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APPLICATION OF ECONOMIC AND MATHEMATICAL MODELS FOR THE RESTAURANT  
ENTERPRISE MANAGEMENT**Abstract.**

The main factors that affect the formation of the revenue side, in particular the net profit of restaurants in Vinnytsia, are identified and analyzed in the article. The mathematical model is developed. Based on the obtained data of correlation-regression analysis, the main recommendations for the work of restaurants to increase their profitability are proposed.

**Keywords:** rest business, mathematical molecule, correlation analysis, restaurant profit, food cost, labor cost, service, service

Effective management of any modern restaurant, only on the first count is not subject to the laws of mathematical analysis.

In fact, the results of the financial activities of restaurants are not possible without the use of modern methods of economic and mathematical modeling as well as economic and statistical analysis. The activity of any cafe, restaurant, pizzeria etc. is affected by many factors. It is possible to estimate their performance by methods of statistics which are based on the development and the analysis of the corresponding mathematical model. For this purpose, the methods of multiple correlation-regression analysis are used, which allow to study and quantify the internal and external investigative links between the factors forming the model and establish the functioning regularities and trends in the development of the investigated result feature.

In this article, we will try to establish a clear relationship between what exactly affects the operation of the restaurant, which factors are key ones and have the greatest impact on the final financial result.

The main tasks of economic and mathematical modeling are: analysis of economic objects and processes; economic forecasting, forecasting the development of economic processes; making management decisions at all levels of the economic hierarchy [16]. Among the large number of models should be distinguished such statistical methods as methods of trend and correlation-regression analysis. The main task of correlation and regression methods of analysis is to analyze statistics to identify the mathematical relationship between the studied features and to establish using correlation coefficients a comparative estimate of the density of the relationship, which has a certain numerical expression [11].

Correlation and regression methods of analysis solve two main problems: determining the analytical form of the relationship between the variation of signs X and Y with the help of regression equations; finding and statistical evaluation of the equation of the relationship between performance and factor characteristics on the basis of regression analysis; interpretation of the obtained equation and its use. The most common types of relationships are: – a factor feature is directly related to

the effective feature; – the effective feature is determined by a set of operating factors; – two effective features are caused by the action of one common cause.

An important sign of the investment attractiveness of restaurant enterprises is the profitability level of the enterprise, in particular indicators that show the financial result (the amount of profit received by the enterprise during the analyzed period). That is why it is necessary to analyze how the profit of the restaurant is formed, to determine the main ways and methods of managing it. In order to identify the main components that affect the amount of profit of restaurants, we will conduct a correlation analysis of individual financial indices of their activities. To determine these dependences, we will perform a correlation-regression analysis and develop an economic-mathematical model.

The analysis of the impact of individual factors on the amount of net income, profitability indices allow us to assess certain trends that have emerged as a result of the activities of restaurants in Vinnytsia region during 2017-2020. We will quantify the total impact of the studied factors on the performance index. The complex interaction of all factors ( $X_1, X_2, \dots, X_n$ ) with the resultant indicator (Y) can be described by the equation of linear multifactor regression of the form:

$$y = a_0 + a_1 x_1 + a_2 x_2 + a_n x_n \quad (3.1.)$$

Using the data of correlation-regression analysis, we determine the influence of the following factors on the amount of net profit, UAH million. (Y) for the restaurants of Vinnytsia region:

- 1) Labor cost, UAH ( $X_1$ );
- 2) Seasonality of products used, % ( $X_2$ );
- 3) Level of service and maintenance, UAH ( $X_3$ );
- 4) The cost of rent, utilities, UAH ( $X_4$ );
- 5) Food cost, UAH ( $X_5$ );
- 6) The average amount received (UAH) - is an index to determine the guests in the price segment of the institution. ( $X_6$ );

These indices were grouped into 5 restaurants of the Vinnytsia restaurant chain "Fine Affairs", which are studied in the dynamics of 2015-2020; the average indices for the studied period were used for the analysis (tab. 3.1)

**Integrated data for the correlation-regression analysis of factor influence on the profit of restaurants in Vinnytsia\***

Роки	Y	X1	X2	X3	X4	X5	X6
2015	10,53	0,22	0,18	0,8	1,87	0,96	332
2016	15,567	0,19	0,22	1,45	1,18	0,59	226
2017	6,171	0,18	0,23	1,32	2,13	0,72	165
2018	-0,740	0,16	0,23	2,14	4,38	0,72	78
2019	9,769	0,17	0,21	3,3	2,76	0,71	84
average value	8,6	0,18	0,22	1,76	1,87	0,96	170,8

