ECONOMETRIC MODELING OF BUSINESS PROCESSES BASED ON TIME SERIES DATA.

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Abstract. This article discusses modeling, one of the urgent problems facing the modern economy. It also shows econometric modeling and ego application in economic and business cases. You can also see the basics of the importance of econometric models and their structure. Also, the study also took into account econometric modeling of business processes and the views of scientists who studied the causes of their occurrence.

Keywords: economics, modeling of business processes, market, model, correlation, regression, factor.

Introduction

Changes in the world economy, acceleration of globalization and integration processes, increased international competition, continuous and significant qualitative changes in technologies, structural changes in sales markets and consumer requirements determine each economic subsystem. This requires the company to create a competitive product, drastically reduce costs in the production process, and make optimal decisions in management, taking into account market requirements.

A fundamental change in the activities of enterprises based on market requirements, the introduction and modernization of modern and promising forms of management, the effective use of modern information systems and technologies are the main requirements of today and the main condition for the survival of an enterprise in conditions of fierce market competition.

"Modeling of business processes" is a science that studies aspects of modeling all processes in a logical sequence in the "life cycle" of the production of goods (services) in firms and enterprises operating in all sectors of the economy.

Market relations are a complex process characterized by elements of risk and uncertainty. Therefore, taking into account these factors, the correct organization of each production "chain" at enterprises and firms contributes to the achievement of the final results of the enterprise. In this regard, the importance of creating a scientifically based method of reorganization using mathematical and instrumental methods for modeling financial and economic activities in modern enterprises is increasing.

Econometric methods do not replace simple traditional methods, but contribute to their further development and analysis of indicators of objective outcome variables through other indicators. One of the advantages of econometric methods and electronic calculators in the management of the national economy is that they can be used to show the influence of factors on the modeling object, and the relationship of resources on the result indicator. This allows for scientific forecasting and management of production results and priorities of the national economy in dozens of industries and thousands of enterprises.

The importance of econometric models can be seen in the following:

1. With econometric methods, material, labor and financial resources are rationally used.
2. Econometric methods and models serve as the leading tool in the development of economic and natural sciences.
3. It is possible to make adjustments in the overall implementation of forecasts made using econometric methods and models.
4. With the help of econometric models, one can not only deeply analyze economic processes, but also reveal their new, unexplored patterns. They can also be used to predict the future development of the economy.
5. Econometric methods and models, along with the automation of calculations, facilitate mental work, organize and manage the work of economic workers on a scientific basis.

This complex has one object of analysis, that is, the economy. Compared to other economic sciences, complex economics is analyzed by various econometric methods.

Literature analysis

An analysis of scientific sources shows that the issues of econometric modeling of business processes based on time series data and its economic aspects have not been studied enough. However, econometric modeling of business processes and their causes are more clearly explained in relation to this problem.

Burt used the Brookings model, the FED-MIT model, the TC Liu model, the OBE model, the Wharton model, and their predecessors as econometric models during his research. A rationale for some of the demand equations is given by J. Chou, "The Multiplier, Accelerator, and Liquidity Preference in Determining National Income in the United States," Review of Economics and Statistics, XLIX (February 1967), pp. 1–15. can be found. Draft versions of this paper were presented at staff meetings of the National Bureau of Economic Research and the Bureau of Labor Statistics, where valuable comments were received. Philip Kagan, Jacob Mintzer, and Thomas Jaster were involved in the initial formulation of the model and often provided advice. Gary Becker, Charlotte Beauchamp, Edwin Koo and Victor Zarnowitz made suggestions at various stages. Expressing our sincere gratitude to the colleagues mentioned above, we must admit that this article would be much better if their many suggestions were taken more seriously [1].

Another researcher's article compared classic econometric business failure models with models derived using modern business intelligence techniques such as logistic regression, random forests, and support vector machines. The authors support five econometric models, both foreign and domestic, and three business analysis methods - logistic regression, as well as one of the most accurate machine learning methods - random forests and vector machines. In the second case, the bankruptcy prediction problem is one of the supervised machine learning problems, a binary classification problem. The comparison of models was carried out by the authors on the data of more than ten thousand Polish enterprises. The choice of this selection is based on the fact that both Poland and Russia are transition countries and have many common features, as well as the fact that the most up-to-date information about Polish enterprises is in the public domain. explained The results of the analysis showed that econometric models, especially classical foreign models, are not fully used to calculate the probability of bankruptcy. At the same time, data-driven analysis methods provide more accurate results[2].

