SECTION 13. QUANTITATIVE METHODS IN ECONOMICS

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13.1 Forecasting business processes based on economic modeling technologies

Currently, the development of economic processes is impossible without predicting the future and forecasting prospects.

Economic forecasts are needed to determine the ways of development of society and economic resources that ensure its achievement, to identify the most likely and cost-effective options for long-term, medium-term and current plans, justify the main directions of economic and technical policy, anticipate the consequences of decisions. In the conditions of scientific and technical progress and improvement of the economic system of the state, forecasting becomes one of the decisive scientific factors. Thus, modern conditions require the maximum expansion of the forecasting front, further improvement of the methodology and methods of forecast development. Than higher the level of forecasting the processes of social development, there more effective planning and management of these processes in society [629].

The task of socio-economic forecasting is to find out the perspective of the near or distant future, taking into account the real processes of today.

The forecasting process consists of a number of stages, each of which solves a certain task [630]:

1) definition of the task – the object of the forecast is clarified, the goal and task are formed, the accuracy and time of forecast advance are determined;

2) formation of the object of the forecast in accordance with the assigned task - the structure of the object is determined, the main factors are singled out, their subordination, hierarchy, and interrelationship are clarified;

3) collection of retrospective information about the object - sources of information are determined, methods of information processing and presentation are developed, and its scope is established;

4) formalization of the task – a method of formalized presentation of information is developed and a class of models describing the forecast object is selected;

5) selection of methods and algorithm – the most suitable forecasting method is selected from among the known ones, an appropriate algorithm is developed and forecast accuracy is assessed;

6) modeling on the basis of retrospective model quality assessment data;

7) issuance of forecast results.

L. Klaip and T. Haavelmo studied complex econometric models. A significant contribution to the improvement of econometric research methods was made by J. Hackman, D. McFedep. The implementation of forecasting with the help of economic models is revealed in the research of R. Frisch and R. Klein. The principles of construction of regression equations are laid down in the works of V. Baraz, I. Lukyanenko, Y. Tolbatov and others.

The object of research is the process of forecasting gross domestic product based on the construction of multifactor regression models.

The subject of the research is the features of the application of modern information technologies for the construction of multifactor linear regression models.

Research methods. During the work were used: system method, methods of analysis and synthesis, induction and, systematization, logical approach, grouping and generalization.

Econometric models are most often used to analyze and forecast economic processes. This is a special class of mathematical models used for research, analysis and forecasting of different levels of economic systems. They contain functional regression equations that express the relationship between the studied quantity and the factors on which it depends. And it is obvious that most economic processes, both at the micro and macro levels, are usually influenced by many factors. Therefore, it is relevant to describe such processes with the help of multifactor regression models. The construction of econometric models is based on the use of a significant array of input data, it is natural today to carry out such processing using modern information

technology. To this goal, we will consider and prove the feasibility of using Eviews software.

EViews is a modern package of econometrics, statistics and forecasting package that offers powerful analytical tools in a flexible, easy-to-use interface. It was developed by Quantitative Micro Software, which is now part of IHS. The advantages of this software product are: it contains a large set of modern tools in econometrics, easy to learn command syntax and interface, fast, easy to reproduce models and obtain graphs, allows you to create personal macros, work with multiple files. Note also that EViews is a commercial software designed for economists and is used in complex econometric procedures. EViews has great functionality and includes various tools that can perform, in particular, the following operations: market forecasting, regression and macroeconomic analysis, finding patterns and dependencies of data during analysis, graphical modeling, creating visual and visual models for various informative blocks.

Note that the main task of correlation analysis is to determine the type and closeness of the relationship between the variables of this econometric model [631]. The practical use of regression analysis in economic research makes it possible to determine what is the relationship between factor characteristics, expressed by the regression equation - reliable or random. To analyze the impact of macroeconomic indicators on the dynamics of economic activity in Ukraine, we use economic and mathematical methods, namely - correlation and regression analysis. Let's make macroeconomic forecasts of real gross domestic product using an econometric model with the growth of the statistical package of Eviews to predict the growth or fall of economic indicators for the next 5 years.

Currently, the most common and universal indicator for measuring the economy of a country is gross domestic product (hereinafter GDP). Thus, we will make a statistical analysis of real GDP in Ukraine over the past ten years, examine the impact of certain factors on its growth and decline.

Let`s apply a multifactor regression model. Before building such an econometric model, let's identify the main factors that affect economic growth [632]:

– Exports in% to GDP;

– Imports in% of GDP;
– Inflation;
– The US dollar exchange rate (relative to the hryvnia) (Table 1).

