УДК 330; 330.4
DOI: http://dx.doi.org/10.21686/2500-3925-2023-2-21-40

Н.С. Айюбова
Бакинский Государственный Университет, Баку, Азербайджан

Анализ влияния мировых цен на нефть на ВВП (на примере Азербайджанской Республики)

Цель исследования. *В статье анализируется влияние мировых цен на нефть (внешние и внутренние факторы) на ВВП страны, рассматриваются колебания мировых цен на нефть, их влияние на национальную экономику Азербайджана и интегрируемость этих макроэкономических показателей.*

Материалы и методы. *Изучение динамики функционирования временных рядов на основе исходных данных выявило их нестационарность, что не позволяет построить «качественную» прогностическую модель. Для достижения целей исследования и «повышения качества» формируемой модели, которая используется для расчета прогнозных оценок, были проведены соответствующие эконометрические процедуры и исследована интегрируемость временных рядов. В частности, используется метод векторной модели коррекции ошибок – VECM. Тест основан на использовании уравнений коинтеграции между переменными, где длина лагов и определения причинности по Грейнджеру решаются в рамках этой модели. При формировании модели VECM выдвинутые в работе гипотезы проверялись на основе использования эконометрических тестов. Отклики импульсной функции на независимые переменные модели изучались методом графического представления на основе значений модели и ее невязок.*

Результаты. *Определено, что долгосрочную равновесную связь между переменными можно считать устойчивой, так как после нарушения в краткосрочные периоды от шоковых реакций устойчивость восстанавливается. Примененный метод декомпозиции дисперсий ошибок прогноза для определения влияния экзогенных переменных на эндогенную переменную показал, что наибольшую неопределенность в прогноз для ВВП, марок Azeri_light, Brent и West дают собственные изменения в течение первого триместра рассматриваемого периода.*

Заключение. *Полученные результаты могут быть полезными для выявления реальных тенденций ВВП Азербайджана и определения его взаимозависимостей с другими макроэкономическими переменными, для определения его взаимозависимостей с вариацией цен на энергоносители на основе анализа динамики рассматриваемых показателей, для разработки рекомендаций и образования направлений перспективного развития ВВП.*

Ключевые слова: *ВВП Азербайджана, мировые цены на нефть, векторная модель коррекции ошибок, реакции импульсных функций отклика, декомпозиции переменных.*

Natavan S. Ayyubova
Baku State University, Baku, Azerbaijan

Analysis of the Impact of Global Oil Prices On GDP (on the Example of the Azerbaijan Republic)

Purpose of the study. *The article analyzes the impact of world oil prices (external and internal factors) on the country's GDP, considers fluctuations in world oil prices, their impact on the national economy of Azerbaijan and the integrability of these macroeconomic indexes.*

Materials and methods. *The study of the dynamics of the functioning of time series based on the initial data revealed their non-stationarity, which does not allow creating a "qualitative" predictive model. In order to achieve the goals of the study and "improve the quality" of the model being formed, which is used to calculate predictive estimates, appropriate econometric procedures were carried out and the integrability of time series was investigated. In particular, the method of vector error correction model - VECM is used. The test is based on the use of cointegration equations between variables, where lag lengths and Granger causality definitions are solved within this model. When forming the VECM model, the hypotheses put forward in the work were tested using econometric tests. The responses of the impulse function to the independent variables of the model were studied by the method of graphical representation based on the values of the model and its residuals.*

Results. *It has been determined that the long-term equilibrium relationship between variables can be considered stable, since after short-term disturbances from shock reactions, stability is restored. The applied method of decomposition of forecast error variances to determine the influence of exogenous variables on the endogenous variable showed that the greatest uncertainty in the forecast for GDP, Azeri_light, Brent and West is given by their own changes during the first trimester of the period under consideration.*

Conclusion. *The results obtained can be useful for identifying real trends in Azerbaijan's GDP and determining its interdependencies with other macroeconomic variables, for determining its interdependencies with variations in energy prices based on an analysis of the dynamics of the indexes under consideration, for developing recommendations and forming directions for the long-term development of GDP.*

Keywords: *Azerbaijan GDP, world oil prices, error correction vector model, reactions of impulse response functions, decompositions of variables.*

Introduction

When improving the system of state macroeconomic regulation, the effectiveness of the application of elements of economic policy is important. It is of great importance to identify and study the relationships between indicators of sectors of the economy, between internal and external indicators, quantify these relationships, identify patterns, develop trends that characterize the dynamics of development of different areas of the economy and their application in management.

Econometric models based on mathematical and statistical methods make it possible to identify relationships between the quantitative characteristics of economic objects in order to prepare mathematical conditions for the forecast, to determine the values of all parameters in the model and ensure its adequacy with the real behavior of the parameter under study, to obtain effective values of the model parameters, to check the theoretical and economic provisions and conclusions based on empirical information [1, 2, 3, 4].

The issue of forecasting important economic indicators is very relevant in the management and state regulation of the economy. Forecast estimates of the main indicators of the state of the economy, such as GDP dynamics, price index, current account balance of payments, crisis prediction, etc. may vary. The structure, structure of various economic indicators in solving an identical problem may dictate specific requirements, an individual approach to each of them, which requires a preliminary detailed study and analysis of phenomena.

Relevance

In econometric studies, the modeling of economic indicators with the study of the reactions of indicators to various shocks has become widespread. That is, forecasting is not only quantitative, but also qualitative. In other words, the researcher can simply indicate the quantitative change in the indicator under study, and can also indicate on what other indicators this change may depend and how. Preparation of models for forecasting is a statistical analysis of data, analysis of dependencies and relationships between factors.

To predict changes in the future of the studied economic objects, such as rising or falling prices, changes in the exchange rate, GDP growth, economic crises, etc. specialists in economic phenomena prefer to rely on experience, knowledge in the relevant field and on intuition. In such situations, the relationship of economic indicators may be incorrectly assessed, or some of them may be missed, which can have a strong enough impact on the analyzed situation. But, they do not take into account the advantages of mathematical modeling, where all the relationships of variables can be evaluated both quantitatively and qualitatively. Such econometric models, with a clear economic interpretation of specialists, make it possible to predict a better and more reliable forecast. Moreover, the simplicity and clarity of the explanations of the mechanisms and the obtained results of the models increases the corresponding audience.

Dynamic models include relationships of variables over time. In statistical models, in particular, series values are used, which are variables in dynamic models. Such models apply mechanisms, variational calculations, difference and differential equations, describe the nature and strength of mutual influences in the economy, which determine the algorithm of economic processes.

Vector autoregressive models and vector error correction models, the use of which has become very popular in econometric studies due to their wide possibilities, allow representation in a structural form, allow solving analytical problems, the solution of which was impossible or created difficulties in the implementation of regression modeling.

Work analysis

A complex algorithm of macroeconomic indicators associated with economic crises, cycles, with a change in economic trends and with an unstable economy associated not only with internal but also with external phenomena make the analysis, study of non-stationary time series and the construction of econometric models based on them especially relevant and important.

The mathematical model of an economic indicator in the form of a system of equations, logical and interrelated relationships, graphs is its homomorphic display, in a conditional way. Analysis, study of these models substantiate and develop more effective solutions to the issues under study.

The work of Polbin A.V. [5] is devoted to the econometric assessment of the impact of changes in the conditions of trading operations, world oil prices, fixed capital accumulation, household consumption in Russia, using the method of constructing a vector model of error correction with exogenous variables. The results of the author's research demonstrate that permanent the change in oil prices generated a «domed» response in the dynamics of the level of production. The author concludes that the impact of the increase in oil prices on GDP growth rates is positive in the short term and negative in the medium term. Analysis of the sensitivity of national economies to changes in world oil prices has always been an interesting and researched issue[6] considers in his work the problem of modeling the dynamics of oil prices. The author, substantiating the need to distinguish two periods, offers aggregated models. These models reflect the conditions in the oil market and in the national economy for the selected periods. The paper assesses the impact of possible monetary policy priorities on the dynamics of macroeconomic indicators and oil prices. Also, the importance of supplementing the analysis with a study of the impact of high oil prices on the most sensitive to rising fuel prices, intensive industries and industries is substantiated. Zulfigarov F. and Neuenkirch M. in [7] analyze oil price shocks in a six-variable model, where most variables are presented in the form of the first logarithmic difference, determines the significance of shocks in oil prices for the variances of the considered variables. Using variance decomposition, the author predicts the variation of variables when a shock is applied to the oil price variable and to each of the other macro variables included in the system. Rautava in work [8] analyzes the impact of world oil prices and the real exchange rate on the Russian economy and fiscal policy using the VAR methodology and cointegration methods. The results show that in the long run, a 10% increase or decrease in world oil prices is associated with an increase or decrease in Russian GDP by 2.2%. The influence of external economic conditions on the dynamics of the Russian economy is considered in most econometric models developed by Russian scientists. In the article[9], the author, analyzing the relationship of economic indicators in the Russian economy with the volatility of world oil prices, evaluates and proposes a system of simultaneous econometric equations, with the help of which he puts forward and tests a number of hypotheses about the sensitivity of macroeconomic stability to fluctuations in external factors. By studying the relationship between macroeconomic parameters and world oil prices, researchers in [10] identify factors that have a long-term positive relationship with oil prices, using mathematical approaches such as vectorial autoregression, Granger, Dickey-Fuller. It was revealed that a 1% increase in GDP leads to a strengthening of the ruble by 1.47%, that the price of oil and GDP has the greatest impact on the ruble exchange rate in the short term according to Granger, and actions are formulated to improve the effectiveness of macro indicators. Ybrayev Z. analyzes [11] the exposure of Kazakhstan's long-term economic growth to macroeconomic constraints. Balance-of-payments-constrained growth models predict that a country's growth rate can be approximated by the ratio of export growth rate to the income elasticity of demand for imports. The Johansen cointegration method was used to evaluate trading parameters. A vector error correction model is used to analyze short-term adjustments in income elasticity. The results show that average growth rates project long-term economic growth in Kazakhstan at about 2%, and current economic growth is limited by aggregate demand. A study [12] examines the direction of the causal relationship between the balance of trade and oil price shocks in the context of Pakistan over the period 1975–2010. The result shows that there is a significant negative relationship between oil prices, exchange rate and trade balance in Pakistan i.e. oil prices and exchange rate cause trade imbalance in Pakistan. Also, there is a positive relationship between the output gap and the trade balance, which indicates inefficient allocation and use of resources in production. The Granger causality result indicates that there is a bidirectional causal relationship between oil prices and the exchange rate in Pakistan. In work Pilnik N.P. and Shaikhutdinova M.F. [13] formulates a model that allows you to explore and predict foreign economic activity using and applying balance of payments indicators. The developed model makes it possible to accurately characterize the dynamics of the balance of payments indicators in the format of econometric and balance ratios and presented in three scenarios of the state of the balance of payments and can be used for short-term forecasting, which takes into account different combinations of external economic conditions, prices on world markets, etc. The work [14] studies the modeling of the dynamics of the balance of payments of Azerbaijan based on changes in the exchange rate, export-import operations, general and foreign investments in Azerbaijan. On the basis of statistical methods and an analytical approach to the analysis of the problem, an econometric model has been developed in the form of a multiple regression equation, which takes into account the influence of the main factors on the country's balance of payments. Also, to check the adequacy of the model and the significance of explanatory factors, the corresponding econometric tests with accompanying comparisons were carried out. Using the model, the authors interpret the dynamics of the development of the main macro-indicator of the country's foreign trade. The article [15] conducts an econometric analysis of the dynamic processes of Azerbaijan's balance of payments, discusses the formation of an econometric trend suitable for forecasting. Stationarity verification is important for econometric models, which is given sufficient space in this paper. Hypotheses about the absence of autocorrelation, heteroscedasticity in residuals, etc. are also tested. In [16], to create a cointegration ratio that can be used to measure the impact of Azerbaijan's GDP on the current account balance of payments in the long run and then to create a model for correcting errors and predicting economic development. Pre-econometric analysis of the time series of macroeconomic indicators taken into account for the presence of stationary was performed. According to the results of the Johansen test, linear and quadratic trends with similar results indicate the presence of cointegration relation and carried out Trace and Maximum Eigenvalue tests. In this work, both test statistics show the presence of one cointegration relation. As a result, an alternative hypothesis about the existence of one vector of cointegration and from two trends with similar results, a linear one was chosen trend. The results of this study provide an opportunity to identify actual trends development of the current account of the balance of payments and determine its interdependence with GDP. In [17], the impact of oil shocks and the change in the dynamics of oil price uncertainty associated with economic and political events are determined. In contrast to previous studies, the results of this study show that the sharp increase in oil price uncertainty over recent decades has a detrimental effect on output growth and that output growth responds symmetrically or asymmetrically to positive and negative shocks over the period.