In his research, J. Kenneth addressed two econometric issues in business cycle modeling: (1) the nature and sources of secular, cyclical, and seasonal fluctuations and the econometric implications of pre-filtering to remove some of these components from aggregated time series, and (2) methods for solving : used these solutions to create non-linear, dynamic stochastic business cycle models and moment conditions to estimate unknown parameters[3].

Jan Tinbergen's pioneering work on empirical macroeconomic models has since shaped business cycle research and thus our current understanding of the business cycle. His models, first the Dutch economy and then the US economy, share several important features that are present in many modern models. V modeliax Tinbergena delovye cykly rassmatrivalis kak result potryaseniy ili impulsov, rasprostranyayushchihsya po economie s techeniem vremeni, chto privodit k slojnym dynamicheskim modeliam; The special characteristic model is simple, simple, linear, and structurally stable, with a single period, and the resulting system can demonstrate cyclical dynamics. Separate equations of the model had an economic basis. The theory and the model itself served as the basis for linking a large number of variables. His work, described in the first volume of his report to the League of Nations, contains many important details that remain part of modern macroeconometric methodology. Notably, his focus on testing business cycle theories led to the evaluation of these models for their predictive power and the stability of their parameters over time. Finally, Tinbergen used his models for both positive and normative analysis, that is, as a tool for evaluating economic theories and analyzing macroeconomic policies[4].

In his research, James Stock focused on developing an econometric model for estimating the value of a restaurant business in Erbil, Kurdistan. The general opinion of consumers is that restaurant food in Erbil is expensive. Restaurants are also struggling to stay in business. A base estimate is done to evaluate all cost drivers and create an equation to refine the cost estimate and compare it to the sales of the business. Thus, the research questions are formulated as follows: what are the various cost drivers associated with the restaurant business, what are the most important costs that significantly affect the business, and what would be the standard econometric cost entry model. factors? 215 restaurants were selected as representatives of the industry. Variables and data are sent to SPSS for analysis. Five aspects of the cost structure in relation to cost were examined: cost, labor cost, product cost, sales volume, and cost of sales. The conclusion of the study, based on data analysis, is that the cost of production is the least important, labor costs have a negative trend, and an increase in sales leads to a large decrease in labor costs, resulting in an increase in sales. . to a slight increase in production costs. , The sale price is questionable. Finally, an econometric equation model is presented, assuming a standardized equation for this particular case[5].

Methodology

Objects in society and economy can be observed using mathematical models. This concept is called modeling. The word model comes from the Latin word module, which means measure, standard. The economic model is a simplified copy of economic objects. At the same time, the viability of the model and its compliance with the modeled object are important. However, it is impossible to reflect all aspects of the object under study in one model. It shows the most characteristic and important features of the process.

Therefore, the validity of the model depends on the amount of data collected, the level of accuracy, the skill of the researcher and the modeling process, and the nature of the problem being defined. It should not be forgotten that a very simplified model does not fully meet the requirements, and a complex model, on the contrary, creates difficulties in the process of its solution [6].

The creation of econometric models consists of several stages. Let's consider them separately:

The first step is specification. Statement of the economic problem - a group of main factors is selected, an economic problem is collected, the main factor and a group of influencing factors are determined: the factors participating in the econometric model are determined by the method of correlation analysis.

Correlation coefficient:

$$r_{x/y} = \frac{\overline{x \cdot y} - \bar{x} \cdot \bar{y}}{\sigma_x \cdot \sigma_y}$$

$$\sigma_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} \sigma_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n}}$$

The correlation coefficient (r) ranges from -1 to +1. If r=0, then there is no connection between the factors, if $0 \leq r \leq 1$, then the connection is correct. $-1 \leq r \leq 0$ - feedback, if r = 1 - functional connection.

Multiple correlation coefficient:

$$R_{y/x_j} = \sqrt{1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

The second stage is identification

The parameters of the econometric model are determined using the "method of least squares". When performing the "method of least squares" we use the system of normal equations:

$$\begin{cases} a_0 \cdot n + a_1 \cdot \sum x_1 + a_2 \cdot \sum x_2 = \sum y \\ a_0 \cdot \sum x_1 + a_1 \cdot \sum x_1^2 + a_2 \cdot \sum x_2 \cdot x_1 = \sum y \cdot x_1 \\ a_0 \cdot \sum x_2 + a_1 \cdot \sum x_1 \cdot x_2 + a_2 \cdot \sum x_2^2 = \sum y \cdot x_2 \end{cases}$$

The econometric model can be built in a linear or non-linear form based on selected factors.

