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ANALYSIS OF ECONOMIC AND MATHEMATICAL MODELING OF INDUSTRIAL ENTERPRISE FUNCTIONING AT MULTICOLLINEARITY BASED ON PARAMETERIZATION

Purpose. Investigation of multicollinearity in multifactorial economic and mathematical regression models of activity of Inhulets Mining and Processing Plant and reduction of its negative influence based on application of the parameterization method.

Methodology. To reduce the negative impact of multicollinearity in multifactorial regression models, a technique is developed that is based on the transition from the function of several variables to its parametric representation by analyzing the correlation matrix between factors in order to eliminate mutual correlation.

Findings. Economic and mathematical modeling of the activity of the JSC Inhulets Mining and Processing Combine showed that the presence of multicollinearity when applying a multifactor regression model leads to a distortion of the obtained results, which reduces the practical value of the model. The application of the parametrization method made it possible to reduce the influence of multicollinearity by providing parametric representations of the economic-mathematical model of holding the real economic process. The application of the parameterization method makes it easier to construct an economic-mathematical model in the form of regression equations, to reduce the negative impact of multicollinearity in the implementation and meaningful analysis of features of economic and mathematical modeling using multivariate regression equations.

Originality. For the first time, the application of the parameterization method is proposed, which allows us to simplify the construction of an economic-mathematical model in the form of regression equations. Using the parameterization method allows reducing the uncertainty in the synthesis of multivariate regression equations, ensuring appropriate adequacy.

Practical value. The analysis of the obtained results of economic and mathematical modeling of the activity of the Inhulets Mining and Processing Plant based on significant statistical material using the developed algorithm of elimination of multicollinearity confirmed the effectiveness of the proposed approach. It is recommended to include the developed algorithm for elimination of multicollinearity by parametrization in the practice of management of economic activity of mining enterprises.

Keywords: *mining, regression, multifactorial model, multicollinear, parameterization, financial activity*

Introduction. The current state of Ukrainian mining industry is characterized by uncertainty, which is largely related to the economy. In this context, it is important to make a reasonable and timely assessment of the economic difficulties arising in the activities of mining enterprises. At the same time, the rapid development of events leads to the need to apply new approaches based on the use of modern mathematical apparatus with the use of the latest advances in IT technologies. One of the possible and effective approaches to solving emerging matters is the mathematical modeling method. It is clear that such modeling should adequately describe economic phenomena. Given that there is uncertainty in the studied economic phenomena in mathematical modeling, multivariate regression models are used in mathematical modeling, the question arises about the validity of the methods used in their construction. In particular, consideration of multicollinearity is a rather important matter. The construction of a multivariate regression model in the presence of multicollinearity leads to a distortion of the results obtained due to the correlation of the input variables. As a consequence, it is important to evaluate the impact of multicollinearity on the simulation result and, if possible, to eliminate it.

Literature review. Along with traditional statistical methods of data analysis, mathematical and statistical methods based on the known methodology are used in the study of real socio-economic phenomena and processes.

The complexity of the use of mathematical and statistical methods involves a more complete disclosure of the essence, patterns and trends of specific phenomena and processes in order to adequately display the properties, reserves and prospects of development and ways of improvement.

Modern studies in the field of economics and its application in production are largely devoted to the analysis of the activity of enterprises through their economic and mathematical modeling. The works by scientists-economists M. I. Bakanov, A. D. Sheremet [1], R. S. Saifulin [2], G. V. Savitska [3] and others focus on efficiency and methods of its evaluation in economics. The content of mathematical modeling of economic activity is revealed in the works by scientists V. V. Vitlinskyi [4], M. O. Kyzym [5], M. O. Ponomarenko [6], O. M. Tryded [7]. In [8] it is proposed to use the value of average geometrical from the list of indicators as criterion of efficiency; according to the authors, the indicators define efficiency of management of industrial activity of enterprises. U. Mereste proposes to use matrix method to measure production efficiency [9]. According to the scientist, it will allow defining changes in the process of functioning and revealing reserves of improvement of activity of the enterprise. O. P. Levchenko notes that as a result of the analysis of components of economic activity of the enterprise, the most significant in the economic mechanism is the economic component [10].