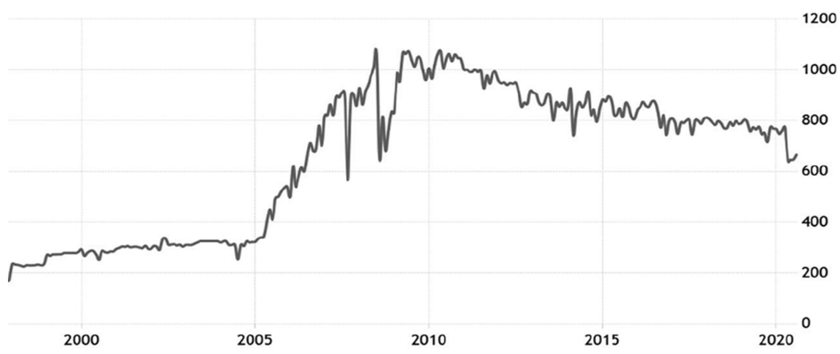

Fig. 1. Production of crude oil in Azerbaijan from 2000 to 2020 [18]

Рис. 1. Добыча сырой нефти в Азербайджане с 2000 по 2020 гг. [18]

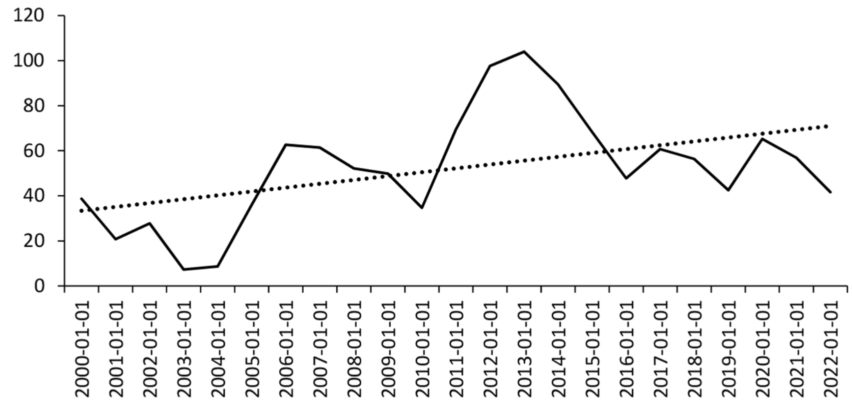

Fig. 2. Azeri Light oil price dynamics from 2000 to 2022 [19]

Рис. 2. Динамика цен на нефть Azeri Light с 2000 по 2022 гг. [19]

Analysis of the state of time series by model parameters

The most important exogenous factor of the Azerbaijani economy is oil prices, which is justified by the structure of the national economy and the country's export potential. Changes in world oil prices inevitably affect the volume of GDP, investment in the country, the real exchange rate, the level of average income and life of the population, and so on. Despite the steadily strengthening exchange rate of the national currency due to regulated measures at the state level, the increase in world oil prices, which increase the financial flow to the country and are closely related to the prices of other energy carriers, the growth or decrease in world oil prices strongly affects the dynamics of economic processes in the country of traders. oil products. This fact makes the close dependence of the Azerbaijani economy on the export of oil products an acute problem affecting the country's macroeconomic stability.

Having reached a record high of 1072 barrels per day per thousand in June 2009 and a record low of 168 barrels per day per thousand in February 1997, Azerbaijan's crude oil production as of April 2022 was 690 barrels per day per thousand. Fig. 1 presents data on crude oil production in Azerbaijan (2000-2020).

Azerbaijan's exports for the first quarter of 2022 increased by 2.1 times, which amounted to 8.1 billion dollars, and imports by 16.8%, which amounted to 2.7 billion dollars. Oil and gas exports increased 2.2 times and amounted to 7.4 billion dollars. The average market price for Azeri light oil reached $86.5 in the first quarter of 2022, and by the third quarter it rose by $3.5 to $128.80. In March 2022, this mark reached its all-time high this year at $136 per barrel. The dynamics of prices for Azeri light oil can be seen in Fig. 2.

Fig. 3 shows the dynamics of Brent and West Texas Intermediate oil prices from 1996 to 2020.

Analysis of Fig. 2 and Fig. 3 allows us to trace similar price dynamics for the three brands Azeri Light, Brent and West Texas Intermediate. According to the State Statistics Committee, Azerbaijan's GDP in 2021 increased by 5.6% compared to the previous period, and by 6.2% in the first half of 2022. The growth of the oil and gas sector

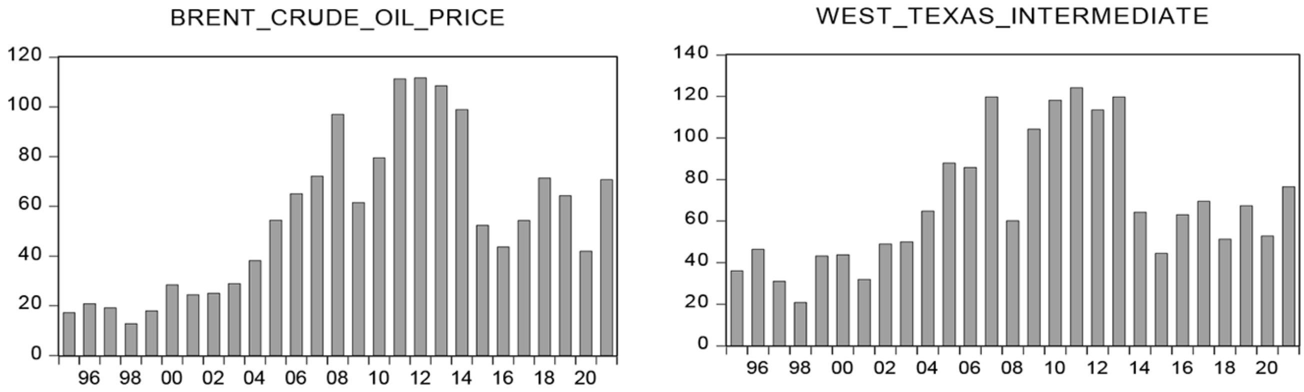

Fig. 3. Brent and West Texas intermediate oil prices dynamics (1996-2020) [20,21]

Рис. 3. Динамика промежуточных цен на нефть марок Brent и West Texas (1996-2020 гг.) [20,21]

amounted to 1.8% and 0.2%, respectively. In 2021, the nominal volume of Azerbaijan's GDP amounted to 92 billion 857.7 million manats. For 6 months, the same indicator amounted to 63 billion 364.4 million manats.

In the first half of 2022, 75.7% of the production volume fell on the mining industry, 20.4% on the processing industry, 3.4% on the production and distribution of electricity, 0.5% on the water supply and waste processing. Investments in fixed assets for the 1st half of 2022 amounted to 6.3 billion manats, which is an increase of 0.7% over 6 months of 2021, in the structure of which the volume of foreign investments amounted to 1.606 billion manats, and the volume of domestic investments 4.693 billion manats[22].

To visually analyze the relationship between GDP and oil prices, we use a graphical method. Fig. 4 shows a combined graph of Azerbaijan's GDP and Azeri Light, Brent, West Texas Intermediate oil prices. The figure clearly shows similar dynamics of all four parameters, which confirms the close and strong impact of oil prices on the economic growth of Azerbaijan.

The main results of the study

First of all, it should be noted the main advantage of vector error correction models, which allow expanding the applicability of regression models, also to non-stationary time series. The assumption that model variables are interdependent can form several equations when tested. These equations can be reduced to one after testing the degree of exogeneity of the variables.

To find the rank of cointegration of the vector model for Azerbaijan's GDP and world oil prices, a preliminary analysis of time series by parameters should be carried out. Statistical data for conducting econometric tests were taken from the official website of the State Statistics Committee of Azerbaijan [24], from the website of the Central Bank of Azerbaijan [25], from open international information Internet sources [26].