- Linear : $y = a_0 + a_1 x_1 + a_2 x_2 + \cdots + a_n x_n$
- Without a line:

Parabolic function of degree n $y = a_0 + a_1 x_1 + a_2 x^2 + \cdots + a_n x^n$

hyperbolic function $y = a_0 + \frac{a_1}{x_1} + \frac{a_2}{x_2} + \cdots + \frac{a_n}{x_n}$

rank function $y = a_0 \cdot a_1^{x_1} + a_2^{x_2} + \cdots + a_n^{x_n}$

The construction of the regression equation consists in calculating and determining (a_0, a_1,... a_n coefficients of the regression equation) by the least squares method.

The third stage is verification

The significance of the constructed model is checked in 4 directions.

1. The quality of the model is evaluated using the coefficient of determination:

$$D = R^2 \cdot 100\% \qquad 0 < D < 1$$

2. Model significance is assessed using Fisher's test.

$$F_{statistika-fisher} = \frac{R^2}{1 - R^2} * \frac{n - m - k}{k}$$

3. The reliability of the parameters of the model is evaluated according to the Student criterion. T_{stat}

4. The significance of the "Method of Least Squares" is checked using the Durbin-Watson test.

Fourth stage. Using the developed and evaluated econometric model, the main economic indicators for the forecast period are calculated. The above stages are closely related to each other, complement each other and serve to achieve a common goal. It should be noted that there should be a standard program for solving the problem using electronic calculators. Therefore, we will perform the above steps in the study using the Stata14 application package.

Result and discussion

Based on the refinement stage, the income of the Kokan locomotive depot was taken as the main factor and 8 factors influencing it were obtained (Fig. 1). Brief descriptive statistics on the variables were then obtained (frame 2). We can also determine the factors involved in the econometric model using the correlation analysis method. In doing so, we have achieved the following results:

variable name	storage type	display format	value label	variable label
Y	long	%8.0g		Daromad
x1	int	%8.0g		Ishchilar soni
x2	double	%8.0g		Oylik
x3	float	%8.0g		Ijtimoiy sug`urta
x4	long	%8.0g		Xom ashyo xarajati
x5	double	%8.0g		Yoqilg`i xarajati
x6	double	%8.0g		Energiya xarajati
x7	double	%8.0g		amortizatsiya xarajati
x8	double	%8.0g		boshqa xarajatlar
date	float	%tq		

Figure 1. Information about variables

Based on the above picture, the income of the Kokan Locomotive Depot of the Kokan Regional Railway Hub is represented by its expenses and the number of employees working in it.

Variable	Obs	Mean	Std. Dev.	Min	Max
Y	21	4234806	2751152	822984	1.13e+07
x1	21	1109.952	59.85355	1054	1262
x2	21	1.98e+07	1.15e+07	4080487	5.01e+07
x3	21	3576526	1888331	1019708	7983867
x4	21	7896334	5367672	1332234	2.10e+07
x5	21	1.90e+07	9436171	5122685	3.42e+07
x6	21	1.08e+07	7930680	38985	3.03e+07
x7	21	2512812	2397086	208715	1.01e+07
x8	21	5282249	4333316	527981	1.43e+07

Figure 2. Brief descriptive statistical result of variables

Based on the picture shown above, the income of the Kokan locomotive depot in 21 quarters was on average 4,234,806 soums, and the lowest income was 822,984 and the highest income was 11,293,230 soums.

	Y	x1	x2	x3	x4	x5	x6	x7	x8
Y	1.0000								
x1	0.0374	1.0000							
x2	0.5925	-0.3625	1.0000						
x3	0.8105	-0.0358	0.7206	1.0000					
x4	0.4688	-0.4078	0.9582	0.5479	1.0000				
x5	0.8428	-0.2212	0.8471	0.9064	0.7476	1.0000			
x6	0.4574	-0.4790	0.9659	0.6091	0.9562	0.7853	1.0000		
x7	0.3755	-0.4014	0.8778	0.3737	0.8896	0.5944	0.8884	1.0000	
x8	0.8211	-0.1680	0.8125	0.7154	0.7601	0.8841	0.7640	0.7097	1.0000

Figure 3. Correlation analysis matrix

The result of the correlation analysis shows that the variables x2, x3, x5 and x8 depend on the income of the Kokan locomotive depot. Thus, we see in the simulation that the monthly social insurance costs, fuel costs and other expenses are functionally dependent on income. To do this, we determine the parameters of the econometric model using the "Least Squares Method" through the identification stage and implement it through the application package.