\* Grouped and calculated based on author's calculations

Using MS Office Excel - 2007 the following regression equation was obtained:

$$Y = -92,6 - 325,3 x_1 + 555,3 x_2 + 11,6 x_3 - 12,9 x_4 - 166,7 x_5 + 0,26 x_6 \quad (3.2.)$$

This equation shows that the greatest influence of all 6 factors on the performance indicator has:

1) Seasonality – if the weight of the seasonality index increases by 1%, the profit will increase by UAH 555.

2) Food cost – when increasing this factor by UAH 1, the amount of net income will decrease by almost UAH 167.

3) Labor cost – with the expansion of the assortment structure by 1%, profits will decrease by 325 UAH.

To determine the relative strength of the individual factors influence on the result, it is necessary to calculate the partial elasticity coefficients ( $\varepsilon_i$ ), which show how many percent will change the average performance characteristic by changing 1% of each factor and the fixed position of other factors by the formula:

$$\varepsilon_i = \frac{a_i * x_i}{y} \quad (3.3.)$$

Where  $a_i$  is the regression coefficient for the i-th factor;

$x_i$  is the mean value of the i-th factor;

$y$  is the mean value of the productive feature.

Based on the formula, the following was established:

1) if the average amount received increases by 1%, the amount of net profit will decrease by 5.4%;

2) if the impact of seasonality of products increases by 1%, the amount of net profit will increase by 11.5%;

3) if the service level increases by 1%, the amount of net profit will increase by 1.87%;

4) if rent increases by 1%, the amount of net profit will decrease by almost 3%;

5) if Foodcost increases by 1%, the amount of net profit will decrease by 12.4%;

6) if Laborcost increases by 1%, the amount of net profit will decrease by 4%;

Thus, based on the correlation-regression analysis, we can conclude that the growth of profits of the studied agricultural enterprises is possible with the relevant rules of financial analysis. That is, each restaurant should review the range of menus, and focus on several main types of dishes that form the main average check of most guests. The organization of multidisciplinary production and the presence of a large number of indus-

tries lead to their fragmentation. And this, in turn, reduces the possibility of introducing advanced technologies, technical complexes, and hence – the growth of efficiency and production.

The economic significance of specialization is that it opens wide opportunities for the organization of mass and rhythmic production; allows to improve the technology of preparation and increase the return on capital investment; creates favorable opportunities for the creation of dishes of the author's menu, attracting the experience of leading experts in specialized cuisine of the peoples of the world. In addition, along with the increase in gross output, its quality improves, the culture of production grows, the qualification of personnel increases, new opportunities appear; costs are reduced and profitability of production is increased [9].

Regarding the inverse effect of the factor index – the rent, it should be noted that the reduction of the role of its activity is possible provided an increase in the flow of customers. The reduction of the latter will negatively affect the company's net profit. After all, the competitiveness of modern restaurants, the efficiency of labor resources is largely determined by its material and technical base, which is based on fixed assets. For agricultural enterprises, the provision of the main flow of regular customers largely determines their production potential and efficiency of the institution.

The value of the multiple correlation coefficient is  $R = 0.9$ , which indicates a very close relationship between the factor and the resultant trait (Annex D). [16]. The value of the multiple determination coefficient of the obtained six-factor linear regression  $R^2 = 0.84$  means that the variation in the amount of net profit of the studied number of enterprises by 84% is due to the above factors. Important in the method of correlation-regression analysis is the verification of the model for the multicollinearity – a linear relationship between factors. There is a stochastic (probabilistic) and functional form of multicollinearity. In the functional form, the model must have at least one factor that is functionally related to any other factor in the model or to all others. In this case, the pairwise correlation coefficient  $r_{ij} = \pm 1$  [10].

In economic models, multicollinearity is usually manifested in stochastic form, when there is a close correlation between the factors of the model, which does

not reach the functional level ( $r_{ij} > 0.6$ , for direct connection and  $r_{ij} > -0.6$  for inverse connection). To verify

the model for the multicollinearity, we form a correlation matrix using MS Office Excel - 2007 (Table 3.2).