To conduct tests that determine cointegration relations, it is necessary to make sure that the series under study are first-order integrated series. According to the results of the regression analysis, where *GDP* was taken as dependent variables, and *Azeri Light, Brent, West* as independent variables, the formal model looks like this:

$$GDP = 354.02267Azeri\_light + 540.268Brent - 105.9412West - 6701.798 \quad (1)$$

R^2 was found to be 82%, *F-statistic* 27.1(Probability 0.000001), *Akaike* info criterion 21.55, *Schwarz* criterion 21.75, *Durbin-Watson* statistic 0.78,

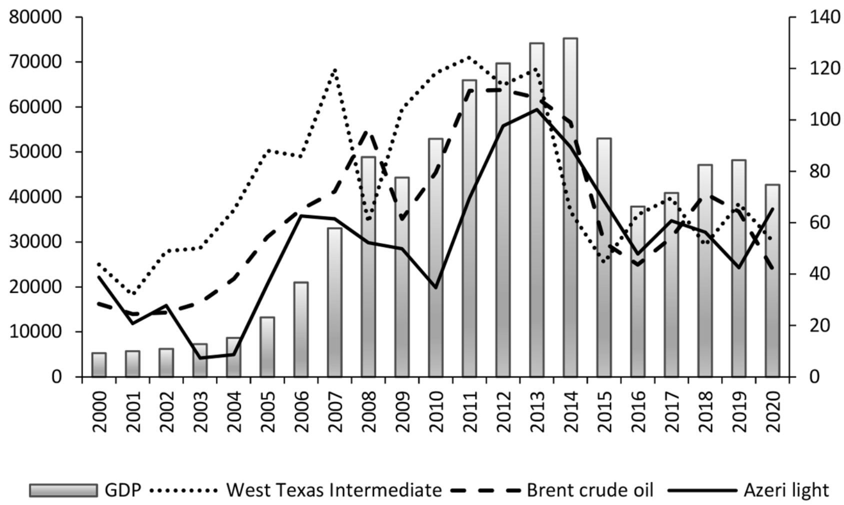

Fig. 4. Combined graph of Azerbaijan's GDP and Azeri Light, Brent, West Texas Intermediate oil prices (2000-2020) [23]

Рис. 4. Комбинированный график ВВП Азербайджана и промежуточных цен на нефть марок Azeri Light, Brent, West Texas (2000-2020 гг.) [23]

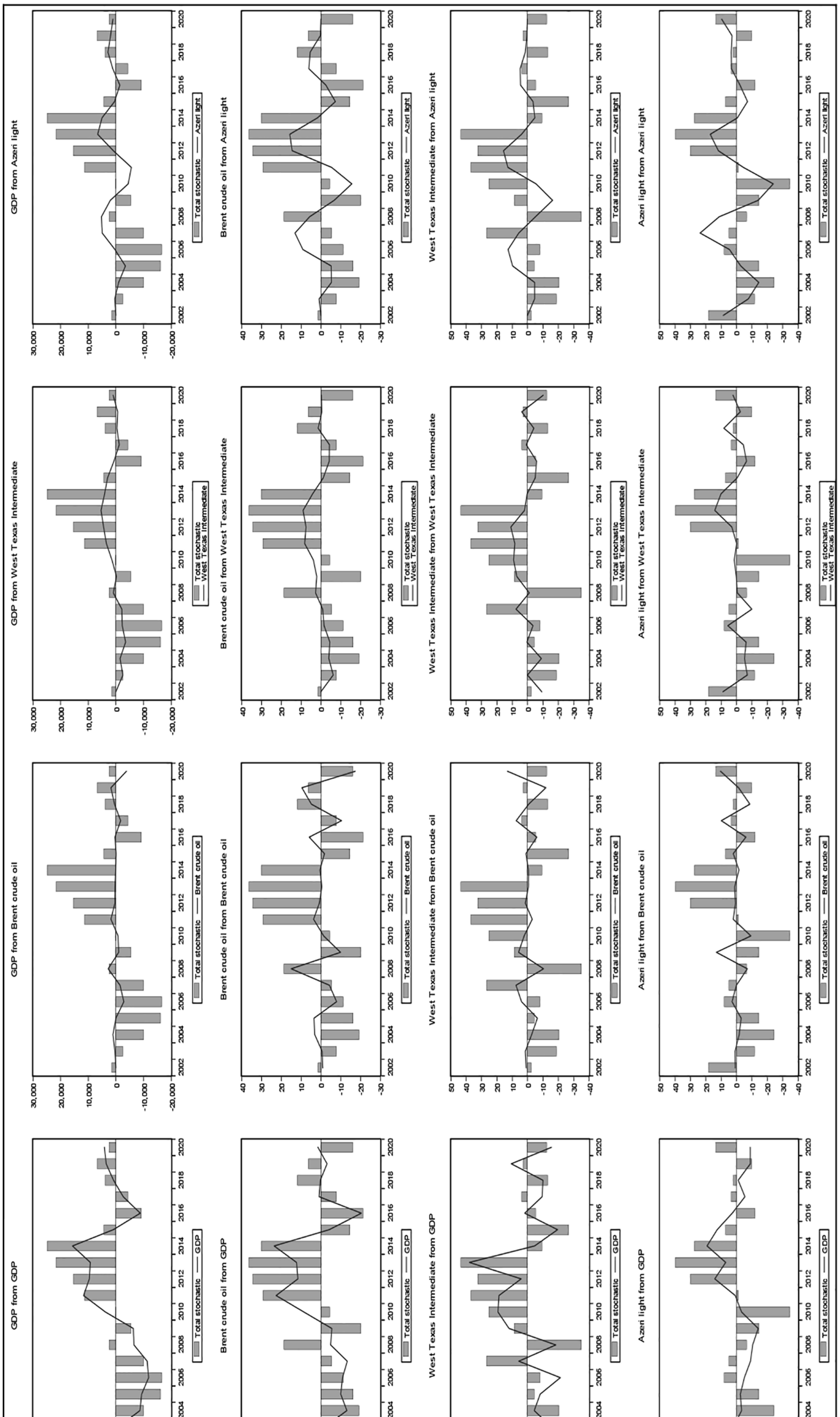

Fig. 5. Historical decomposition using Cholesky weights for variables in split form

Рис. 5. Историческая декомпозиция с использованием весов Холецкого для переменных в разделенной форме

t-criterion for *Azeri Light* 2.442708(Probability 0.0258), for *Brent* 3.318517 (Probability 0.0041) and for *West* -0.927554 (Probability 0.3666). Among the results there are positive indicators for modeling. The coefficient of determination explains the choice of factors for the model by 82%, leaving 18% for random components, which is assessed as satisfactory. The *Fisher criterion* is 27.75 with a high probability, the Student criteria for *Azeri Light* and Brent are also obtained with high probabilities. But, the statistics of *Durbin Watson* are very unsatisfactory and indicate the presence of a positive autocorrelation. By the number of observations $n_1 = 21$ and by the number of degrees of freedom $n_2 = 3$, respectively, the lower and upper limits of the critical points, with 95% probability, are $d_l = 1.026$ and $d_u = 1.669$. Since the criterion is $DW = 0.78$ and is located to the left of these points, this explains the positive autocorrelation in the regression model and the non-stationarity of the model.

Using the *Historical Decomposition using Cholesky weights* procedure in the Eviews package, decomposition was carried out for time series and, based on the results, in all cases a trend was found that characterizes the series as non-stationary. Graphs were built for each variable separately and in combined form and are presented in Fig. 5 and 6.

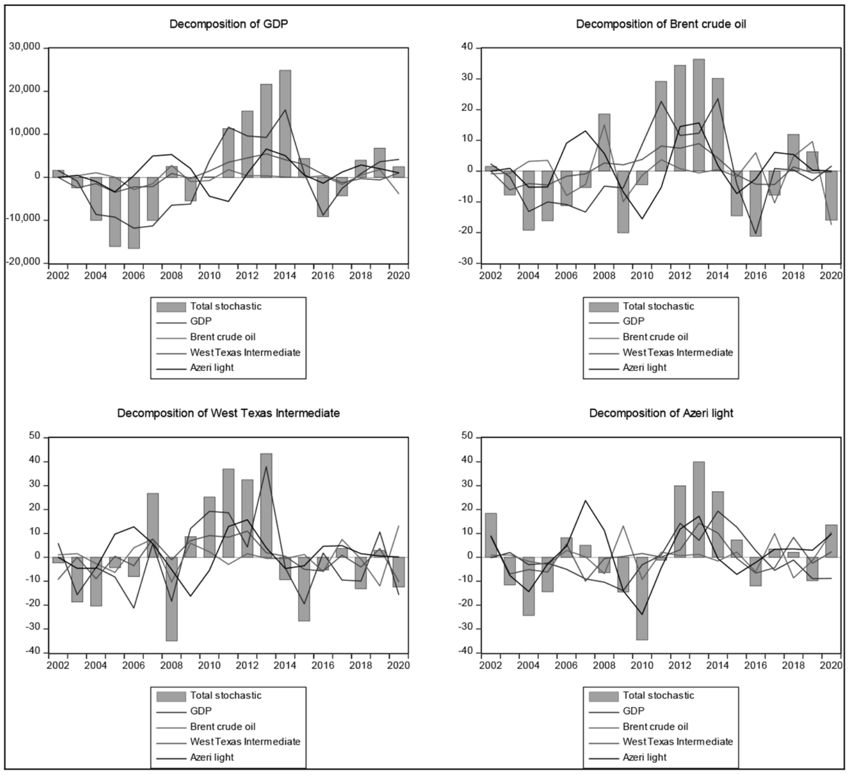

Fig. 6. Historical decomposition using Cholesky weights for variables in combined form

Рис. 6. Историческая декомпозиция с использованием весов Холецкого для переменных в комбинированной форме

To study the stationarity, dynamics, nature of time series, it is also important to analyze the residuals of these series. In Fig. 7, for each time series, with the help of *VAR Structural Residuals using Cholesky Factors,* graphs were constructed showing the structure of the residuals for the variables under study.

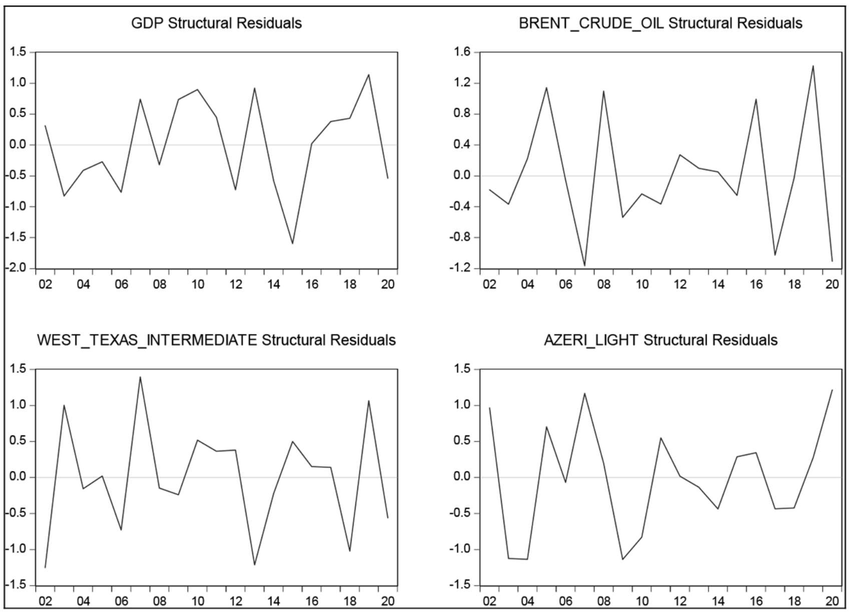

Fig. 7. Structural VAR Residuals Using Cholesky Factors

Рис. 7. Структура остатков по факторам с использованием разложения по Холецкому

As can be seen from the graphical analysis of decompositions and the structure of the residuals of the original time series covering the period from 2000 to 2020, the *GDP, Azeri Light, Brent, West* series are non-stationary, which requires consideration of data from a different aspect, since in this situation according to the initial data, the construction of an adequate model suitable for forecasting is impossible. Based on the first or second data difference for variables, time series can be revised and reexamined for stationarity [27], which is an advantage of the *Augmented Dickey-Fuller test.* In some cases, this procedure allows you to get the desired results and continue the study.

