УДК 338.242.2

Application of economic and mathematical methods in the analysis of accounts receivable

G. N. Udeneeva, N. E. Kolsanova, G. T. Gubaidullina
E-mail: Galina.udeneeva@mail.ru

Annotation:
The author has constructed a multiple linear regression equation describing the dependence of the resultant indicator on the identified factors. Economic interpretation of the parameters of the equation of multiple linear regression was carried out. The quality of the obtained regression equation was evaluated from an economic and mathematical point of view. Multicollinearity was performed to eliminate the occurrence of errors in the mathematical model.

General statement of the problem

Nowadays the relevance of analysis and control of accounts receivable is increasing, because the successful activity of the organization is ensured by its stable financial position.

In order to avoid losses and penalties, as well as to control compliance with financial and payment discipline of settlements, it is necessary to strictly monitor the level of accounts receivable.

For this purpose, it is necessary to identify what factors have the greatest impact on the level of accounts receivable of the organization. The most appropriate technique is to build an economic and mathematical model of the dependence of the level of accounts receivable. That will further allow you to analyze it and make appropriate management decisions.

The analysis of accounts receivable is studied by many authors: S. I. Adamenkova [1], M. A. Vakhrushina [2], T. I. Grigorieva [3], Z. V. Kiryanova [4], V. G. Kogdenko [5], N. P. Lyubushin [6], V. Y. Pozdnyakov [7], G. V. Savitskaya [8], V. I. Strazhev [9], A. D. Sheremet [10] and others.

Meanwhile, without giving examples of the use of economic and mathematical methods in the analysis of accounts receivable, they only consider the possibility of their application. This leads to unexplored issues that subsequently leave gaps and inaccuracies in practical research.

Having built a model and carried out a correlation and regression analysis of the dependence of accounts receivable on output per employee, the level of utilization of production facilities and the implementation of a production plan using computer technology on the example of JSC “Minsk Bearing Plant”.

The purpose of this study is to establish and evaluate the dependence of accounts receivable on:

1. output per worker;
2. the level of utilization of production capacity;
3. fulfillment of the plan for production output.

Objectives of the study:

1. To build a multiple linear regression equation describing the dependence of the resultant indicator on the identified factors.
2. To carry out economic interpretation of the parameters of the equation of multiple linear regression.
3. To evaluate the quality of the obtained regression equation from the economic and mathematical points of view.
4. To independently carry out critical (to identify shortcomings) and supporting analysis (to identify advantages) of the constructed economic and mathematical model.

Research methodology

Research methods are used:

1. Correlation analysis.
2. Regression analysis (multiple linear regression).
3. least squares method.

For the first time developed a model describing the relationship between the level of accounts receivable, output per worker, the level of utilization of production capacity and fulfillment of the plan for production output (Fig. 1).

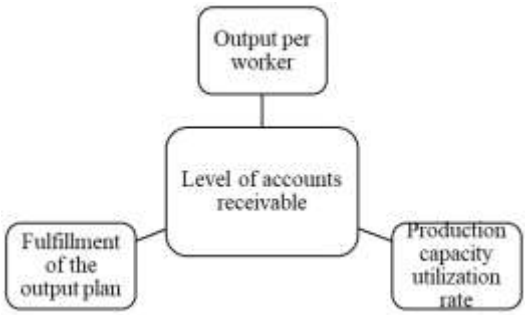


Figure 1 - Economic and mathematical model of the level of accounts receivable

To assess the quality of the model, we will conduct a correlation and regression analysis of accounts receivable with the use of computer technology. Out of the whole set of programs for conducting correlation and regression analysis, it was most appropriate to use the program product "DSTAT". This program is distinguished not only by its accessibility for users, but also by:

1) the simplicity of the interface;

2) the presence of a large list of built-in functions and data analysis package for economic-mathematical and statistical calculations;

3) the ability to quickly adjust the initial data;

4) low probability of inaccuracies.