Table 3.2

**Matrix of net profit model correlation coefficients \***

	X1	X2	X3	X4	X5	X6
X1	1					
X2	-0,530	1				
X3	-0,415	-0,043	1			
X4	-0,460	0,134	0,630	1		
X5	0,383	-0,162	-0,233	-0,056	1	
X6	0,636	-0,311	-0,835	-0,795	0,172	1

\* Grouped and calculated based on author's calculations

Analyzing the data in Table 3.2 we can conclude that between the pairs of factors  $X_1$  and  $X_6$  and  $X_3$  and  $X_4$  there is a direct correlation of significant density, which indicates the possibility of the presence of multicollinearity. Since the expansion of the assortment structure requires the involvement of additional labor, it is clear that the increase in the average amount received will lead to labor costs. As for the close relation-

ship between the indices of the second factor, it is explained by the fact that as the level of service increases, sales revenue will increase.

In order to eliminate multicollinearity, we will deduce the following factors from the model:  $X_6$  - Labor cost and  $X_1$  - average amount received. We will perform a regression analysis between the indices of the dependent and independent variables (Table 3.3) using the MS Regression mode in Excel.

Table 3.3

**Initial data for correlation - regression analysis \***

Роки	Y	X2	X3	X4	X5
2015	6,06	0,23	1,14	1,33	1,07
2016	0,59	0,24	1,58	2,99	0,96
2017	-1,27	0,23	2,14	4,38	0,72
2018	-0,38	0,22	2,16	2,86	0,8
2019	0,99	0,22	2,84	3,4	0,83
2015	0,65	0,21	3,3	2,76	0,71

\* Grouped and calculated based on author's calculations

The generated results of regression analysis by regression statistics are presented in Table 3.4.

Table 3.4.

**Strength relation coefficients of correlation coefficients**

Regression statistics	
Multiple R	0,951748312
R-squared	0,90582485
Normalized R-squared	0,83048473
Standard error	1,717477348
Observation	5

\* Grouped and calculated based on author's calculations

The value of the multiple correlation coefficient  $R$  characterizes the quality of the obtained model. According to the obtained results, this coefficient is 0.95, which indicates the presence of a high correlation in the model. The value of the R-squared, i.e. the determination coefficient, indicates the correspondence of the original data and the regression model, because its

value is as close as possible to 1 and is 0.91. Thus, the linear model explains 91% of the variation, which means the correct choice of factor. Only 9% are due to other factors that affect the net profit of the surveyed enterprises, but are not included in the linear regression model (table 3.5).

Table 3.5

**Reliability indices of the correlation - regression model \***

Indices	df	SS	MS	F	F value
Regression	4	141,86	35,465	12,02314	0,00888517
Remainder	5	14,74864	2,949728		
Total	9	156,6086			

\* Grouped and calculated based on author's calculations

The high value of the coefficient and determination correlation indicates that this dependence is quite natural. The significance value F indicates that the evaluation results are quite reliable. It is worth paying attention to the variance and F-statistics, their high value

indicates the variation of the dependent and independent variables, so the regression equation is significant (table 3.6).

Table 3.6

**Correlation-regression model coefficient \***

	Coefficients	Standard error	t-statistics	P-Value	Lower 95.0%	Upper 95.0%
Y	36,6010675	8,96071	4,084614	0,009497	13,566	59,63532
X 1	-104,160357	34,2006	-3,04557	0,028568	-192,0	-16,2449
X 2	-2,77017628	0,93189	-2,97263	0,031063	-5,165	-0,37466
X 3	-1,55801059	0,76362	-2,04029	0,096832	-3,520	0,404938
X 4	-1,33111880	3,99886	-0,33287	0,752733	-11,61	8,948301

\* Grouped and calculated based on author's calculations

Then using the same algorithm, we obtain the following regression equation:

$$Y = 36,6 - 104,16 x_2 + 2,77,3 x_3 + 1,56 x_4 - 1,33 x_5 \quad (3.4.)$$

As a result of the study (Fig 1.), the value of the multiple correlation coefficient  $R = 0.95174$  was established, which indicates a rather close relationship between 4 factors and the effective feature.

	df	SS	MS	F	Значимость F
Регрессия	4	141,8599978	35,46499945	12,02314049	0,0088517
Остаток	5	14,74864221	2,949728441		
Итого	9	156,60864			

  