The *Dickey-Fuller* test and similar procedures *KPSS, Phillips-Perron, Breusch-Godfrey serial correlation LM-test, Ljung-Box* and *Augmented Dickey-Fuller* are used in autoregressive modeling to determine stationarity in series. The *Augmented Dickey-Fuller* test is an extended form of the *Dickey-Fuller* test. With this test, applying the method of differences on series data, you can remove the existing autocorrelation from time series and test them for stationarity. The extended *Dickey-Fuller unit root* test computes a value for the t-test with a p level of significance, and also offers critical values for the t-test with 1%, 5%, and 10% probabilities. These results help to conclude that the series is stationary. The null hypothesis determines the unit root, and stationarity is determined by the alternative hypothesis. The estimate of the coefficient $\xi = 1$ means the presence of a unit root in the time series, which characterizes the non-stationarity of the series [28]. Mathematically, the *Dickey-Fuller* test can be represented as follows:

$$y_t = \xi y_{t-1} + v_t, \quad (2)$$

where y_t – is the time series under study at moment *t;* ξ – is the coefficient determining the unit root; v_t is white noise, which is a random process, a special case of stationary series. This is a random sequence for the values $y_1, ..., y_p$, if they are independent of each other and the conditions $E(y_t) = 0$, $D(y_t)$ = const are satisfied. The unit root test determines whether the stochastic component of the equation consists of a unit root [29].

For an extended analysis of the residuals of the model, a parameter was added as an independent factor representing the residuals and a regression analysis was performed. At the next step, using the *Dickey-Fuller* test for a unit root, the stationarity of the first difference for the variables was tested.

The regression analysis for the multiple model for *GDP* with four independent parameters gave very positive results as follows. R^2 was 98%, *F-statistic* 6.38E + 14 (*Probability* 0.000024), *Akaike info criterion* -9.3, Schwarz criterion -9.04, *DW* statistic 1.88, t criterion for *Azeri Light* 12435701(*Probability* 0.00566), for *Brent* 16894399(*Probability* 0.0038), for *West* -4722128. (*Probability* 0.000002) and for *Mresid* 20990517(*Probability* 0.00003). The *F* criterion is 6.38E + + 14 with the probability 0.000024, which is more than the critical values at all significance levels: $F_{calc.} > 2.25(0.1)$; $F_{calc.} > > 2.87(0.05)$; $F_{calc.} > 4.43(0.01)$. Durbin Watson's statistics are very satisfactory and indicate no autocorrelation. According to the input parameters $n_1 = 21$ and $n_2 = 4$, with 95% probability, the lower and upper limits of the critical values for *DW* are $d_l = 0.927$ and $d_u = 1.812$. Since the criterion is $DW = 1.883$ and is located to the right and approaches the mark 2, which confirms the absence of autocorrelation in the regression model.

Akaike and *Schwarz* information criteria allow you to select the best results. The lowest values of these criteria help researchers in choosing the best model:

$$\text{AIC} = 2k - 2\ln(l);$$
$$\text{BIC} = -2\ln(l) + k\ln(n), \quad (3)$$

where *k* is the number of independent factors; *l* is the log-likelihood estimate; *n* – sample size.

Table 1 (Таблица 1)

Results of the augmented Dickey-Fuller test

Результаты расширенного теста Дики-Фуллера

Variables	crit.value 1%	crit.value.5%	crit.value10%	t statistic	Probability
According to original rows					
GDP	-3.831511	-3.029970	-2.655194	-1.798420	0.3698
Azeri_Light	-3.831511	-3.029970	-2.655194	-2.296535	0.1828
Brent	-3.808546	-3.020686	-2.650413	-1.679454	0.4258
West	-3.808546	-3.020686	-2.650413	-1.679454	0.4258
Mresid	-3.831511	-3.029970	-2.655194	-2.571647	0.1158
By rows with second differences					
GDP	-3.886751	-3.052169	-2.666593	-4.436996	0.0034
Azeri_Light	-4.004425	-3.098896	-2.690439	-4.032918	0.0095
Brent	-4.004425	-3.098896	-2.690439	-4.151370	0.0077
West	-3.857386	-3.040391	-2.660551	-8.843333	0.0000
Mresid	-4.004425	-3.098896	-2.690439	-5.460860	0.0008

Table 2 (Таблица 2)

Results of descriptive statistics of variables

Результаты описательной статистики переменных

	GDP	*Azeri_Light*	*Brent*	*West*	*Mresid*
Mean	*38154.56*	*52.46227*	*63.46000*	*75.53143*	*-0.000529*
Median	*42693.00*	*52.18517*	*61.51000*	*64.78000*	*756.0769*
Maximum	*75234.70*	*103.9699*	*111.6300*	*124.2300*	*16908.11*
Minimum	*5272.800*	*7.319492*	*24.45000*	*31.86000*	*-20587.48*
Std. Dev.	*23615.69*	*25.98500*	*28.84630*	*29.76424*	*9814.413*
Skewness	*-0.068729*	*0.163608*	*0.347257*	*0.451374*	*-0.146638*
Kurtosis	*1.812306*	*2.611764*	*1.966200*	*1.782927*	*2.298478*
Jarque-Bera	*1.250823*	*0.225572*	*1.357204*	*2.009194*	*0.505876*
Probability	*0.535041*	*0.893342*	*0.507326*	*0.366192*	*0.776516*
Sum	*801245.8*	*1101.708*	*1332.660*	*1586.160*	*-0.011100*
Sum Sq. Dev.	*1.12E+10*	*13504.41*	*16642.18*	*17718.20*	*1.93E+09*
Observations	*21*	*21*	*21*	*21*	*21*

The *Akaike* and *Schwartz* criteria do not always select the same model. Criteria values can be the same or different. This is due to certain specific criteria. For the model under study, the *Akaike* and *Schwartz* criteria almost coincide and have the smallest values, respectively, -9.049 and -9.041.

The regression model takes the following form:

$$GDP = 354.0227 Azeri\_light + 540.268 Brent - 105.9412 West + Mresid - 6701.798 \quad (4)$$

Table 1 shows the results of the extended *Dickey-Fuller* test for rows with original data and for rows with second data differences.

By changing the parameters, a *Dickey-Fuller* test was carried out with 2nd order differences, without a trend, with a constant, using the *Schwartz* criterion, with a maximum number of lags of 4, and results were obtained that accept the alternative hypothesis of stationarity for time series for all factors in the model, on all levels of significance.

To build a quality model, it is important that the independent variables in the model, i.e., the regressors, have a fairly wide range of change. The range of variation can be measured on the basis of the coefficient of variation, which is defined as the proportion of the ratio of standard deviations of parameters to their mathematical expectations.

The results of the descriptive statistics in Table 2 were used to analyze the variability of the model variables. All results obtained must be at least 10% to ensure variability, otherwise, if this condition is not met for any variable, then it is more appropriate to remove the variable from the model or replace it with another variable.

There is no need to replace or delete variables, since the required condition is met and the coefficients of variation for all variables have received values of more than 10% (see Table 3).

Table 3 (Таблица 3)

Variation coefficients for variables (%)

Коэффициенты вариации переменных (%)

x_i	*GDP*	*Azeri_Light*	*Brent*	*West*	*Mresid*
v_{x_i}	61.9	49.5	45.4	39.4	18.5

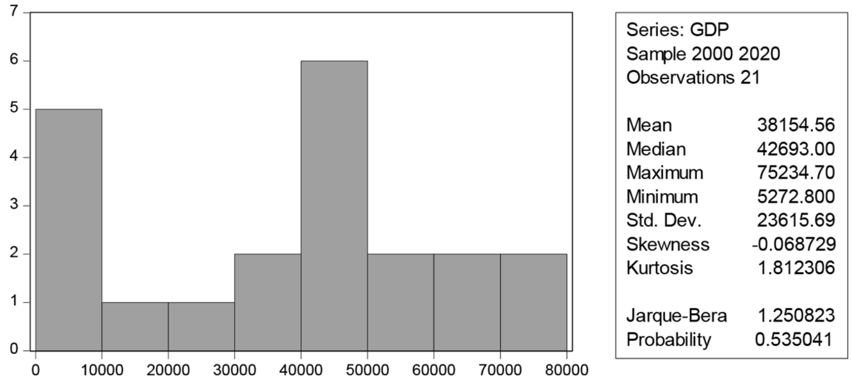

Fig. 8. Histogram of the standard distribution of residuals for the GDP time series

Рис. 8. Гистограмма стандартного распределения остатков для временного ряда ВВП

Table 4 (Таблица 4)

Correlation matrix
Корреляционная матрица

	GDP	*AZERI_ LIGHT*	*BRENT*	*WEST*	*MRESID*
GDP	1	0.83402437667324	0.86490338310344	0.51209909750483	0.41558867083991
AZERI_ LIGHT	0.8340243766732	1	0.767529430116969	0.46458612090521	-5.85995208256e-09
BRENT	0.86490338310344	0.767529430116969	1	0.70408479187499	3.5498988979e-08
WEST	0.51209909750483	0.46458612090521	0.704084791879944	1	2.49011693338e-08
MRESID	0.41558867083991	-5.85995208584e-09	3.549898892879e-08	2.4901169338e-08	1

The *Jarque-Bera* test tests observational errors for normality by checking third and fourth order central moments against the central moment of a normal distribution. This test examines the null hypothesis about the normality of the distribution, against the alternative hypothesis that does not accept the normality of the distribution of observational errors.

For *GDP*, the *Jarque-Bera* test obtained the following value: JB_{GDP} = 1.250823, with *prob.* = 0.535041 > 0.05, which confirms the normality of the distribution. The test results are presented in Table 3 and Figure 8. The null hypothesis of normal distribution is accepted. The histogram in Fig. 8 of the standard residual distributions for the *GDP* time series confirms the test results. At one level, there is a deviation from the general trend with a normal distribution, which is confirmed by the values for the skewness and kurtosis coefficients: $K_{skew.}$ = -0.068; $K_{curt.}$ = 1.812306. There is a very slight deviation of the coefficients from the values for the normal distribution: $K_{skew.}$ = 0; $K_{curt.}$ = 3, which does not interfere with the decision on the normality of the distribution for the observational errors of the *GDP* time series.

Estimates of the tightness and direction of relationships between the parameters are presented in Table 4, in the form of a correlation matrix. Correlation coefficients between factors falling within the interval (0.7; 0.9) are estimated as strong and not random. If these values fall within the interval (0.5; 0.7), then the relationship is of medium tightness, that is, noticeable. In other cases, the relationship is assessed as weak and random. The correlation between the resultant factor *GDP* and the independent factors *Azeri_light* and *Brent* is considered to be close and direct. The connection between *GDP* and *West* is also not weak and quite noticeable.

Structural residuals play an important role in a broad analysis of *VAR*, where their calculations are required, including impulse estimation, decomposition of the forecast variance.

To check the stability of the parameters included in the model over the entire sample, you can use the *Cusum* test, which, by calculating the accumulated sums of recursive residuals and the accumulated sums of squares over the residuals, builds graphs for variables. If the recursive estimates of the residuals for the model parameters go beyond the critical boundaries of the 95% confidence intervals, this indicates their instability. If the blue line does not intersect with the red ones on the graphs, then the model parameters are stable and the null hypothesis is accepted. Otherwise, the H_1 hypothesis about parameter instability is accepted.