The obtained printouts of calculations are placed in the text of the article.

Theoretical assumptions of the research were confirmed on the example of JSC "Minsk Bearing Plant" (Table 1).

A matrix of pairwise correlation coefficients was constructed using computational tools (Fig. 2).

Table 1 – Initial information

Observation number	Level of accounts receivable, thousand rubles	Output per worker, thousand rubles	Production capacity utilization rate, %	Fulfillment of the output plan, %
i	x_1	x_2	x_3	x_4
1	4 745	1,59	19,9	100,6
2	4 875	1,68	20,2	100,8
3	5 231	2,45	21,5	101,2
4	5 121	2,23	21,1	101,5
5	4 997	1,98	20,3	101,3
6	4 867	1,46	20,3	101,1
7	4 983	1,85	20,3	101,7
8	5 123	1,97	20,3	101,9
9	5 889	2,14	21,2	102,3
10	4 987	1,87	20,2	102,8
11	6 234	2,28	21,5	103,5
12	6 457	2,42	21,6	103,9
13	6 312	3,22	22,3	103,4
14	6 241	3,21	22,3	103,3
15	6 123	3,15	22,3	103,9
16	5 937	2,89	21,7	102,6
17	5 873	2,8	21,2	102,1
18	5 982	2,89	21,8	102,5
19	6 678	3,35	22,4	103,2
20	6 498	3,22	22,2	103,1
21	6 543	3,24	22,4	103,4
22	6 231	3	22,2	103,8
23	6 347	3,12	22,3	103,2
24	6 586	3,27	22,5	103,7
25	5 573	2,98	21,9	102,2
26	5 347	2,76	21,7	102,6
27	5 457	2,85	21,7	102,9
28	5 243	2,53	21,6	102,2
29	5 197	2,49	21,6	102,2
30	4 983	1,87	20,2	101,5
31	5 009	1,93	20,3	101,8
32	4 976	1,75	20,2	101,5
33	4 863	1,67	20,1	101,4
34	4 887	1,84	20,3	101,8
35	5 165	1,85	21,2	102,2
36	5 190	1,98	21,6	102,5