Table 1. Macroeconomic indicators

Years	GDP Billions of UAH	The US dollar exchange rate, in UAH	Imports in% of GDP	Exports in% of GDP	Inflation, %
2010	1 082 569	7,98	53,7	50,7	109,1
2011	1 302 079	7,96	59,2	53,8	104,6
2012	1 411 238	7,98	59,3	50,9	99,8
2013	1 454 931	7,99	55,4	46,9	100,5
2014	1 566 728	7,99	53,2	49,2	124,9
2015	1 979 458	15,76	54,8	52,8	143,3
2016	2 383 182	24	55,5	49,3	112,4
2017	2 982 920	27,19	54,3	47,9	113,7
2018	3 558 706	28,06	53,8	45,2	109,8
2019	3 974 564	27,68	49	41,2	104,1
2020	4 194 102	23,68	40,1	39	105

Let's build a model of dependence of GDP on exports, imports, inflation and the dollar against the hryvnia - using the econometric package of analysis Eviews. Then the multifactor linear regression model will look like this:

Y=f(EXPORT, IMPORT, INFLATION, KURS_$)

$y= b_0+b_1x_1+ b_2x_2+\ldots+ b_px_p+E$

where y – independent variable,

$x_1, x_2, \ldots, x_p$ – independent factors,

$b_0, b_1, b_2, \ldots, b_p$ – model parameters,

E – mistake.

The results of calculations of model parameters are presented in Fig. 1.

Dependent Variable: GDP
Method: Least Squares
Date: 10/03/21 Time: 20:02
Sample: 2010 2020
Included observations: 11

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXPORT	-89246.77	65516.06	-1.362212	0.2220
IMPORT	-31206.29	44688.78	-0.698303	0.5111
INFLATION	1966.479	10834.40	0.181503	0.8619
KURS_$	75585.97	14997.28	5.039980	0.0024
C	6798236.	1410580.	4.819462	0.0029

R-squared	0.961359	Mean dependent var	2353680.
Adjusted R-squared	0.935598	S.D. dependent var	1141936.
S.E. of regression	289795.7	Akaike info criterion	28.29470
Sum squared resid	5.04E+11	Schwarz criterion	28.47556
Log likelihood	-150.6208	Hannan-Quinn criter.	28.18069
F-statistic	37.31861	Durbin-Watson stat	2.079859
Prob(F-statistic)	0.000224		

Figure 1. The results of the calculation of the parameters of the regression model

Now let's check the significance of the regression:

As Prob(F-statistic)=0,000224, which is less than 0,05 and 0,01 (level of significance), we can say that at any level of weight there is a significance of regression.

Model coefficients check:

Prob(EXPORT) = 0,222, which is more than 0,05 (level of significance), and then we conclude about the insignificance of the variable EXPORT with significance level 0,05.

We draw the same conclusion about the elements of the IMPORT and INFLATION models, since they have values of 0.5111 and 0.8619, respectively, which is more than 0.05 (significance level).

Prob (KURS_$) = 0,0024, which is less than 0,01 and 0,05 (significance level), then we can say about the significance of the variable KURS_$.

The next step is to build a correlation matrix (Fig. 2).

Correlation

	GDP	EXPORT	INFLATION	IMPORT	KURS_$
GDP	1.000000	-0.856481	-0.109271	-0.745035	0.903456
EXPORT	-0.856481	1.000000	0.368531	0.856498	-0.628803
INFLA...	-0.109271	0.368531	1.000000	0.048352	0.013762
IMPORT	-0.745035	0.856498	0.048352	1.000000	-0.484849
KURS_$	0.903456	-0.628803	0.013762	-0.484849	1.000000

Figure 2. correlation matrix

The correlation matrix estimates the relationship of the dependent variable GDP (GDP) with the independent variables EXPORT, IMPORT, KURS_ $ and INFLATION. Where the relationship is less than 0.7, further analysis and forecasting are not considered. Therefore, after the research, such macroeconomic indicators as exports, imports and inflation are rejected. And after adjustments we build a new model.

Again, we check the significance of the regression: Prob (F-statistic) = 0.000137, which is less than 0.05 and 0.01 (significance level), then the significance of the regression exists at any significance level.

R-squared = 0.81 - this means that in 81.62% of cases, changes in x lead to changes in y. That is, the accuracy of selection of the regression equation is high. The sample regression model will be equal to: GDP = 112423.7*KURS_$ + 449938.4 (Fig.3).