The graphs shown in Fig. 9 show recursive and standardized estimates of residuals as a result of the *CUSUM* test. The analysis of the diagram in Fig. 9 confirms the null hypothesis about the stability of the model parameters, since the corresponding conditions are met. In other words, the recursive estimates of the residuals do not fall outside the confidence interval with 95% probability. So, recursive and standardized estimates of residuals for the residuals of the model indicate the stability, stability of the developed model.

To analyze the autoregressive model of the endogenous variable, the inverse roots of the characteristic equation of the polynomial from the shift operator are calculated, which serves to check the stationarity of the *AR* model. Using the *Roots of Characteristic Polynomial* test,

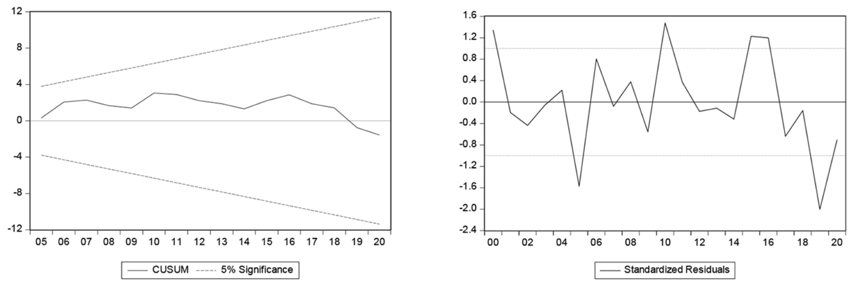

Fig. 9. Recursive and standardized residual estimates

Рис. 9. Рекурсивные и стандартизированные оценки остатков

Table 5 (Таблица 5)

The result of the test for the roots of the characteristic polynomial

Результат проверки корней характеристического полинома

Root	*Modulus*
0.645249 - 0.141177i	0.660513
0.645249 + 0.141177i	0.660513

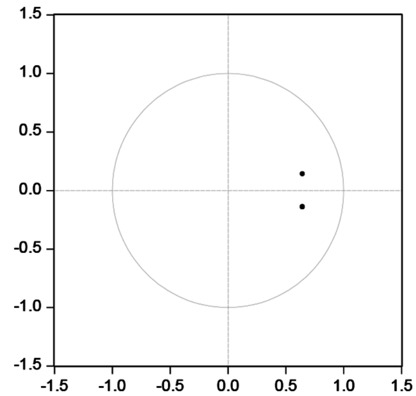

Fig. 10. Plotting unit roots for GDP

Рис. 10. Построение единичных корней для ВВП

inverse *AR* roots for *GDP* were calculated to check the state of stability.

The values of the roots in table 5 do not exceed one. Figure 10 shows a unit circle, which can also be used to determine the state of stability and stationarity of the series. It can be seen that no root lies outside the unit circle. This means that the *VAR* for *GDP* satisfies the stability condition and the considered process is assumed to be stationary.

For linear regression, it is important to check the *Ramsey* test, which determines the significance of non-linear combinations of independent variables in the model, which serves to explain the dependent variable. Using this test, you can determine the presence of variables that are not included in the model, the correlation between explanatory variables and the random component, the incorrect functional form of the dependencies between the resultant and explanatory factors, etc. These phenomena lead to a shift in the mathematical expectation of the residuals of the model.

According to the test, the null hypothesis is accepted if the *F-statistic* value is less than the critical value and the model specifications are accepted as correct. If this condition is not met, then the functional form of the model is incorrect according to the alternative hypothesis. The results of the *Ramsey* test are shown in Table 6. With input parameters $k_1 = 4$, $k_2 = 21$ (in the table of critical values for *F-statistic* for $k_2 = 22$ was used) with probabilities 0.1; 0.05; 0.01 were defined critical values for F-statistic, respectively, 2.22; 2.82; 4.31 and compared with the calculated value for *F-statistic*. Since the condition $F_{calc.} = 0.002273 < F_{crit.}$ on all probabilities, then the hypothesis about the acceptability of the functional form of the model is accepted as correct.

The *White* test is a procedure for testing the random error heteroscedasticity of a linear regression model that does not impose large restrictions on the structure of heteroscedasticity. The null hypothesis assumes that the errors of the model are homoscedastic, under which the *Gauss-Markov* conditions are satisfied. The overall significance of the auxiliary equation is checked using the χ^2 test. If $nR^2 > \chi^2_{\gamma;\kappa}$, where γ – is the significance level; k – degree of freedom, then the homoscedasticity hypothesis is rejected. The number of degrees of freedom k is equal to the number of explanatory variables of the auxiliary equation.

The results of the *White* test are shown in Table 7, where prob. $F(14,6) = 0.4384 > 0.05$. At $n = 21$ $Obs{*}R^2$ – coefficient of determination is equal to 15.45691 and it is less than the value $\chi^2_{0.34}(14) = 17.12$. The required condition for H_0 is satisfied. The corresponding p-value is greater than the significance level of 0.05 (0.34 > 0.05), i.e. the null hypothesis that the random term is homoscedastic may not be rejected. This means that the hypothesis of heteroscedasticity is rejected, and according to the *White* test, we conclude that there is no heteroscedasticity in the residuals.

Autocorrelations of residuals is the relationship between them, as a result of which their values are either overestimated or underestimated, which negatively affects the quality of the model. The *Breusch-Godfrey serial correlation LM*-test is used to test serial correlation in random errors of linear models and is based on the LM-statistic, which is equal to nR^2. Here n is the volume of observations, R^2 is the coefficient of determination of the model. If the value of the *LM* statistics exceeds the critical value of the distribution $\chi^2_{\gamma;\kappa}$, then the autocorrelation is considered significant and the null hypothesis is rejected. If the opposite condition is met, then the autocorrelation is considered insignificant.

The results of the *Breusch-Godfrey LM* test for autocorrelation are shown in Table 8. At $n = 21$, the nR^2 - determination coefficient is 0.005004 and it is less than the critical value $\chi^2_{0.99}(2) = 0.02$. p-value exceeds the significance level of 0.05 (0.9975 > 0.05), i.e. the hypothesis of the significance of autocorrelation is rejected. The serial correlation for the residuals is not significant.

As a result of the *Engle Granger* test and the *Johansen* test, it was determined that the variables are cointegrated and that there are 1 cointegrating equations at the level of 0.05, for all types of trends. Thus, it is possible to present the relations under study in the form of *VECM (vector error correction model)*, which expresses a long-term equilibrium relationship between variables [30]. At this stage of the study, in order to avoid the formation of a singular data matrix with a zero determinant, the *MRESID* variable was removed from the independent variables. Error correction equations for second-order differences for the series *GDP*, *Azeri_light*, *Brent*, *West* based on quarterly initial data were compiled to enable the implementation of the *VEC Estimates* test.

The results of the *Engle Granger* and *Johansen* test for the cointegration of time series with a lag interval from 1 to 3 showed that the best values according to the *Akaike* and *Schwartz* information criteria were -9.451096* and -9.56012*. *Trace* and *Maximum Eigenvalue* tests were carried out with the first differences of the time series variables, where the null and alternative hypotheses were tested (see Table 9). For both tests, when testing hypotheses, in cases where the calculated values of the statistics exceeded the critical values, alternative hypotheses were accepted about the presence of one cointegration equation at a significance level of 0.05. So, one cointegration relation with a 95% probability has been obtained. The results obtained indicate a long-term relationship and the

Table 6 (Таблица 6)

Results of the Ramsey test

Результаты теста Рамси

	Value	*df*	*Probability*
t-statistic	0.047672	15	0.9626
F-statistic	0.002273	(1, 15)	0.9626
Likelihood ratio	0.003181	1	0.9550

Table 7 (Таблица 7)

White's test results

Результаты теста Уайта

F-statistic	1.195072	*Prob. F(14,6)*	0.4384
*Obs*R-squared*	15.45691	*Prob. Chi-Square(14)*	0.3477

Table 8 (Таблица 8)

Results of the Broesch-Godfrey LM test

Результаты LM-теста Бройша-Годфри

F-statistic	0.001668	*Prob. F(2,14)*	0.9983
*Obs*R-squared*	0.005004	*Prob. Chi-Square(2)*	0.9975

Table 9 (Таблица 9)

Trace and Maximum Eigenvalue test results for linear deterministic trend

Результаты теста трассировки и максимального собственного значения для линейного детерминированного тренда

Hypothesis	*Alternative hypothesis*	*Trace Statistic*	*Critical Value 5%*	Probability
$H_0: r = 0$*	$H_A: r > 0$	567.1163	3.841466	0.0000

Hypothesis	*Alternative hypothesis*	*Max-Eigen Statistic*	*Critical Value 5%*	Probability
$H_0: r = 0$*	$H_A: r > 0$	567.1163	3.841466	0.0000

* means rejection of the hypothesis at the 0.05 level.

* означает отклонение гипотезы на уровне 0,05.

authenticity of the correlation between the time series of variables.

When conducting the Granger test of causation, the results showed that there are both direct and inverse relationships between variables. This makes it possible to construct error correction models both for the dependent variable and for all other variables [19].

$$\Delta(\Delta GDP)=0.026(\Delta GDP(-1)-30279.16\Delta Azeri\_light(-1)+33113.55\Delta Brent(-1)-277.54\Delta West(-1)+30603.56)-0.605\Delta(\Delta GDP(-1))-0.299375\Delta(\Delta GDP(2))+368.32\Delta(\Delta Azeri\_light(-1))+22.8\Delta(\Delta Azeri\_light(-2))-350.48\Delta(\Delta(Brent(-1))+33.07\Delta(\Delta Brent(-2))+56.18\Delta(\Delta West(-1))-33.17\Delta(\Delta West(-2)+267.83 \quad (5)$$

$$\Delta(\Delta Azeri\_light) = 0.00018(\Delta GDP(-1)-30279.16\Delta Azeri\_light(-1)+33113.55\Delta Brent(-1)-2771.54\Delta West(-1)+30603.56)-0.00102\Delta(\Delta GDP(-1))-0.00068\Delta(\Delta GDP(2))+3.26\Delta(\Delta Azeri\_light(-1))-3.3622\Delta(\Delta Azeri\_light(-2))-3.3483\Delta(\Delta Brent(-1))+3.3211\Delta(\Delta Brent(-2))+0.034\Delta(\Delta West(-1))-0.147913\Delta(\Delta West(-2))+0.77 \quad (6)$$

$$\Delta(\Delta Brent)=0.00017(\Delta GDP(-1)-30279.16\Delta Azeri\_light(-1)+33113.55\Delta Brent(-1)-2771.54\Delta West(-1)+30603.56)-0.001019\Delta(\Delta GDP(-1))-0.00072\Delta(\Delta GDP(-2))+3.55\Delta(\Delta Azeri\_light(-1))-3.25\Delta(\Delta Azeri\_light(-2))-3.37\Delta(\Delta Brent(-1))+3.24\Delta(\Delta Brent(-2))+0.054\Delta(\Delta West(-1))+0.76\Delta(\Delta West(-2))+0.76 \quad (7)$$

$$\Delta(\Delta West)=0.00022(\Delta GDP(-1)-30279.16\Delta Azeri\_light(-1)+33113.55\Delta Brent(-1)-2771.54\Delta West(-1)+30603.56)-0.0014\Delta(\Delta GDP(-1))-0.00083\Delta(\Delta GDP(-2))+3.9\Delta(\Delta Azeri\_light(-1))-2.75\Delta(\Delta Azeri\_light(-2))-3.8\Delta(\Delta Brent(-1))+2.78\Delta(\Delta Brent(-2))+0.15\Delta(\Delta West(-1))-0.23\Delta(\Delta West(-2))+0.8 \quad (8)$$

The presented vector model of error correction makes it possible to analyze and predict the dynamics of the Azerbaijani economy within the framework of world oil prices.