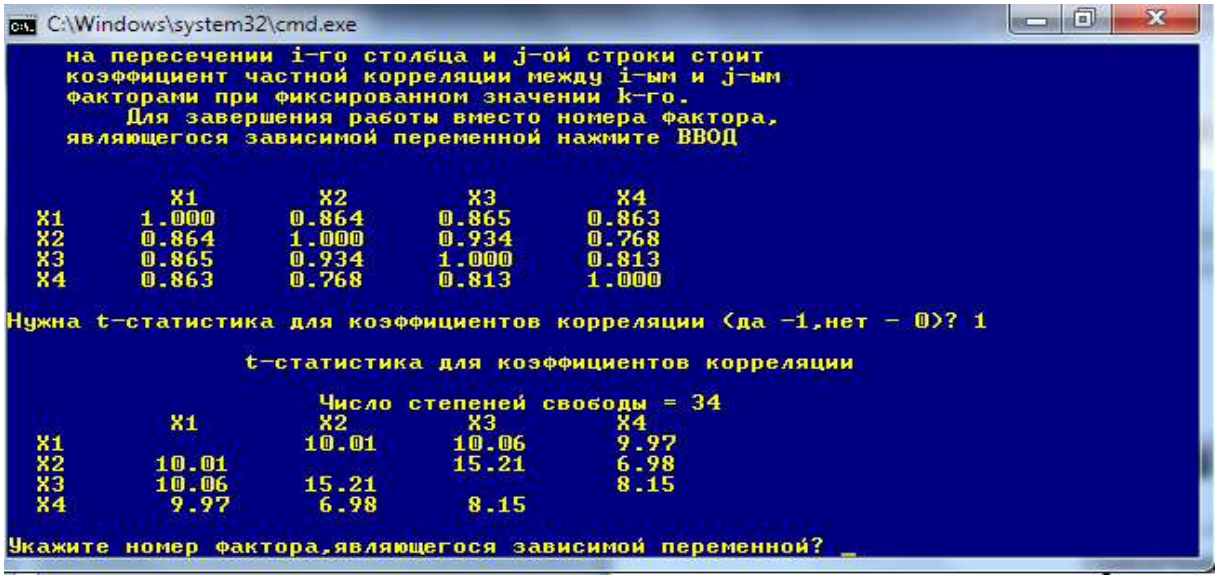


Figure 2 - Matrix of pairwise correlation coefficients

Analyzed the matrix of pairwise correlation coefficients:

1. The dependent variable y is most closely related to variable x3 (rx3y = 0.865). Variables x2 and x4 also have high influence on it.

2. Moreover, factors x2 and x3 have a close relationship with each other (rx2x3 = 0.934 > 0.8), which confirms multicollinearity. Therefore, it is necessary to exclude one of the two variables.

3. It is advisable to exclude the variable x3. Due to the close correlation coefficients, it can be considered possible to exclude any of the two factors.

Next, a linear regression equation is constructed describing the relationship between the factors and the resulting indicator (Fig. 3).

The parameters of the model were calculated. The protocol of regression analysis results is presented below (Fig. 3-4).

Results of the study

An economic interpretation of the parameters was carried out. If the output per worker will increase by one thousand rubles, the change in accounts receivable of the organization will be + 518.22 thousand rubles. With an increase in the implementation of the plan for output by one percent, the accounts receivable of the organization will increase by an average of 333.37 thousand rubles. Factor x2 has a greater impact on the resultant indicator.

