516, and cost-effectiveness was 0.4087 %.

Let us calculate the integral indicator of the asset management efficiency of TANECO JSC for the forecast period:

$$f_{forecast} = 10.5273 \cdot 0.1291 + 7.1215 \cdot 0.2516 + 2.8119 \cdot 0.4087 = 4.3001 < 14.9276\,(C)$$

The discriminant function for the forecast period has a value less than the discrimination constant, and therefore, the values of the performance indicators of TANECO JSC in this period will take their smallest states, which determines an unfavorable trend.

The following forecast values were obtained for LLC TATNEFT Samara (the average growth rate is shown in parentheses): revenue from sales was 7,784,911 thous. rub. (+16.8 %); total costs were 5,460,505 thous. rub. (+11.4 %); profit before tax was 2,130,550 thous. rub. (+18.7 %); the value of operating assets was 6,837,008 thous. rub. (+3.6 %); return on operating assets was 39.0175 %; turnover ratio of operating assets was 1.1386, and cost-effectiveness was 31.162 %.

Let us calculate the predicted value of the integral asset management efficiency indicator for LLC TATNEFT Samara:

$$f_{forecast} = 2.1004 \cdot 39.0175 + 45.2778 \cdot 1.1386 + 1.3885 \cdot 31.162 = 176.7722 > 81.5622\,(C)$$

There has been a positive trend in the dynamics of financial results and profitability indicators since 2015. As a result of extrapolation, this trend is extended for the forecast period, which is based on exceeding the rates of results over the rates of increase in costs (assets). The discriminant function for the forecast period is more significant than the discrimination constant; therefore, the values of the performance indicators for LLC TATNEFT Samara in this period will take on their greatest state, which determines a favorable trend.

As a result of the extrapolation of the financial results of LLC TATNEFT-AZS Center (at the average rate of change), the following forecast values were obtained: revenue from sales was 50,499,218 thous. rub. (+11.3 %); total costs were 49,729,981 thous. rub. (+10.9 %); profit before tax was 768,718 thous. rub. (+25.5 %); the value of operating assets was 23,052,550 thous. rub. (+12.9 %); return on operating assets was 3.3346 %; turnover ratio of operating assets was 2.1906, and cost-effectiveness was 1.5458 %.

Let us calculate the predicted value of the integral asset management efficiency indicator for LLC TATNEFT-AZS Center:

$$f_{forecast} = 2.3564 \cdot 3.3346 + 9.4559 \cdot 2.1906 + 7.9165 \cdot 1.5458 = 41.8091 > 41.4765\,(C)$$

The predicted growth rate of profit before tax is ahead of the change in other indicators; therefore, an increase in profitability indicators of LLC TATNEFT-AZS Center is expected in the future. The turnover ratio of operating capital for the forecast period will be reduced, as the increase in assets will outpace the increase in revenue. The integral indicator is close to the discrimination constant but slightly exceeds it, which means that the values of the performance indicators of LLC TATNEFT Samara will take their greatest state in the forecast period, but a trend towards a reduction in the integral indicator is outlined.

V.CONCLUSION

Measuring the results of the activities of various economic agents by the same parameters leads to opposite conclusions. As such, the application of the discriminant analysis method individually for several companies from the same Group of Companies leads to the definition of various discriminant functions that determine the uneven level of a line on the coordinate axis,

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which distribute the set of objects relative to this chart into groups.

The existing unified models allow estimating only the general financial condition – more precisely, the degree of the subject's proximity to bankruptcy, and have a standard constant (or interval) of discrimination regardless of the research objectives and industry affiliation. The unified multiplicative discriminant models are based on the fulfillment of standard norms by discriminant variables. Noncompliance with the standard of one variable implies a negative deviation from the entire discriminant function.

This article allows conducting a compartment research on specific aspects of the activities of enterprises and identifying the most significant factors in the formation of an integral indicator. After all, if the average return on operating capital is 0.4532 % for the first object of study, 11.8115 % for the second object, and 3.3517 % for the third object, then the universal conclusion would be that the first company from the set of objects under study least effectively manages its assets. A similar conclusion can be made on the turnover ratio. However, the incorrectness of these findings is that the operating capital of TANECO JSC is a slowly liquid asset that is "hardly" involved in a complex operational process. At the same time, the lowest level of return on the operating capital of TANECO JSC implies its determining value in the integral function of this enterprise. At the same time, for other objects of the study, the turnover ratio of operating assets makes the most significant contribution to the formation of the discriminant function. As such, "equalizing" the results and verifying the implementation of common standards are considered to be wrong, even for the companies belonging to the same Group of Companies.

Consequently, individual modeling enables to avoid the unified standards and identify the company's problems, potential for their development, and directions for making managerial decisions.

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