VAR Residual Normality Tests (test about the normal distribution of residuals) checks whether the distribution is normal. The null hypothesis for the test indicates a normal distribution of the residuals. The test results are presented in Table 10.

From the results in Table 10 it can be seen that in the distribution of residuals, the asymmetry for all components is close to zero, which means that the observed asymmetry of the residuals is insignificant, minimal. The kurtosis slightly exceeds the value of 3, that is, the peaked distribution is also insignificant. For both characteristics, the distribution can be considered normal. According to the *Jarque-Bera* test, the distribution is also normal. *JB*=36.09779, with *prob.*= 0.5327>0.05, which indicates the normal distribution of the residuals. The hypothesis of a normal distribution of model residuals was accepted.

The impulse response functions characterize the time of return of the endogenous variable to the equilibrium trajectory under a single shock of the

Table 10 (Таблица 10)

Table 10. Results of the test about the normal distribution of residuals

Таблица 10. Результаты теста на нормальное распределение остатков

Component	*Skewness*	*Chi-sq*	*degree of freedom*	*probability*
1	0.006312	0.000571	1	0.9809
2	-0.131035	0.246105	1	0.6198
3	0.102521	0.150651	1	0.6979
4	-0.607311	5.286520	1	0.0815
Joint		*5.683846*	4	0.2240
Component	*Kurtosis*	*Chi-sq*	*degree of freedom*	*probability*
1	3.898909	2.895466	1	0.0888
2	5.405499	20.73470	1	0.0855
3	3.671168	1.614169	1	0.2039
4	4.201117	5.169611	1	0.0730
Joint		30.41394	4	0.3401
Component	*Jarque-Bera*		*degree of freedom*	*probability*
1	2.896037		2	0.2350
2	20.98080		2	0.3355
3	1.764821		2	0.4138
4	10.45613		2	0.0547
Joint	36.09779		8	0.5327

exogenous variable. The response responses of the impulse function characterize the median estimate with a 90% confidence interval of the endogenous variable to the standard deviation of the exogenous variable. As a result of the evaluation of the *VECM* model, we obtained the functions of impulse responses to structural shocks. So, the graphs of the responses of the considered series built on EViews 10 for a 10-year time period are shown in Figure 11. As can be seen from the graphs of the response of impulse functions of variables to structural shocks, they cover the first 3 years of a 10-year period, with a further gradual transition to a stable period. Also, Figure 12 shows graphs for the reactions of variables to innovations, and Figure 13 shows the reactions of impulse response functions of variables individually. These charts show similar responses of impulse functions except for the responses of Brent impulse functions to shocks from *GDP*, *Azeri_light*, *West*, which cover a longer period of 4-5 years in a 10-year period. An analysis of the tabulated values of the response of impulse functions of variables to structural shocks presented in Table 11 confirms the above conclusions.

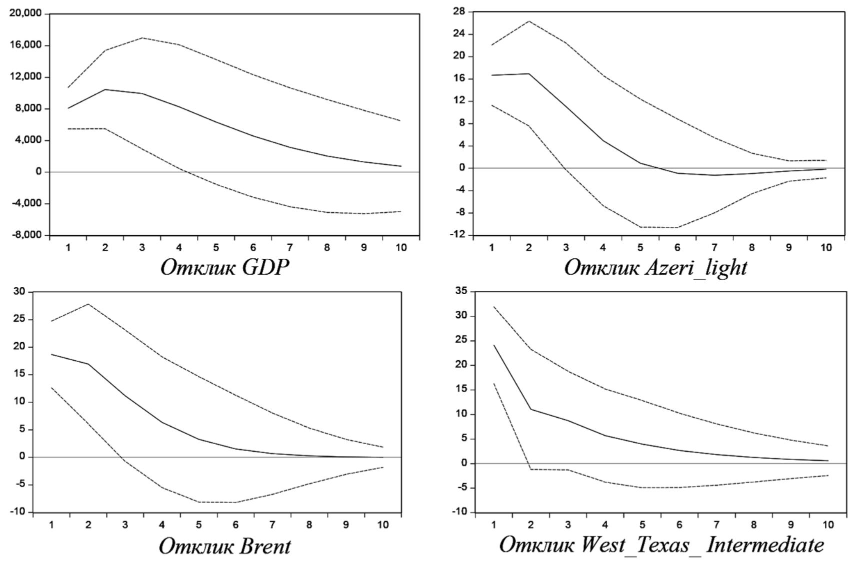

Fig. 11. Reactions of impulse response functions

Рис. 11. Реакции функций импульсного отклика

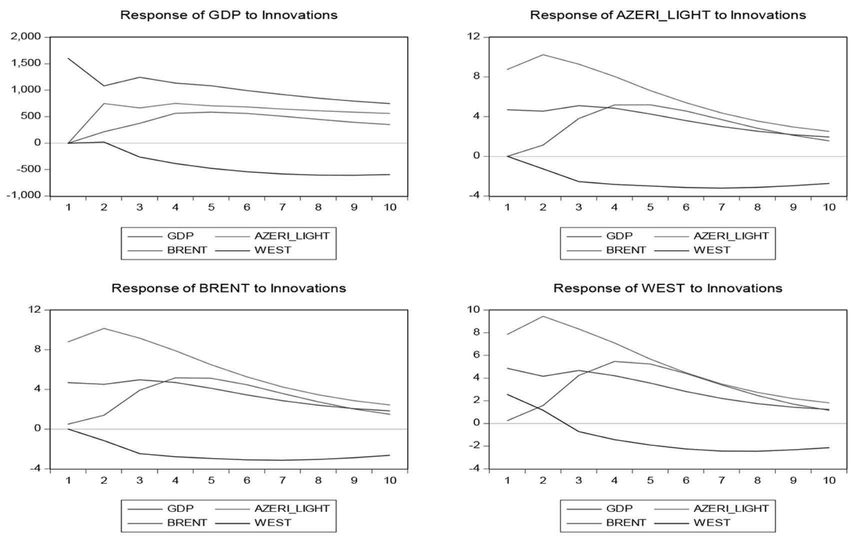

Fig. 12. Responses of variables to innovation

Рису. 12. Реакция переменных на инновации

To determine the influence of exogenous variables on the endogenous variable, the econometric method of decomposition of forecast error variances was also applied. This method determines the contribution of the change in the considered variable to its variance of forecast errors and the variance of other variables. The test was carried out for the next 10 years. The results of the verification of the relevant tests are shown in Table 12.

The results in Table 12 show that in the annual *GDP* forecast, the largest errors are in the *GDP*, *Azeri_light, Brent* and *West* shocks, respectively, at 86% in the second year, 20.3% in the tenth year, 9.8% in the ninth year and 11.08% for the tenth year; for *Azeri_light* these values are in the respective order 22.3% for the first year, 79.9% for the second year, 15.13% for the ninth year, 8.99% for the tenth year; for *Brent*, respectively, 22.1% for the first year, 79.7% for the second year, 15.4% for the ninth year and 8.86% for the tenth year; for *West*, respectively, 25.7% for the first year, 74.6% for the second year, 19.27% for the eighth year and 7.15% for the first year. The results of the analysis show that the greatest uncertainty in the forecast for *GDP, Azeri_light, Brent* and *West* is given by their own changes during the first trimester of the period under review.

Conclusions

According to the results of the study devoted to the construction of a vector model for error correction, the following conclusions can be drawn:

- The constructed model is quite adequate, demonstrates stationarity for time series for both endogenous and exogenous variables, and can be used to determine forecast values of GDP both in the short term and in the long term;

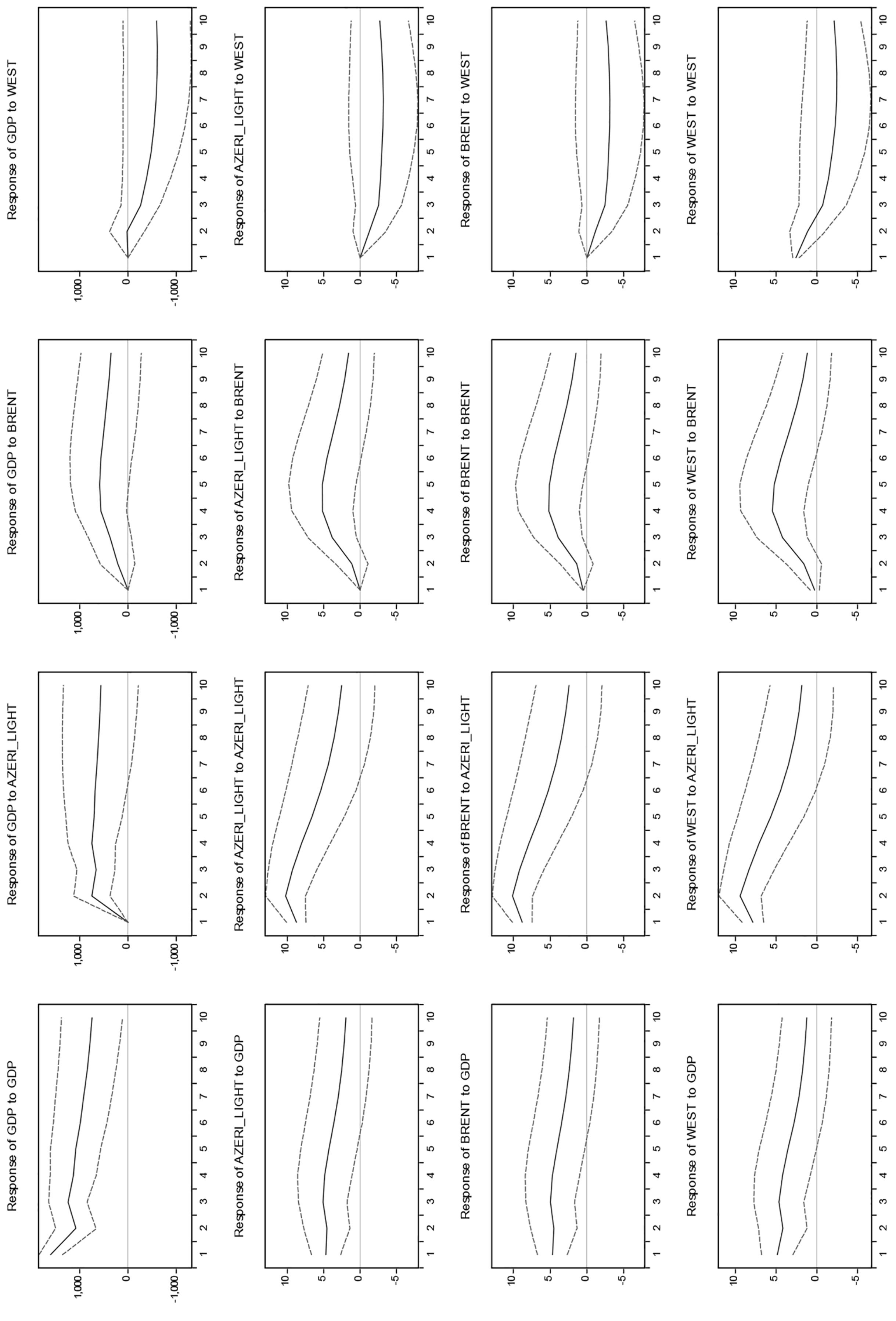

Figure 13. Responses of impulse response functions of variables individually
Рисунок 13. Реакции функций импульсного отклика переменных по отдельности