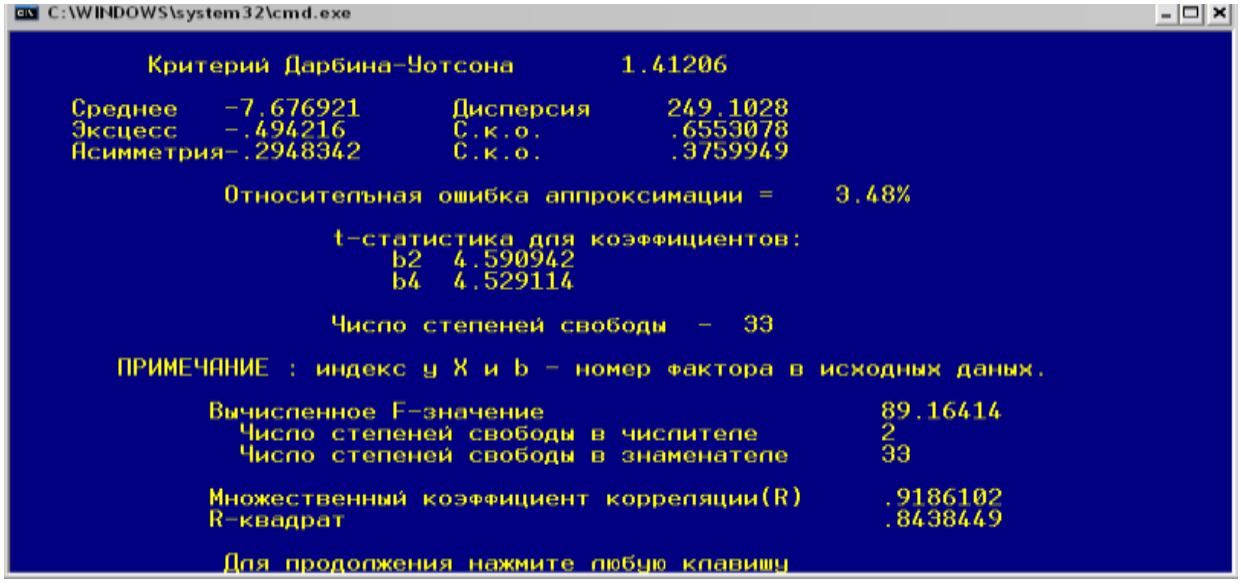


Figure 3 - Estimation of regression parameters by the least squares method

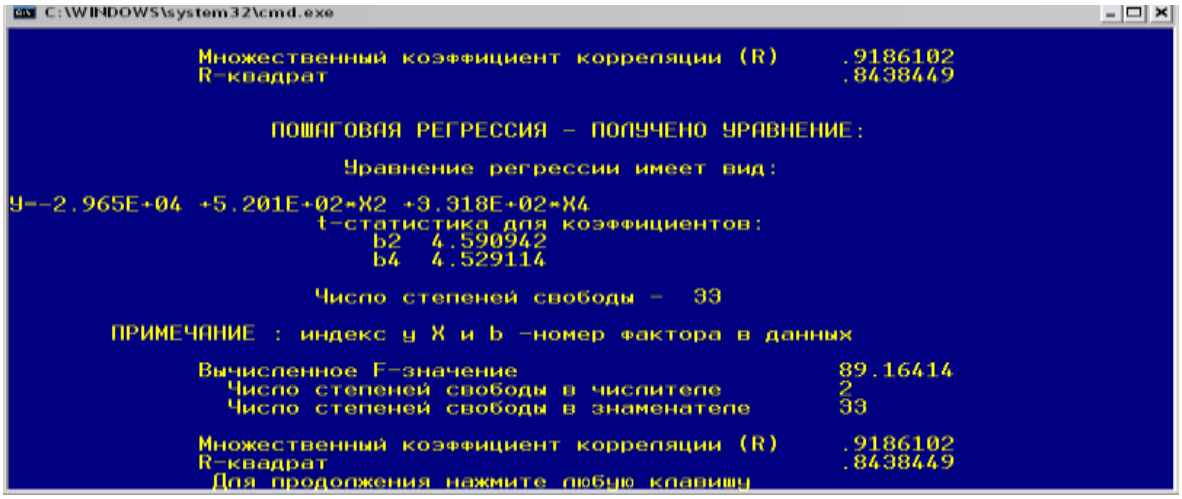


Figure 4 - Multiple stepwise regression

The quality of the obtained regression equation is evaluated from an economic and mathematical point of view. From the value of the coefficient of determination R^2 = 0.844 it follows:

1) the coefficient of determination is close to one (more than 0.7), so the quality of regression is good;

2) the variability of accounts receivable of the organization by 84.4% is determined by the variability of output per worker and fulfillment of the plan for production output and by 15.6% by the influence of unrecorded and random factors.

In order to test the significance of the coefficient b1 the author:

1) formulated the hypothesis H0, consisting in the fact that the true parameter β1 = 0;

2) determined trac = 518.22 / 4.570 = 113.3961;

3) chose the significance level of hypothesis testing α = 0.05 (5%);

4) by means of computer technology determined tcr. = 2.0345;

5) | trac. | = 113.3961 > tcr. = 2.0345.

Conclusion - the H0 hypothesis is likely to be recognized as incorrect 1 – α = 1 – 0,05 = 0,95, the parameter β1 is significantly different from 0. The coefficient b1 is significant and the output per worker has a significant impact on the level of accounts receivable of the organization.

In order to test the significance of the coefficient b2 the author:

1) formulated the hypothesis H0, which is that the true parameter β2 = 0;

2) determined trasch. = 333,37 / 4,541 = 73,4134;

3) chose the significance level of hypothesis testing α = 0.05 (5%);

4) by means of computer technology determined tcr. = 2.0345;

5) | trac. | = 73.4134 > tcr. = 2.0345.

We came to the conclusion that the hypothesis H0 is recognized as incorrect with probability 1 – α = 1 – 0,05 = 0,95 the parameter β2 is significantly different from 0. The coefficient b2 is significant and the implementation of the output plan has a significant impact on the level of accounts receivable of the organization.