Variable	Coefficient	Std. Error	t-Statistic	Prob.
KURS_$	112423.7	17781.31	6.322574	0.0001
C	449938.4	338922.2	1.327556	0.2170

R-squared	0.816233	Mean dependent var	2353680.
Adjusted R-squared	0.795814	S.D. dependent var	1141936.
S.E. of regression	516006.3	Akaike info criterion	29.30859
Sum squared resid	2.40E+12	Schwarz criterion	29.38094
Log likelihood	-159.1973	Hannan-Quinn criter.	29.26299
F-statistic	39.97494	Durbin-Watson stat	0.628109
Prob(F-statistic)	0.000137		

Figure 3. Adjusted regression model

Moving to the next step in the sequence of the forecasting process, we first note what is trend analysis. Trend analysis is a tool for researching macroeconomic phenomena, which determines the development trends of the national economy. Using MS Excel, a graph of the US dollar exchange rate function for 2010-2020 is constructed, where the respective years are independent variables. In addition, we found the equation and the value of the level of approximation of the linear trend R^2, where we use the option "add trend line" (Fig.4).

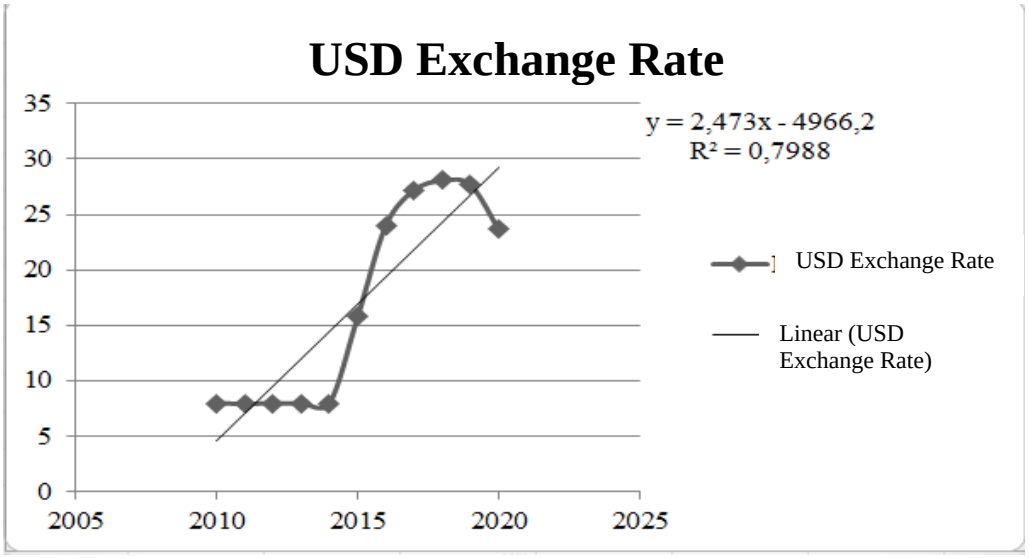

Figure 4. Graph and trend equation of the US dollar exchange rate series

Thus, the level of approximation indicates that the trend line is 79.8% closer to reliable data. The trend equation can be used for further predictions if the approximation level is at least 0.5.

We introduce a table in which we indicate the equation of trends and levels of approximation for the studied factors (Table 2).

Table 2. Equation of trends in GDP factors

Characteristic	Trend equation	Approximation level
US dollar exchange rate, UAH	Y= 2,473x-4966,2	R^2=0,7988

Based on the trend analysis, was made a forecast of the above factor for the future 2021-2025 years. The data are shown in Table 3.

Table 3. Forecasts of the indicator for the period 2021-2025

Years	US dollar exchange rate, UAH
2021	26,153
2022	28,626
2023	31,099
2024	33,572
2025	36,045

In order to develop a scenario for the forecast of gross domestic product, it is necessary to substitute the forecast values of macroeconomic factors in the appropriate formulas. The most probable forecast scenario includes the forecast values of the factors that were obtained on the basis of the studied trend equations and trend analysis.

We offer the most probable option for calculating the level of GDP using the formula (*). After the calculations, Table 4 summarizes the results of the scenario analysis of globalization factors of the national economy that have the greatest impact on its level of development and were introduced into the multifactor economic-mathematical model.

Based on the trend analysis, was made a forecast of the above factor for the future 2021-2025 years. The data are shows on Figure 5.

From the data in the table we can see that the real GDP of the state will increase annually.