Burova T. A. proposes to identify systems of indicators, which will allow forming an assessment of the efficiency of the enterprise [11]. Research on the methodology of statistical evaluation of the economic strategy of enterprises, which contributes to the formation of a model of their strategic development, is considered in [12]. Orientation to solving practical problems that can be described using a mathematical model is given in detail in [13].

Unsolved aspects of the problem. At the same time, attention is not fully paid to the influence of uncertainty and randomness in economic and mathematical modeling. In particular, this applies to the peculiarities of the application of multivariate regression models, where such an aspect as multicolinearity is quite simplified [14].

The purpose of the article is to investigate and eliminate the influence of multicollinearity on the result of economic and mathematical modeling when constructing a multivariate regression model by applying the parameterization method.

Results. There are various ways to identify multicollinearity using statistical methods. In particular, one such method is the Farrar-Glauber algorithm [4]. The peculiarity of the mentioned algorithm is that it allows identifying the presence of multicollinearity, but does not indicate an effective way to eliminate it. In this paper, an attempt is made to eliminate multicollinearity by presenting a multivariate regression model in a parametric form. Let us consider a linear three-factor regression model whose equation is

$$y = a_0 + a_1 \cdot x_1 + a_2 \cdot x_2 + a_3 \cdot x_3 + u, \quad (1)$$

where y is the output variable; x_1, x_2, x_3 are input variables (factors); a_0, a_1, a_2, a_3 are parameters; u is perturbation.

Let us suppose that there is certain multicollinearity, that is, there is a correlation between the factors. According to the Farrar-Glauber algorithm, based on the submitted statistical material and using Pearson's criterion, the presence of multicollinearity is established. If there is no multicollinearity, then the parameters included in equation (1) are found, in particular by the ordinary least squares (OLS). In the presence of multicollinearity, options are possible. At the first stage, using the Farrar-Globe algorithm, we establish the existence of a correlation dependence of one factor on the other two. Let us consider the case where there is a correlation dependence of the factor x_3 on the factors x_1 and x_2, moreover, this dependence is confirmed by the statistical criterion, in this case, the Fisher criterion. Then it is natural to write a linear two-factor regression model in the form.

$$x_3 = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + u_3, \quad (2)$$

where b_0, b_1, b_2 are parameters; u_3 is perturbation.

Substituting (2) into equation (1), we obtain an equation that contains only two factors.

$$y = a_0 + a_1 \cdot x_1 + a_2 \cdot x_2 + a_3 \cdot (b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + u_3) + u,$$

or

$$y = c_0 + c_1 \cdot x_1 + c_2 \cdot x_2 + u_4,$$

where

$$c_0 = a_0 + a_3 \cdot b_0; \quad c_1 = a_1 + a_3 \cdot b_1; \quad c_2 = a_2 + a_3 \cdot b_2;$$
$$u_4 = u + a_3 \cdot u_3.$$

The next step is to establish the existence of multicollinearity of the variables x_1 and x_2. To do this, we can use Student's criterion according to the Farrar-Glauber algorithm. If there is no multicollinearity, then there is no correlation between the variables x_1 and x_2. In this case, we obtain a system of two equations depending on two variables.

$$\begin{cases} y = c_0 + c_1 \cdot x_1 + c_2 \cdot x_2 + u_4 \\ x_3 = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + u_3 \end{cases}. \quad (3)$$

The use of OLS allows estimating the values of the parameters included in (4). The result is a system of equations

$$\begin{cases} \hat{y} = \hat{c}_0 + \hat{c}_1 \cdot x_1 + \hat{c}_2 \cdot x_2 \\ \hat{x}_3 = \widehat{b_0} + \widehat{b_1} \cdot x_1 + \widehat{b_2} \cdot x_2 \end{cases}, \quad (4)$$

where $\hat{c}_0, \hat{c}_1, \hat{c}_2, \widehat{b_0}, \widehat{b_1}, \widehat{b_2}$ are values of the parameters found using OLS; $\hat{y}$, $\hat{x}_3$ are estimates of the source variable y and factor x_3.