Having analyzed the obtained value of the average approximation error (3.48%). We came to the conclusion that the obtained dependence equation has a sufficient degree of accuracy in describing the dependence.

Having analyzed the obtained Durbin-Watson criterion. The calculated criterion is equal to 1.4145. Since this criterion is within the boundaries from du to 4 - du (1.41 < 1.4145 < 2.41), we can conclude that there is no autocorrelation in the model under study.

We conclude that the resulting coupling equation has a sufficient degree of accuracy in describing the dependence.

It was carried out:

1) exponential smoothing of the series;

2) a graph was drawn;

3) a trend line was drawn;

4) the trend equation was made;

5) the reliability of approximation was checked;

6) a forecast of the level of accounts receivable for 10 periods ahead was made.

The protocol of results is presented below (Fig. 5-8).

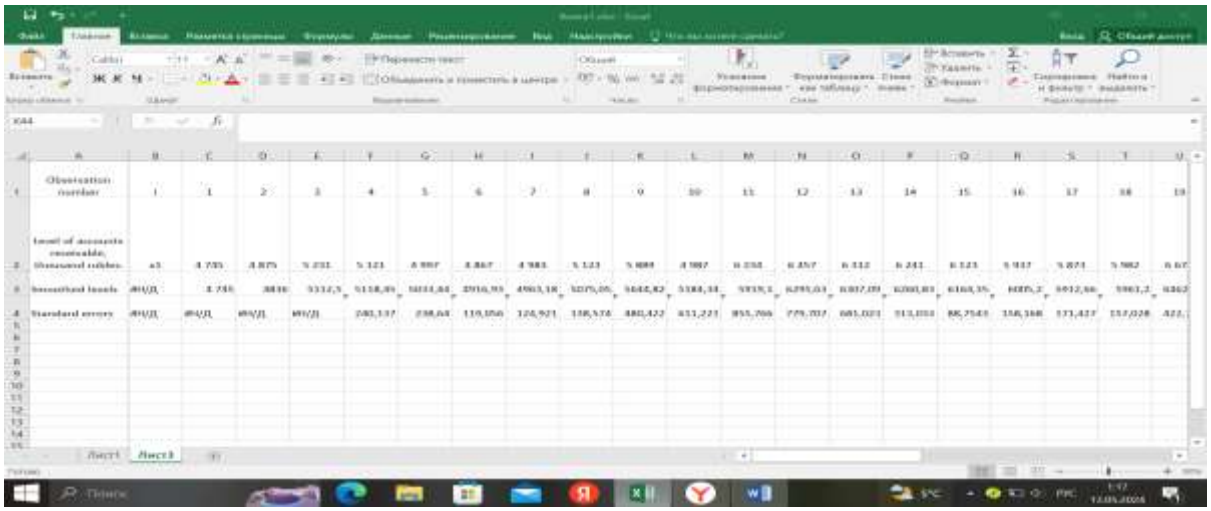


Figure 5 - Exponential smoothing

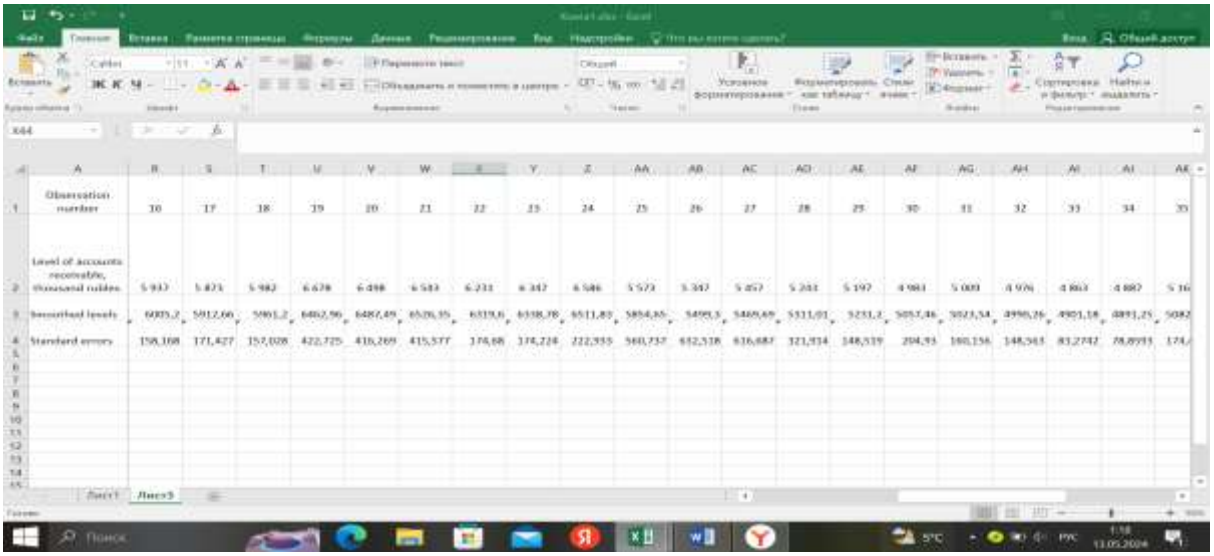


Figure 6 - Exponential smoothing

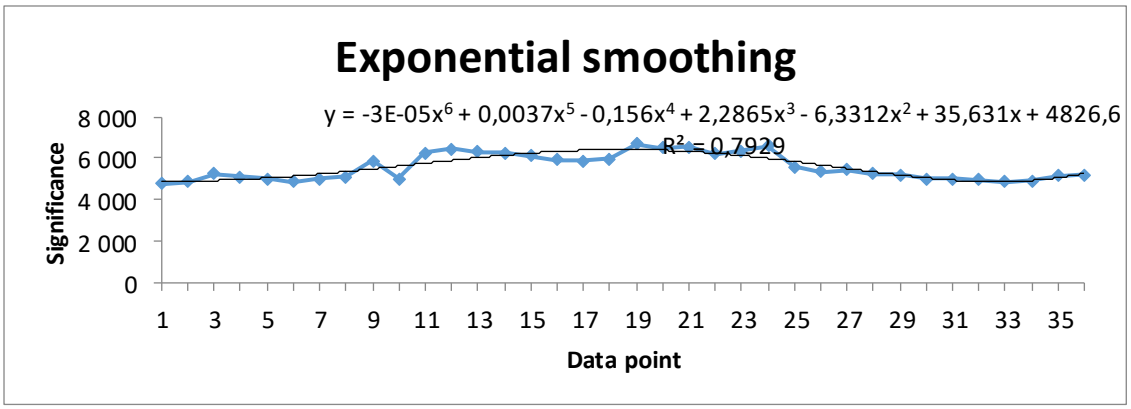
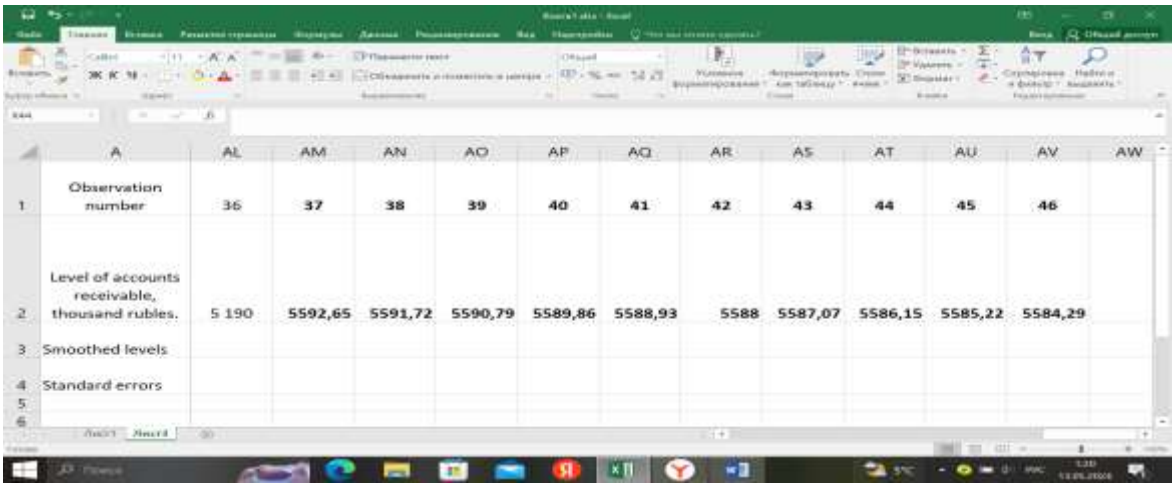