Source	SS	df	MS			
				Number of obs	=	21
				F(4, 16)	=	21.63
Model	1.2775e+14	4	3.1938e+13	Prob > F	=	0.0000
Residual	2.3624e+13	16	1.4765e+12	R-squared	=	0.8439
				Adj R-squared	=	0.8049
Total	1.5138e+14	20	7.5688e+12	Root MSE	=	1.2e+06

Y	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
x2	-.1205578	.0461142	-2.61	0.019	-.2183155	-.0228002
x3	.6590174	.3810155	1.73	0.103	-.1486995	1.466734
x5	.0774473	.1215525	0.64	0.533	-.1802325	.3351272
x8	.4277146	.1517649	2.82	0.012	.1059873	.7494419
_cons	538752.7	702319.2	0.77	0.454	-950097.6	2027603

Figure 4. Regression analysis result

According to the results of the regression analysis, the coefficient of our influencing factor x5 turned out to be unreliable, so we exclude it from the model and make up the second multivariate linear regression equation. To build a multivariate linear model, we conducted a regression analysis using the Stata 14 application package, and it turned out to be the following:

Source	SS	df	MS			
				Number of obs	=	21
				F(3, 17)	=	29.75
Model	1.2715e+14	3	4.2385e+13	Prob > F	=	0.0000
Residual	2.4223e+13	17	1.4249e+12	R-squared	=	0.8400
				Adj R-squared	=	0.8117
Total	1.5138e+14	20	7.5688e+12	Root MSE	=	1.2e+06

Y	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
x2	-.1099019	.042217	-2.60	0.019	-.198972	-.0208317
x3	.8576102	.2152788	3.98	0.001	.4034116	1.311809
x8	.4918429	.1115868	4.41	0.000	.2564153	.7272705
_cons	748747.9	609250.5	1.23	0.236	-536658.3	2034154

Figure 5. Regression analysis

Based on the results of the above regression analysis, the following multifactor linear model was created:

$$Y = 748747.9 - 0.1099 * x2 + 0.8576 * x3 + 0.4918 * x8 + \varepsilon$$

We also created non-linear models using the Stata application suite, and compared to them, we considered the multivariate linear model to be the optimal model. The third stage helped us come to this decision. At the verification stage, we created the following table and selected the optimal model from it.

Table 1

Models and their test results

Model nomi	Model	R^2	F-fisher	t-student
Liner model	$Y = 748747.9 - 0.1099 * x2 + 0.8576 * x3 + 0.4918 * x8 + \varepsilon$	0.84	29.75 p(0.000)	1.23 (0.236) -2.60 (0.019) 3.98 (0.001) 4.41 (0.000)
Log-liner model	$LnY = 13.9043 - (8.90e - 10) * x2 + (2.39e - 07) * x3 + (5.48e - 08) * x8 + \varepsilon$	0.73	16.05 p(0.000)	66.67 (0.000) -0.06 (0.952) 3.24 (0.005) 1.43 (0.170)
Liner-log model	$Y = -(3.68e + 07) - 2018845 * Lnx2 + 2630884 * Lnx3 + 2332366 * Lnx8 + \varepsilon$	0.76	18.87 p(0.000)	-3.37 (0.004) -1.68 (0.111) 2.66 (0.017) 2.73 (0.014)
Log-log model	$LnY = -1.528212 + 0.1399 * Lnx2 + 0\,.7744 * Lnx3 + 0.1755 * Lnx8 + \varepsilon$	0.80	23.80 p(0.000)	-0.57 (0.575) 0.48 (0.640) 3.20 (0.005)

				0.84 (0.412)

Based on the results of the above table, we chose the multivariate linear regression model (Liner model) as the optimal model. Then we sent it to the fourth stage, and using this model we calculate the forecast values of the Kokan locomotive depot of the Kokan regional railway junction.

Conclusions and suggestions

In econometric modeling of business processes based on time series data, it can be concluded that each production "chain" is properly organized at enterprises and firms, taking into account the factors and achieving the final results of the enterprise's activities, modeling financial and economic activities at modern enterprises should use mathematical and instrumental methods . We can also see the use of optimal models in creating a science-based reorganization methodology to make accurate predictions for the future.

In this study, using the analysis of scientific sources, the issues of econometric modeling of business processes based on time series data and its economic aspects have not been sufficiently studied. However, we can see that econometric modeling of business processes and their causes is more clearly explained in relation to this problem.

Then, in the study, it was seen that the monthly wages of key workers, social security, fuel cost, and other expenses are highly correlated with company income, and brief descriptive statistics about the variables were considered. It should be noted that in order to increase the income of the enterprise, it is necessary to increase the cost of workers and fuel. Nonlinear models were also created, and in comparison with them, the multifactorial linear model was recognized as the optimal model.

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