If multicollinearity is present, there is a correlation between the variables x_1 and x_2. The specification of such dependency can be set by the correlation field of variables x_1 and x_2. If there is a linear correlation relationship, then the regression equation can be written as

$$x_2 = d_0 + d_1 \cdot x_1 + u_5, \quad (5)$$

where are parameters; is perturbation.

Substituting (5) into system (3) and taking into account (6), we obtain a system of three equations that depend on one variable

$$\begin{cases} y = e_0 + e_1 \cdot x_1 + u_6 \\ x_2 = d_0 + d_1 \cdot x_1 + u_5, \\ x_3 = f_0 + f_1 \cdot x_1 + u_7 \end{cases} \quad (6)$$

where $e_0 = c_0 + c_3 \cdot d_0$; $e_1 = c_1 + c_2 \cdot d_1$; $f_0 = b_0 + b_2 \cdot d_0$; $f_1 = b_1 + b_2 \cdot d_1$; $u_6 = u_4 + c_2 \cdot u_5$; $u_7 = u_3 + b_2 \cdot u_5$.

The use of OLS allows estimating the values of the parameters included in (7). The result is a system of equations

$$\begin{cases} \hat{y} = \hat{e}_0 + \hat{e}_1 \cdot x_1 \\ \hat{x}_2 = \widehat{d_0} + \widehat{d_1} \cdot x_1, \\ \hat{x}_3 = \widehat{f_0} + \widehat{f_1} \cdot x_1 \end{cases} \quad (7)$$

where $\hat{e}_0, \hat{e}_1, \widehat{d_0}, \widehat{d_1}, \widehat{f_0}, \widehat{f_1}$ are values of the parameters found using OLS; $\hat{y}, \hat{x}_2, \hat{x}_3$ are estimates of the source variable y and factors x_2 and x_3.

The systems of equations (5) and (8) allow representing the three-factor regression model (1) in parametric form, thus eliminating multicollinearity.

In the general case, if the n-factor regression model is considered, then, in the presence of multicollinearity, the transition to a parametric representation of the regression model sequentially from $n - 1$ parameters to one parameter is carried out in accordance with the above algorithm, if possible. Such representation of the n-factor regression model will eliminate the negative impact of multicollinearity.

The application of the developed algorithm on the example of financial activity analysis of Inhulets Mining Combine (InMC) of Kryvyi Rih city [15, 16] is presented below. Table 1 provides statistical material according to the InMC.

Based on economic considerations, the three-factor regression model of income (Y) dependence on three factors: labor costs (X_1), current assets value (X_2) and residual value (X_3), is to be found in the form of a production function of power form.

$$y = a_0 \cdot x_1^{a_1} \cdot x_2^{a_2} \cdot x_3^{a_3} \cdot u, \quad (8)$$

where a_0, a_1, a_2, a_3 are parameters; u is perturbation.

We reduce equation (8) to a linear form by taking logarithms.

$$\ln y = \ln a_0 + a_1 \cdot \ln x_1 + a_2 \cdot \ln x_2 + a_3 \cdot \ln x_3 + \ln u. \quad (9)$$

In the new notations, equation (9) takes the form.

$$z = a + a_1 \cdot t_1 + a_2 \cdot t_2 + a_3, \quad (10)$$

where

$$z = \ln y; \quad a = \ln a_0; \quad t_i = \ln x_i \ (i = 1, 2, 3); \quad w = \ln u.$$

Table 1

Statistical data on the production activities of the InMC enterprise

Years	Income (Y) (unit of currency)	Labor costs (X_1) (unit of currency)	Current assets value (X_2) (unit of currency)	Residual cost (X_3) (unit of currency)
2001	796 086	72 498	378 681	821 313
2002	886 660	90 422	348 862	792 836
2003	1136460	118 874	525 939	915 598
2004	1 446 530	146 511	406 689	735 313
2005	2 053 653	207 203	835 021	812 229
2006	2 084 934	249 876	852 886	1 012 412
2007	2 998 135	306 953	1 617 929	1 228 221
2008	6 441 396	317 326	6 726 606	1 312 242
2009	4 384 200	287 365	5 632 716	4117950
2010	8 897 838	338 240	7 225 286	4 041 718
2011	9 875 431	342 604	11 822 216	4 361 040
2012	9 986 708	335 975	12 263 759	6 506 394
2013	10 352 257	355 995	17 185 530	6 626 622
2014	11 341 151	405 726	17 032 936	8 940 619
2015	9 489 519	469 718	25 161 471	10 461 594
2016	11 306 531	517 181	23 501 747	11 449 166
2017	15 711 286	667 177	35 096 304	11 570 129
2018	18 706 815	926 033	40 843 517	11 874 357