Table 11 (Таблица 11)

Response values of impulse response functions of variables in individual order. Response of GDP

Значения реакций функций импульсного отклика переменных в индивидуальном порядке. Реакция ВВП

Period	*GDP*	*Azeri_light*	*Brent*	*West*
1	1601.757	0.000000	0.000000	0.000000
2	1082.972	748.7850	215.8003	21.14351
3	1245.389	663.5198	374.7529	-263.0360
4	1135.223	751.0387	562.5039	-384.7947
5	1086.088	704.9781	585.3035	-477.8916
6	992.4868	682.4451	562.1951	-540.7227
7	919.0981	643.0173	506.0328	-583.8947
8	849.9804	612.4495	447.2353	-603.4631
9	793.6230	584.0202	393.2147	-605.5368
10	745.6509	560.4645	350.0791	-594.6483
Response of *Azeri_light*				
Period	*GDP*	*Azeri_light*	*Brent*	*West*
1	4.688542	8.759332	0.000000	0.000000
2	4.555509	10.23990	1.141442	-1.261373
3	5.118996	9.282723	3.813678	-2.540903
4	4.852163	8.041928	5.179456	-2.830709
5	4.278502	6.636689	5.188674	-2.994585
6	3.599932	5.399687	4.560590	-3.142687
7	3.007089	4.367038	3.694193	-3.199349
8	2.530941	3.565660	2.838273	-3.130662
9	2.182655	2.962164	2.114631	-2.959465
10	1.940680	2.519814	1.568056	-2.723135
Response of *Brent*				
Period	*GDP*	*Azeri_light*	*Brent*	*West*
1	4.692027	8.797974	0.507269	0.000000
2	4.508444	10.14590	1.409810	-1.157245
3	4.982358	9.165276	3.913333	-2.461722
4	4.701179	7.899264	5.174092	-2.782250
5	4.120872	6.497934	5.127036	-2.948699
6	3.450418	5.268465	4.470623	-3.089352
7	2.868926	4.248602	3.598068	-3.135857
8	2.406218	3.459594	2.748051	-3.058609
9	2.070230	2.867423	2.035928	-2.881784
10	1.838811	2.434322	1.501853	-2.643104
Response of *West*				
Period	*GDP*	*Azeri_light*	*Brent*	*West*
1	4.861297	7.856381	0.257976	2.565969
2	4.162328	9.441776	1.590181	1.155655
3	4.661874	8.328819	4.240741	-0.715871
4	4.221017	7.100060	5.466879	-1.424341
5	3.558137	5.678466	5.244684	-1.896281
6	2.816507	4.471999	4.419610	-2.251627
7	2.209924	3.483271	3.408855	-2.441646
8	1.746843	2.742530	2.469097	-2.453650
9	1.431444	2.204033	1.710193	-2.332216
10	1.231158	1.826606	1.163504	-2.129252

Table 12 (Таблица 12)

Values of decompositions of variables in individual order. Variance Decomposition of GDP

Значения декомпозиции переменных в индивидуальном порядке. Дисперсионная декомпозиция ВВП

Period	*St.error*	*GDP*	*Azeri_light*	*Brent*	*West*
1	1601.757	100.0000	0.000000	0.000000	0.000000
2	2084.742	86.01760	12.90059	1.071518	0.010286
3	2558.716	80.79156	15.28842	2.856402	1.063612
4	2977.297	74.20981	17.65506	5.679189	2.455942
5	3333.442	69.81532	18.55670	7.613505	4.014478
6	3629.193	66.37891	19.19151	8.822866	5.606719
7	3876.372	63.80521	19.57369	9.437697	7.183401
8	4085.096	61.78091	19.87228	9.696498	8.650308
9	4263.827	60.17442	20.11729	9.751095	9.957191
10	4418.879	58.87301	20.33897	9.706430	11.08159
Variance Decomposition of Azeri_light					
Period	*St.error*	*GDP*	*Azeri_light*	*Brent*	*West*
1	9.935206	22.27009	77.72991	0.000000	0.000000
2	15.07350	18.80858	79.91773	0.573428	0.700259
3	18.98905	19.11877	74.25468	4.394823	2.231727
4	21.99181	19.12223	68.73362	8.823467	3.320687
5	24.12221	19.03969	64.69859	11.96055	4.301173
6	25.58657	18.90225	61.95852	13.80769	5.331549
7	26.58324	18.79103	60.09835	14.72290	6.387718
8	27.26986	18.71807	58.81974	15.07412	7.388073
9	27.75633	18.68606	57.91494	15.13078	8.268218
10	28.11412	18.68997	57.25354	15.05919	8.997294
Variance Decomposition of Brent					
Period	*St.error*	*GDP*	*Azeri_light*	*Brent*	*West*
1	9.983826	22.08650	77.65534	0.258157	0.000000
2	15.04224	18.71278	79.70322	0.992132	0.591870
3	18.88039	18.84176	74.15670	4.925827	2.075717
4	21.80552	18.77387	68.71869	9.323254	3.184188
5	23.86770	18.65085	64.76897	12.39615	4.184029
6	25.27567	18.49438	62.09879	14.18203	5.224799
7	26.22824	18.37187	60.29398	15.05251	6.281644
8	26.88096	18.29176	59.05780	15.37548	7.274954
9	27.34125	18.25439	58.18597	15.41664	8.143000
10	27.67838	18.25378	57.55069	15.33779	8.857741
Variance Decomposition of West					
Period	*St.error*	*GDP*	*Azeri_light*	*Brent*	*West*
1	9.591959	25.68559	67.08578	0.072334	7.156295
2	14.22470	20.24156	74.56181	1.282594	3.914035
3	17.66184	20.09685	70.60288	6.597124	2.703145
4	20.29985	19.53661	65.67834	12.24650	2.538549
5	22.09280	19.08812	62.05694	15.97498	2.879957
6	23.25137	18.70059	59.72587	18.03567	3.537872
7	23.98385	18.42480	58.24275	18.97098	4.361475
8	24.45230	18.23596	57.29049	19.27068	5.202864
9	24.76258	18.11597	56.65595	19.26774	5.960337
10	24.97850	18.04708	56.21548	19.15306	6.584385

- The vector model of error corrections (5-8) developed during the study can be considered statistically significant. This justifies the positive results of a large number of hypotheses and graphical analysis tests;
- The constructed vector model of error correction makes it possible to quantify the characteristics of the studied indicators, the links between them in the short and long term, to evaluate the prospective dynamics of the indicators;
- The long-term equilibrium relationship between variables can be considered stable, since after a violation in short-term periods from shock reactions, stability is restored. The constructed models make it possible to measure both deviations from the equilibrium state and the rate of equilibrium restoration. Analysis of graphs and tabular values showed that the reactions of impulse functions of variables to structural shocks cover the first 1-3 years of a 10-year period, with a further gradual transition to a stable period;
- The method of decomposition of forecast error variances was applied to determine the influence of exogenous variables on the endogenous variable. The analysis of the results showed that the greatest uncertainty in the forecast for GDP, Azeri light, Brent and West is given by their own changes during the first trimester of the period under review;
- The results obtained can be useful for identifying real trends in Azerbaijan's GDP and determining its interdependencies with other macroeconomic variables, for determining its interdependencies with variations in energy prices based on an analysis of the dynamics of the indicators under consideration, for developing recommendations and forming directions for the long-term development of GDP.

References

1. Musa A., Salisu A.A., Abulbashar S. et al. Oil price uncertainty and real exchange rate in a global VAR framework: a note. J Econ Finan. 2022; 46: 704–712. DOI: 10.1007/s12197-022-09592-w.

2. Kim Quoc Trung N. Determinants of stock market modern development: Evidence from Vietnam. Journal of Eastern European and Central Asian Research (JEECAR). 2022; 9(6): 951-964. DOI: 10.15549/jeecar.v9i6.987.

3. Kozlova O., Noguera-Santaella J. Relative efficiency of oil price versus oil output in promoting economic growth: Is OPEC's strategy right? Empirical Economics. 2019; 57(6). DOI: 10.1007/s00181-018-1537-1.

4. Banerjee A., Dolado J.J., Galbraith J.W., Hendry D. Co-Integration, Error Correction, And the Econometric Analysis of Non-Stationary Data. The Economic Journal. 1993; 106(439). DOI: 10.1093/0198288107.001.0001.

5. Polbin A.V. Assessing the Impact of Oil Price Shocks on the Russian Economy in a Vector Error Correction Model. Voprosy ekonomiki = Questions of Economics. 2017; 10: 27-49. DOI: 10.32609/0042-8736-2017-10-27-49. (In Russ.)

6. Varshavsky L.E. Modeling the dynamics of oil prices under different modes of development of the oil market [Internet]. Prikladnaya ekonometrika = Applied econometrics. 2009; 1(13). Available from: https://cyberleninka.ru/article/n/modelirovanie-dinamiki-tseny-na-neft-pri-raznyh-rezhimah-razvitiya-rynka-nefti/ (In Russ.)

7. Zulfigarov F., Neuenkirch M. Azerbaijan and its Oil Resources: Curse or Blessing? University of Trier. Research Papers in Economics. 2019; 11(19). Available from: https://www.academia.edu/42215904/The_Impact_of_Oil_Price_Shocks_on_the_Economy_of_Azerbaijan_A_Vector_Autoregressive_Analysis.

8. Rautava J. The Role of Oil Prices and the Ral ExChange Rate in Russia's Economy. Helsinki: Bank of Finland [Internet]. Institute for Economies in Transtion Discission Paper. 2002; 3. Available from: https: nbn-resolving.de/urn:nbn:fi:bof-201408072172.

9. Melnikov R.M. Impact of oil price dynamics on the macroeconomic indicators of the Russian economy. Applied Econometrics. 2010; 1(17): 20-29.

10. Mikhailov A.Yu., Burakov D.V., Didenko V.Yu. Relationship between oil prices and macroeconomic indicators in Russia. Finansy: teoriya i praktika = Finance: Theory and Practice. 2019; 23(2): 105-116. DOI: 10.26794/2587-5671-2019-23-2-105-116. (In Russ.)