Figure 7 - Graph (line and trend equation)



	A	AL	AM	AN	AO	AP	AQ	AR	AS	AT	AU	AV	AW
1	Observation number	36	37	38	39	40	41	42	43	44	45	46	
2	Level of accounts receivable, thousand rubles.	5 190	5592,65	5591,72	5590,79	5589,86	5588,93	5588	5587,07	5586,15	5585,22	5584,29	
3	Smoothed levels												
4	Standard errors												
5													
6													

Figure 8 - Forecast of the level of accounts receivable

Conclusions

We came to the following main conclusions:

1. A multiple linear regression equation was constructed describing the dependence of the resulting indicator on the identified factors. The parameters of the model were calculated.

2. The economic interpretation of the parameters of the multiple linear regression equation is carried out.

Thus, if the output per worker will increase by one thousand rubles, the change in accounts receivable of the organization will be + 518.22 thousand rubles. With an increase in the implementation of the plan for output by one percent, the accounts receivable of the organization will increase by an average of 333.37 thousand rubles. Factor x2 has a greater impact on the resultant indicator. It is necessary to strengthen control over compliance with financial and payment discipline of settlements to avoid losses and penalties, as well as control over the level of accounts receivable.

This information is the basis for making appropriate management decisions.

3. The quality of the obtained regression equation was evaluated from an economic and mathematical point of view.

From the value of the coefficient of determination R^2 = 0.844 it follows:

1) the coefficient of determination is close to one (more than 0.7), so the quality of regression is good;

2) the variability of accounts receivable of the organization by 84.4% is determined by the variability of output per worker and fulfillment of the plan for production output and by 15.6% by the influence of unaccounted and random factors. Coefficient b1 is significant and output per worker has a significant impact on the level of accounts receivable of the organization. The coefficient b2 is significant and the fulfillment of the plan on production output has a significant impact on the level of accounts receivable of the organization. Having analyzed the obtained value of the average approximation error (3.48%). We came to the conclusion that the obtained dependence equation has a sufficient degree of accuracy in describing the dependence. Having analyzed the obtained Durbin-Watson criterion. The calculated criterion is equal to 1.4145. Since this criterion is within the boundaries from du to 4 - du (1.41 < 1.4145 < 2.41), we can conclude that there is no autocorrelation in the model under study.

4. Having conducted a critical and justifying analysis of the constructed economic and mathematical model. As a result, a number of advantages and disadvantages were identified.

Disadvantages:

Limited source data: using data for only 36 observations may not reflect longer economic cycles and trends.

Advantages:

1. Multicollinearity was checked and the variable x3 was excluded, which eliminates the risk of errors and distortion of the results of the economic-mathematical model.

2. The value of the average approximation error has been calculated and analyzed, which confirms the sufficiency of the degree of accuracy in describing the dependence.