We transform the data of Table 1 according to formulas (10) (Table 2) and use the OLS to find the parameters. As a result, model (10) will take the form

$$z = 3.27 + 0.45 \cdot t_1 + 0.516 \cdot t_2 - 0.091 \cdot t_3.$$

In this case, the coefficient of determination amounted to $R^2 = 0.973$ and Fisher's criterion – $F = 132$. Given that the critical value of the Fisher criterion is equal to $F = 132 > 3.59$, we conclude that the regression equation is significant (10).

However, taking into account that the regression model (10) is multivariate, it is possible to distort the obtained results. First of all, this may be due to the existence of multicollinearity. Therefore, it is necessary to check for multicollinearity. For this purpose, we use the Farrar- Glauber algorithm. Let us present the initial data in a standardized form according to the formulas

$$t^*_{jk} = \frac{t_{jk} - \overline{t}_k}{s_k},$$

where $\overline{t}_k$ is the average value t_{jk}; s_k is standard deviation.

The results of the calculations are presented in Table 2.

Table 2

Results of calculations by the Farrar-Glauber algorithm

Years	z	t_1	t_2	t_3	t^*_1	t^*_2	t^*_3	$t^*_1 \cdot t^*_2$	$t^*_1 \cdot t^*_3$	$t^*_2 \cdot t^*_3$	$t^*_1 \cdot t^*_1$
2001	13.59	11.19	12.84	13.62	-2.08	-1.28	-0.99	2.66	2.07	1.27	4.33
2002	13.70	11.41	12.76	13.58	-1.69	-1.33	-1.03	2.25	1.74	1.37	2.87
2003	13.94	11.69	13.17	13.73	-1.22	-1.07	-0.89	1.30	1.08	0.95	1.48
2004	14,19	11.90	12.92	13.51	-0.85	-1.23	-1.10	1.05	0.94	1.36	0.72
2005	14.54	12.24	13.64	13.61	-0.24	-0.78	-1.00	0.19	0.24	0.79	0.06
2006	14.55	12.43	13.66	13.83	0.09	-0.77	-0.79	-0,07	-0.07	0.60	0.01
2007	14.91	12.63	14.30	14.02	0.45	-0.37	-0.59	-0.17	-0.27	0.22	0.20
2008	15.68	12.67	15.72	14.09	0.51	0.52	-0.53	0.26	-0.27	-0.28	0.26
2009	15.29	12.57	15.54	15.23	0.33	0.41	0.61	0.14	0,20	0,25	0.11
2010	16.00	12.73	15.79	15.21	0.62	0.57	0.59	0.35	0.37	0.33	0.38
2011	16.11	12.74	16.29	15.29	0.64	0.88	0.67	0.56	0.43	0.58	0.41
2012	16.12	12.73	16.32	15.69	0.61	0.90	1.06	0.55	0.64	0.95	0.37
2013	16.15	12.78	16.66	15.71	0.71	1.11	1.08	0.79	0.77	1.20	0.50
2014	16.24	12.91	16.65	16.01	0.94	1,10	1.38	1.03	1.29	1.52	0.88
2015	16.07	13.06	17.04	16,16	1.19	1.35	1.53	1.61	1.83	2.07	1.43
2016	16.24	13.16	16.97	16.25	0.90	0.98	1.22	0.89	1.11	1.20	–
2017	16.57	13.41	17.37	16.26	1.29	1.21	1.23	1.56	1.59	1.49	–
2018	16.74	13.74	17.53	16.29	1.78	1.30	1.26	2.31	2.24	1.63	–
amount	15.37	12.55	14.29	14.89	0	0	0	–	–	–	–
stand. deviation	1.04	0.66	1.72	1.11	–	–	*k.cor*	0.920	0.850	0.957	–

According to Table 2, we make up the correlation matrix

$$r = \begin{pmatrix} 1 & 0.833 & 0.732 \\ 0.833 & 1 & 0.878 \\ 0.732 & 0.878 & 1 \end{pmatrix}. \quad (11)$$

We calculate the determinant of the correlation matrix

$$|r| = 0.07. \quad (12)$$

Since the determinant is quite small, we can conclude that there are multicollinearity factors.