	Коэффициент	стандартная ошибка	t-статистика	P-Значение	Нижние 95%	верхние 95%	нижние 95,0%	верхние 95,0%
Y-пересечение	36,60106758	8,960715756	4,084614284	0,009496795	13,56681443	59,63532	13,56681	59,63532
Переменная X 1	-104,1603575	34,20060508	-3,045570603	0,0285684	-192,0758116	-16,2449	-192,076	-16,2449
Переменная X 2	-2,770176285	0,931895167	-2,972626517	0,031062836	-5,165689074	-0,37466	-5,16569	-0,37466
Переменная X 3	-1,558010592	0,763620267	-2,040294972	0,096832375	-3,520958979	0,404938	-3,52096	0,404938
Переменная X 4	-1,331118807	3,998869048	-0,332873818	0,752733214	-11,61053894	8,948301	-11,6105	8,948301

Fig 1. The value of the multiple correlation coefficient

The multiple determination coefficient ( $R^2 = 0.9058$ ) indicates that the variation in the net profit of the surveyed enterprises by 91% is due to factors such as: average amount received, service level and quality, Food cost, Labor cost, which were introduced into the correlation model. The significance of the determination coefficient relation will be checked using the Table F-criterion for 5% significance level. The actual value of the F-criterion is determined by the formula [78]:

$$F = \frac{n^2}{1 - n^2} = 3,75 \quad (3.5.)$$

The critical value of  $F_T(0.95) = 2.74$ , which is 1.1 less than the actual,  $F_T(0.95) < F_{\Phi}(2.74 < 3.75)$ , which confirms the significance of the correlation between the studied features [78].

Based on the obtained parameters of the regression equation and the calculation of partial elasticity coeffi-

cients, it can be concluded that if the net profit decreases by 1%, 2.19% will increase, if the service level increases by 1%, the net profit will decrease by 0.5%, if the cost of rent increases by 1%, the amount of net profit will decrease by almost 0.35%. At the same time, Food cost has the greatest influence on the formation of net profit.

Multicollinearity verification of this model showed that there is no close correlation between all pairs of factor features, and therefore this model can be used as the main one. Thus, as a result of correlation-regression analysis we can develop the following recommendations to increase net profit as the main effective feature of the restaurant industry in Vinnytsia, in particular: it is necessary to re-evaluate fixed assets to ensure their reproduction; review the range of dishes, to focus production on the most popular dishes, and ad-

here to a certain specialization in production; if it is impossible to avoid the seasonality factor, try to rationally take it into account.

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### SCIENTIFIC AND METHODOLOGICAL APPROACH TO ASSESSING THE EFFECTIVENESS OF PUBLIC EXPENDITURE IN THE PUBLIC PROCUREMENT SYSTEM.

#### Abstract.

*The article considers the procedure established by law for the preparation, consideration, approval and implementation of the state budget. Based on the systematization of literature sources, the author's definition of the concept of "efficiency of public spending" is proposed. Topical issues of analysis of the implementation and effectiveness of state budget expenditures are considered. Methodical bases of estimation of efficiency of the state expenses are developed. Methodical approaches to the assessment of the efficiency of public expenditures are considered and analyzed. The own technique of estimation of efficiency of the state expenses is offered. The purpose of measuring the efficiency of public procurement is described. Based on the analysis of the advantages of responsible management of the efficiency of public procurement, a conceptual approach to the analysis of the efficiency of the public procurement system is proposed. The methodology for improving the efficiency of public procurement has been improved, which takes into account qualitative factors in choosing the best offer, the degree of competition by type of economic activity, the share of socially significant projects, the level of order fulfillment. The proposed method of analysis of public (public) procurement allows to comprehensively assess their effectiveness and forms a methodological basis for substantiating the main areas of improvement of public bidding procedures and identifying reserves of budget savings. The use of such a methodology will allow optimal use of public resources and direct them to priority areas.*

**Keywords:** state budget expenditures, efficiency, public procurement, electronic bidding.

**Formulation of the problem.** The procedure established by law for the preparation, review, approval and implementation of the state budget requires the use of certain tools to measure the current state of public expenditure and further compare it with the strategic

guidelines of budget policy. In this context, the opinion of M. Garage [6] is appropriate, which states that we control what we can evaluate. If you are not able to evaluate your activities, then you will not be able to control and manage the process, as well as improve it.