3. The Durbin-Watson criterion has been calculated and analyzed, which excludes autocorrelation in the model under study.

4. All calculations were made with the help of computing equipment, which reduces the risk of errors and distortion of results.

Literature

1. Adamenkova, S. I. Analysis of production and financial activity: study-method. manual / S. I. Adamenkova, O. S. Evmenchik – Minsk: Publishing House “Register”, 2017. – 384 c.

2. Analysis of financial statements: textbook / edited by M. A. Vakhrushina – M.: INFRA - M, 2011. – 429 c.

3. Grigorieva, T. I. Financial analysis for managers: evaluation, forecast: textbook for undergraduate and graduate studies / T. I. Grigorieva. – 3rd ed., revision and addendum – M.: Yurait Publishing House, 2017. – 486 c. – Series: Bachelor and Master. Akademicheskiy kurs.

4. Kiryanova, Z. V. Analysis of financial statements: a textbook for bachelors / Z. V. Kiryanova, E. V. Sedova – 2nd edition, revised. and supplement. – M.: Yurait Publishing House, 2014. – 428 c.

5. Kogdenko, V. G. Economic analysis: textbook for university students studying in the specialties "Finance and Credit", "Accounting, Analysis and Audit", "World Economy", "Taxes and Taxation" / V. G. Kogdenko. – 2nd ed., revision and addendum – Moscow: UNITI-DANA, 2013. – 392 c.

6. Lyubushin, N. P. Economic analysis: textbook for university students studying in the specialties "Accounting, analysis and audit" and "Finance and credit" / N. P. Lyubushin. – 3rd ed., revision and addendum – Moscow: UNITI-DANA, 2010. – 575 c.

7. Pozdnyakov, V. Ya. Analysis and diagnostics of financial and economic activity of the enterprise: Textbook / Edited by Prof. V.Ya. Pozdnyakov. – M.: INFRA- M, 2012. – 617 c.

8. Savitskaya, G. V. Comprehensive analysis of economic activity of the enterprise: Textbook / G. V. Savitskaya – 6th ed., revision and addendum – M.: INFRA - M, 2015. – 607 c.

9. Strazhev, V. I. Theoretical foundations of accounting and analysis: textbook / V. I. Strazhev [et al]; ed. by V. I. Strazhev. – Minsk: Vysheyshaya shkola, 2016. – 319 p.: ill.

10. Sheremet, A. D. Comprehensive analysis of economic activity: Textbook for universities / A. D. Sheremet – Ed. revised and additional – M.: INFRA-M, 2009. – 416 c.

Уденеева Г.Н., Колсанова Н.Е., Губайдуллина Г.Т. Применение экономико-математических методов в анализе дебиторской задолженности. *Построено уравнение множественной линейной регрессии, описывающее зависимость результативного показателя от выявленных факторов. Проведена экономическая интерпретация параметров уравнения множественной линейной регрессии. Оценили качество полученного уравнения регрессии с экономической и математической точек зрения. Провели мультиколлинеарность для устранения возникновения ошибок математической модели.*

Ключевые слова: *дебиторская задолженность, экономико-математические методы, множественная регрессия, корреляционный и регрессионный анализ, метод наименьших квадратов*

Udeneeva G.N., Kolsanova N.E., Gubaidullina G.T. Application of economic and mathematical methods in the analysis of accounts receivable. *The author has constructed a multiple linear regression equation describing the dependence of the resultant indicator on the identified factors. Economic interpretation of the parameters of the equation of multiple linear regression was carried out. The quality of the obtained regression equation was evaluated from an economic and mathematical point of view. Multicollinearity was performed to eliminate the occurrence of errors in the mathematical model.*

Keywords: *accounts receivable, economic and mathematical methods, multiple regression, correlation and regression analysis, least squares method.*

Статья поступила в редакцию 06.06.2024
Рекомендована к публикации доцентом Карабчевским В. В.