According to the Farrar-Glauber algorithm, we compute χ^2 – the statistics by the formula

$$\chi^2 = -\left(n - 1 - \frac{1}{6}(2p+1)\right)\ln r. \quad (13)$$

Given that $n = 15$, $p = 3$ and (12), we find by formula (13)

$$\chi^2 = 32.4.$$

Critical value of the Pearson criterion is equal to

$$\chi^2_{kp}\left(\frac{p(p-1)}{2};\alpha\right) = \chi^2_{kp}(3;0.05) = 7.81.$$

If

$$\chi^2 = 32.4 > 7.81,$$

then multicollinearity takes place.

Then, we determine the relationship between the selected factor and the other two using the Fisher criterion. We find a matrix inverse of the correlation matrix (11),

$$r^{-1} = \begin{pmatrix} 3.27 & -2.72 & -0.004 \\ -2.72 & 6.644 & -3.845 \\ -0.004 & -3.845 & 4.381 \end{pmatrix}. \quad (14)$$

We calculate the Fisher criterion by the formula

$$F_k = (c_{kk} - 1)\frac{n-p}{p-1}, \quad (15)$$

where c_{kk} is diagonal elements of the matrix (14).

Substituting in (15) the diagonal elements of the matrix (14), we find

$$F_1 = 13.62; \quad F_2 = 33.87; \quad F_3 = 20.28.$$

The critical value of the Fisher criterion is

$$F_{kp}(\alpha, p-1, n-p) = F_{kp}(0.05; 2; 12) = 3.89. \quad (16)$$

Since $F_1 = 13.62 > 3.89$; $F_2 = 33.87 > 3.89$; $F_3 = 20.28 > 3.89$ then each factor correlates with the other two.

Given that t_1 correlates with t_2 and t_3, the regression equation can be written as

$$t_1 = b_0 + b_1 \cdot t_2 + b_2 \cdot t_3. \quad (17)$$

Using OLS, we find

$$t_1 = 9.24 + 0.482 \cdot t_2 - 0.277 \cdot t_3. \quad (18)$$

Thus, $R^2 = 0.824$, $F = 28.1$, $F_{kp}(0.05; 12; 2) = 3.89$. Since $28.1 > 3.89$, equation (18) is significant.

Substitute (17) into (10)

$$z = a + a_1(b_0 + b_1 \cdot t_2 + b_2 \cdot t_3) + a_2 \cdot t_2 + a_3 \cdot t_3,$$

or

$$z = c_0 + c_1 \cdot t_2 + c_2 \cdot t_3. \quad (19)$$

Consider the correlation t_2 and t_3. In this case, the correlation matrix takes the form

$$\mathbf{r} = \begin{pmatrix} 1 & 0.878 \\ 0.878 & 1 \end{pmatrix}. \quad (20)$$

The determinant of the matrix (20) is equal to

$$|r| = \begin{vmatrix} 1 & 0.878 \\ 0.878 & 1 \end{vmatrix} = 0.229. \quad (21)$$

According to the Farrar-Glauber algorithm, we compute χ^2 – the statistics according to formula (13). Given that $n = 15$, $p = 3$ and (21), by formula (13) we calculate $\chi^2 = 17.9$. According to the table, we find (2; 0.05) = 4.303. Since $17.9 > 4.303$, multicollinearity is present. Therefore, we can write the regression equation between t_2 and t_3. To specify the regression equation, we construct a correlation field (Figure).