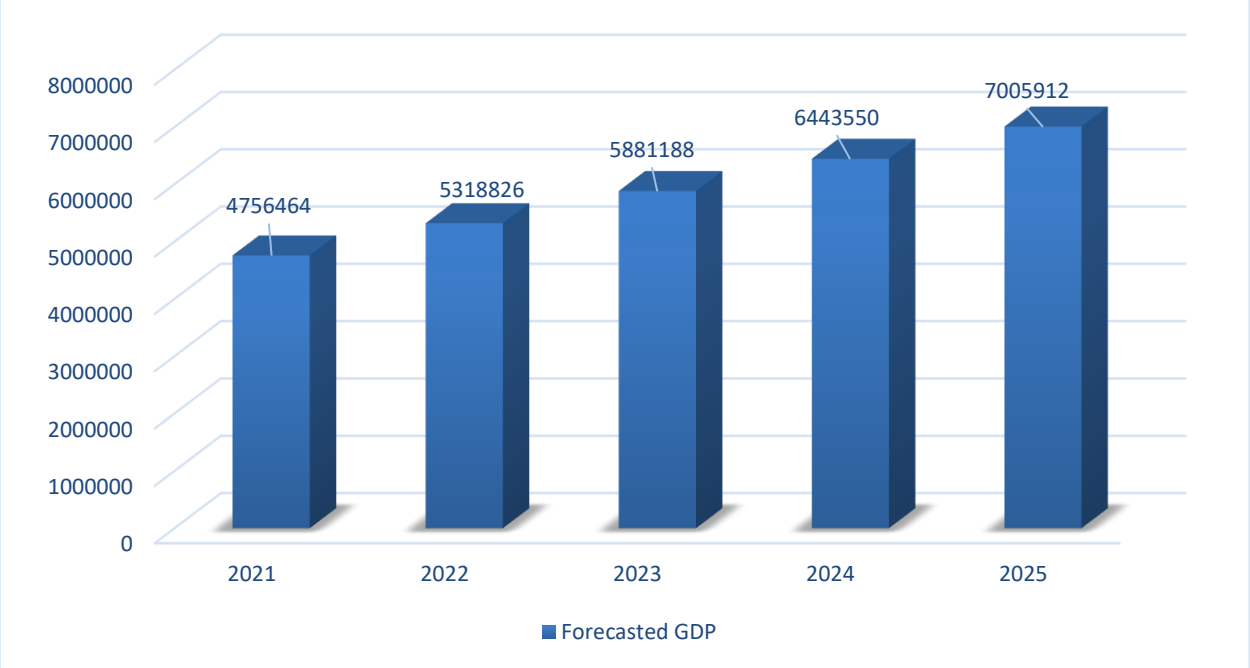

Figure 5. Forecasts of GDP for the future period of 2021-2025

Now forecast the GDP for the future and determine the dependence of factors that will affect on the economic growth of the state using Excel spreadsheet (Fig.6).

	A	B	C	D	E	F
1		*GDP*	*RATE*	*IMPORT*	*EXPORT*	*INFLATION*
2	GDP	1				
3	RATE	0,9034597	1			
4	IMPORT	-0,745039	-0,4848493	1		
5	EXPORT	-0,856481	-0,62880292	0,856498114	1	
6	INFLATION	-0,109256	0,013762027	0,048351819	0,3685306	1

Figure 6. Calculations using the Correlation tool

MS Excel includes a set of data analysis tools designed to solve statistical problems. In order to calculate the matrix of pairwise correlation coefficients R, we used the Correlation tool and set the analysis parameters in the dialog window. Mathematical calculations of correlation coefficients in EVIEWS and calculations obtained using the built-in functions of MS Excel are the same, so the calculations are performed correctly. The following steps will be the same as described above.

Now let's compare statistical packages of analyzes and determine which was easier to work with in this case. The EViews statistical package has been successfully developed for the analysis and construction of regression models. In addition, practitioners note that they successfully use EViews to solve the following tasks: macroeconomic forecasting, modeling of economic processes, forecasting market conditions, and so on. However, in our example, in the macroeconomic analysis of GDP, we still had to turn to the spreadsheet MS Excel in order to perform trend analysis and perform certain mathematical calculations. MS Excel is a spreadsheet with powerful mathematical capabilities, where some statistical functions are just additional built-in formulas. Of course, MS Excel is well suited for data collection, intermediate conversion, previous statistical calculations, to build some types of charts. However, the final statistical analysis must be done in programs that are specifically designed for this purpose [632]. Therefore, in our opinion, it is better to perform such tasks using the statistical package EViews (or others), because the program provides more features and functions for more accurate forecasting.

From the results of the study we can conclude that with the help of econometric forecasting it is advisable to forecast future trends in economic processes with the use of modern information technology. And the use of these technologies (in particular, Eviews software, MS Excel spreadsheet) allows you to do it quickly, clearly and conveniently. However, the final statistical analysis must be done in programs that are specifically designed for this goals.