Analysis of the correlation field in Figure shows that there is a linear correlation. This allows us to record the regression equation as

$$t_3 = \gamma_0 + \gamma_1 \cdot t_2. \quad (22)$$

Using OLS, we find

$$t_3 = 5.79 + 0593 \cdot t_2. \quad (23)$$

Thus $R^2 = 0.886$, $F = 100$, $F_{cor}(0.05; 13; 1) = 4.67$. Since $100 > 4.67$, then equation (23) is significant. Substitute (22) into (19)

$$z = c_0 + c_1 \cdot t_2 + c_2 \cdot (d_0 + d_1 \cdot t_2),$$

or

$$z = \alpha_0 + \alpha_1 \cdot t_2. \quad (24)$$

Considering (24), formula (17) takes the form

$$t_1 = b_0 + b_1 \cdot t_2 + b_2 \cdot (d_0 + d_1 \cdot t_2),$$

or

$$t_1 = \beta_0 + \beta_1 \cdot t_2. \quad (25)$$

Using OLS, we find

$$t_1 = 7.64 + 0.318 \cdot t_2. \quad (26)$$

Thus $R^2 = 0.797$, $F = 51$, $F_{cor}(0.05; 13; 1) = 4.67$. Since $51 > 4.67$, then equation (26) is significant.

Finally, let us consider equation (28). Using OLS, we find

$$z = 6.15 + 0.604 \cdot t_2. \quad (27)$$

Thus, $R^2 = 0.956$, $F = 281$, $F_{cor}(0.05; 13; 1) = 4.67$. Since $281 > 4.67$, then equation (27) is significant.

Thus, the system of equations (27, 26 and 23), which determines the model of regression of financial activity of InMC, is obtained.

$$\begin{cases} z = 6.15 + 0.604 \cdot t_2 \\ t_1 = 7.64 + 0.318 \cdot t_2 \\ t_3 = 5.79 + 0.593 \cdot t_2 \end{cases}. \quad (28)$$

From a mathematical point of view, there is a parametric representation of the regression model. In this case, the basic parameter is a variable t_2.

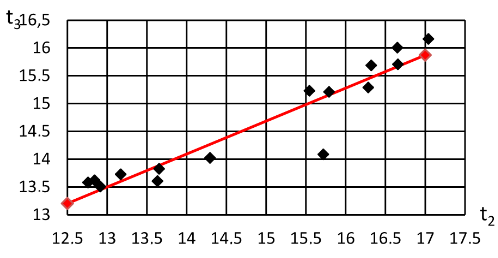

Fig. Correlation field and regression line

It is clear that any of the variables that are more economically viable can be selected as the base parameter.

Given the substitution (10), the system (28) can be written in a power form

$$\begin{cases} y = 469 \cdot x_2^{0.604}, & \left(R^2 = 0.874, F = 90\right) \\ x_1 = 2076 \cdot x_2^{0.318}, & \left(R^2 = 0.832, F = 64.4\right). \\ x_3 = 328 \cdot x_2^{0.593}, & \left(R^2 = 0.858, F = 78.5\right) \end{cases} \quad (29)$$

Since each of the calculated values of the Fisher criterion in (29) is greater than this value, we conclude that the equations found are significant.

In conclusion, it should be emphasized that the construction of the model of multivariate regression allows not only taking into account the multicollinearity of the factors, but also calculating the values of these factors, depending on the value of the basic factor taken as a parameter.

Conclusions. Market relations in Ukraine require the use of modern management methods in the economy, which are based on economic and mathematical modeling. Particular attention should be paid to the adequacy of mathematical models, since their synthesis occurs when taking into account uncertainties. Considering that multivariate regression analysis is used in the construction of models, multicollinearity is significantly influenced by the correctness of the conclusions drawn. The elimination of multicollinearity by applying a parametric approach allowed avoiding this negative influence. In addition, the developed algorithm made it possible to simplify the regression model for its further application. The efficiency of the proposed algorithm is confirmed on the example of the economic activity analysis of Inhulets Mining Combine.

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Аналіз економіко-математичного моделювання функціонування промислового підприємства при мультиколлінеарності на основі параметризації

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Мета. Дослідження мультиколінеарності в багатофакторних регресійних економіко-математичних моделях діяльності Інгулецького гірничо-збагачувального комбінату та зменшення її негативного впливу на основі застосування методу параметризації.

Методика. Для зменшення негативного впливу мультиколлінеарності в багатофакторних регресійних моделях розроблена методика, що заснована на переході від функції декількох змінних до її параметричного подання шляхом аналізу кореляційної матриці між факторами з метою усунення взаємної кореляції.

Результати. Економіко-математичне моделювання діяльності ПрАТ «Інгулецький гірничо-збагачувальний комбінат» показало, що наявність мультиколінеарності при застосуванні багатофакторної регресійної моделі призводить до спотворення отриманих результатів, це знижує практичну цінність моделі. Застосування методу параметризації дозволило зменшити вплив мультиколінеарності, надавши параметричного подання економіко-математичній моделі утримання реального економічного процесу. Застосування методу параметризації дозволяє спростити побудову економіко-математичної моделі у вигляді регресійних рівнянь, зменшити негативний вплив мультиколінеарності при реалізації та змістовному аналізі особливостей економіко-математичного моделювання за допомогою багатофакторних регресійних рівнянь.

Наукова новизна. Уперше запропоноване застосування метода параметризації, що дозволяє спростити побудову економіко-математичної моделі у вигляді регресійних рівнянь. Використання метода параметризації дозволяє зменшити невизначеність при синтезі багатофакторних регресійних рівнянь, забезпечивши відповідну адекватність.

Практична значимість. Аналіз отриманих результатів економіко-математичного моделювання діяльності Інгулецького гірничо-збагачувального комбінату на значному статистичному матеріалі із застосуванням розробленого алгоритму усунення мультиколінеарності підтвердив дієвість запропонованого підходу. Рекомендується включити розроблений алгоритм із усунення мультиколінеарності шляхом параметризації до практики управління економічною діяльністю гірничорудних підприємств.

Ключові слова: *гірничорудна промисловість, регресія, багатофакторна модель, мультиколінеарніть, параметризація, фінансова діяльність*

Анализ экономико-математического моделирования деятельности промышленного предприятия при мультиколлинеарности на основе параметризации

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Цель. Исследование мультиколлинеарности в многофакторных регрессионных экономико-математических моделях деятельности Ингулецкого горно-обогатительного комбината и уменьшения ее негативного влияния на основе применения метода параметризации.

Методика. Для уменьшения негативного влияния мультиколлинеарности в многофакторных регрессионных моделях разработана методика, которая основана на переходе от функции нескольких переменных к ее параметрическому представлению путем анализа корреляционной матрицы между факторами с целью устранения взаимной корреляции.

Результаты. Экономико-математическое моделирование деятельности ЧАО «Ингулецкий горно-обогатительный комбинат» показало, что наличие мультиколлинеарности при применении многофакторной регрессионной модели приводит к искажению полученных результатов, это снижает практическую ценность модели. Применение метода параметризации позволило уменьшить влияние мультиколлинеарности, придав параметрическому представлению экономико-математической модели содержание реального экономического процесса. Применение метода параметризации позволяет упростить построение экономико-математической модели в виде регрессионных уравнений, уменьшить негативное влияние мультиколлинеарности при реализации и содержательном анализе особенностей экономико-математического моделирования с помощью многофакторных регрессионных уравнений.

Научная новизна. Впервые предложено применение метода параметризации, что позволяет упростить построение экономико-математической модели в виде регрессионных уравнений. Использование метода параметризации позволяет уменьшить неопределенность при синтезе многофакторных регрессионных уравнений, обеспечив соответствующую адекватность.

Практическая значимость. Анализ полученных результатов экономико-математического моделирования деятельности Ингулецкого горно-обогатительного комбината на значительном статистическом материале с применением разработанного алгоритма устранения мультиколлинеарности подтвердил действенность предложенного подхода. Рекомендуется включить разработанный алгоритм по устранению мультиколлинеарности путем параметризации в практику управления экономической деятельностью горнорудных предприятий.

Ключевые слова: *горнорудная промышленность, регрессия, многофакторная модель, мультиколлинеарность, параметризация, финансовая деятельность*

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