11. Ybrayev Z. Balance-of-payments-constrained growth model: an application to the Kazakhstan's economy. Eurasian Econ Rev. 2022; 12: 745–767. DOI: 10.1007/s40822-022-00217-5.

12. Hassan S.A., Zaman K. Effect of oil prices on trade balance: New insights into the cointegration relationship from Pakistan. Economic Modeling, Elsevier. 2012; 29(6): 2125-2143. DOI: 10.1016/j.econmod.2012.07.006.

13. Pilnik N.P., Shaikhutdinova M.F. Modeling the State of Russia's Balance of Payments. Ekonomika i biznes = Economics and Business. 2017; 5: 84-101. (In Russ.)

14. Orudzhev E.K., Ayyubova N.S. Empirical analysis of factors influencing the balance of payments in Azerbaijan [Internet]. Actual Problems in Economics. 2016; 181: 400-411. Available from: https://www.proquest.com/scholarly-journals/empirical-analysis-factors-affecting-balance/docview/1812274952/se-2. (In Russ.)

15. Ayyubova N.S. Econometric analysis and modeling of the dynamics of the balance of payments' development in Azerbaijan. Statistika i

Economika = Statistics and Economics. 2022; 19(2): 14-22. DOI: 10.21686/2500-3925-2022-2-14-22

16. Ayyubova N.S. On the measurement of cointegration relations between indicators of the time series of the current account of the balance of payments and GDP (on the example of the Republic of Azerbaijan). Voprosy statistiki = Questions of statistics. 2022; 29(5): 35-45. DOI: 10.34023/2313-6383-2022-29-5-35-45. (In Russ.)

17. Charles A., Chua C.L., Darne O. et al. On the pernicious effects of oil price uncertainty on US real economic activities. Empirical Economics. 2020; 59: 2689–2715. DOI: 10.1007/s00181-019-01801-6.

18. Azerbaijan Crude Oil Production [Internet]. Trading economics. Available from: https://tradingeconomics-com.translate.goog/azerbaijan/crude-oil-production?_x_tr_sl=en&_x_tr_tl=ru&_x_tr_hl=ru&_x_tr_pto=sc.

19. Breakeven Fiscal Oil Price for Azerbaijan (AZEPZPIOILBEGUSD) [Internet]. Fred-Economic data. Economic Research Resources. International Monetary Fund Available from: https://fred.stlouisfed.org/series/AZEPZPIOILBEGUSD.

20. Crude Oil Prices: Brent - Europe [Internet]. Fred-Economic data. Economic Research Resources. Available from: https://fred.stlouisfed.org/series/DCOILBRENTEU.

21. Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma [Internet]. Fred-Economic data. Economic Research Resources. Available from: https://fred.stlouisfed.org/series/DCOILWTICO#0.

22. GDP growth in Azerbaijan in the 1st half of the year amounted to 6.2%, industrial production - 2.1% [Internet]. Information agency "Finmarket". Available from: http://www.finmarket.ru/news/5762598.

23. Crude Oil Prices - 70 Year Historical Chart [Internet]. Macrotrends is the premier research platform for long-term investors. Available from: https://www.macrotrends.net/1369/crude-oil-price-history-chart.

24. Macroeconomic indicators [Internet]. Official website of the State Statistics Committee of the Republic of Azerbaijan. 2023. Available from: https://www.stat.gov.az/.

25. Macroeconomic statistics [Internet]. Official website of the Central Bank of Azerbaijan. 2023. Available from: https://www.cbar.az/page-41/macroeconomic-indicators.

26. Average annual Brent crude oil price from 1976 to 2022. Empowering people with data. [Internet]. Statista.com. 2023 Available from: https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/.

27. Dickey D.A., Fuller W.A. Distribution of Estimators for Autoregressive Time Series with a Unit Root [Internet]. Journal of the American Statistical Association. 1979; 74: 427-431. Available from: https://www.jstor.org/stable/2286348. DOI: 10.2307/2286348.

28. Granger Clive, WJ. Time Series Analysis, Cointegration, and Applications [Internet]. American Economic Review. 2004; 94(3): 421-425. DOI: 10.1257/0002828041464669. Available from: https://www.aeaweb.org/articles?id=10.1257/0002828041464669.

29. Kontorovich G.G. Lectures: Time Series Analysis [Internet]. Ekonomicheskiy zhurnal Vysshey shkoly ekonomiki = Economic Journal of the Higher School of Economics. 2003; 1(7): 79-103. Available from: https://ej.hse.ru/en/2003-7-1/26547295.html. (In Russ.)

30. Johansen S., Juselius K. Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money. Oxford Bulletin of Economics and Statistics. 1990; 52: 169-210.

Литература

1. Musa A., Salisu A.A., Abulbashar S. et al. Oil price uncertainty and real exchange rate in a global VAR framework: a note // J Econ Finan. 2022. № 46. С. 704–712. DOI: 10.1007/s12197-022-09592-w.

2. Kim Quoc Trung N. Determinants of stock market modern development: Evidence from Vietnam // Journal of Eastern European and Central Asian Research (JEECAR). 2022. № 9 (6). С. 951–964. DOI: 10.15549/jeecar.v9i6.987.

3. Kozlova O., Noguera-Santaella J. Relative efficiency of oil price versus oil output in promoting economic growth: Is OPEC's strategy right? // Empirical Economics. 2019. № 57 (6). DOI: 10.1007/s00181-018-1537-1.

4. Banerjee A., Dolado J.J., Galbraith J.W., Hendry D. Co-Integration, Error Correction, And the Econometric Analysis of Non-Stationary Data // The Economic Journal. 1993. № 106 (439). DOI: 10.1093/0198288107.001.0001.

5. Полбин А.В. Оценка влияния шоков нефтяных цен на российскую экономику в векторной модели коррекции ошибок // Вопросы экономики. 2017. № 10. С. 27–49. DOI: 10.32609/0042-8736-2017-10-27-49.

6. Варшавский Л.Е. Моделирование динамики цены на нефть при разных режимах развития рынка нефти [Электрон. ресурс] // Прикладная эконометрика. 2009. № 1(13). Режим доступа: https://cyberleninka.ru/article/n/modelirovanie-dinamiki-tseny-na-neft-pri-raznyh-rezhimah-razvitiya-rynka-nefti/.

7. Zulfigarov F., Neuenkirch M. Azerbaijan and its Oil Resources: Curse or Blessing? University of Trier // Research Papers in Economics. 2019.

№ 11(19). Режим доступа: https://www.academia.edu/42215904/The_Impact_of_Oil_Price_Shocks_on_the_Economy_of_Azerbaijan_A_Vector_Autoregressive_Analysis.

8. Rautava J. The Role of Oil Prices and the Ral ExChange Rate in Russia's Economy. Helsinki: Bank of Finland [Электрон. ресурс] // Institute for Economies in Transtion Discission Paper. 2002. № 3. Режим доступа: https: nbn-resolving.de/urn:nbn:fi:bof-201408072172.

9. Melnikov R.M. Impact of oil price dynamics on the macroeconomic indicators of the Russian economy // Applied Econometrics. 2010. № 1 (17). С. 20–29.

10. Михайлов А.Ю., Бураков Д.В., Диденко В.Ю. Взаимосвязь цен на нефть и макроэкономических показателей в России // Финансы: теория и практика. 2019. № 23(2). С. 105–116. DOI: 10.26794/2587-5671-2019-23-2-105-116.

11. Ybrayev Z. Balance-of-payments-constrained growth model: an application to the Kazakhstan's economy // Eurasian Econ Rev. 2022. № 12. С. 745–767. DOI: 10.1007/s40822-022-00217-5.

12. Hassan S.A., Zaman K. Effect of oil prices on trade balance: New insights into the cointegration relationship from Pakistan // Economic Modelling, Elsevier. 2012. № 29 (6). С. 2125–2143. DOI: 10.1016/j.econmod.2012.07.006.

13. Пильник Н.П., Шайхутдинова М.Ф. Моделирование состояния платежного баланса России // Экономика и бизнес. 2017. № 5. С. 84–101.

14. Оруджев Э.К., Айюбова Н.С. Эмпирический анализ факторов влияния на платежный баланс в Азербайджане [Электрон. ресурс] // Actual Problems in Economics. 2016. № 181. С. 400–411. Режим доступа: https://www.proquest.com/scholarly-journals/empirical-analysis-factors-affecting-balance/docview/1812274952/se-2.

15. Ayyubova N.S. Econometric analysis and modeling of the dynamics of the balance of payments' development in Azerbaijan // Statistics and Economics. 2022. № 19(2). С. 14–22. DOI: https: 10.21686/2500-3925-2022-2-14-22.

16. Айюбова Н.С. Об измерении коинтеграционных соотношений между показателями временных рядов текущего счета платежного баланса и ВВП (на примере Азербайджанской Республики) // Вопросы статистики. 2022. № 29(5). С. 35–45. DOI: 10.34023/2313-6383-2022-29-5-35-45.

17. Charles A., Chua C.L., Darné O. et al. On the pernicious effects of oil price uncertainty on US real economic activities // Empirical Economics. 2020. № 59. С. 2689–2715. DOI: 10.1007/s00181-019-01801-6.

18. Azerbaijan Crude Oil Production [Электрон. ресурс] // Trading economics. Режим доступа: https://tradingeconomics-com.translate.goog/azerbaijan/crude-oil-production?_x_tr_sl=en&_x_tr_tl=ru&_x_tr_hl=ru&_x_tr_pto=sc.

19. Breakeven Fiscal Oil Price for Azerbaijan (AZEPZPIOILBEGUSD) [Электрон. ресурс] // Fred-Economic data. Economic Research Resources. International Monetary Fund Режим доступа: https://fred.stlouisfed.org/series/AZEPZPIOILBEGUSD.

20. Crude Oil Prices: Brent – Europe [Электрон. ресурс] // Fred-Economic data. Economic Research Resources. Режим доступа: https://fred.stlouisfed.org/series/DCOILBRENTEU.

21. Crude Oil Prices: West Texas Intermediate (WTI) – Cushing, Oklahoma [Электрон. ресурс] // Fred-Economic data. Economic Research Reseurces. Режим доступа: https://fred.stlouisfed.org/series/DCOILWTICO#0.

22. GDP growth in Azerbaijan in the 1st half of the year amounted to 6.2%, industrial production – 2.1% [Электрон. ресурс] // Information agency «Finmarket». Режим доступа: http://www.finmarket.ru/news/5762598.

23. Crude Oil Prices – 70 Year Historical Chart [Электрон. ресурс] // Macrotrends is the premier research platform for long-term investors. Режим доступа: https://www.macrotrends.net/1369/crude-oil-price-history-chart.

24. Macroeconomic indicators [Электрон. ресурс] // Official website of the State Statistics Committee of the Republic of Azerbaijan. 2023. Режим доступа: https://www.stat.gov.az/.

25. Macroeconomic statistics [Электрон. ресурс] // Official website of the Central Bank of Azerbaijan. 2023. Режим доступа: https://www.cbar.az/page-41/macroeconomic-indicators.

26. Average annual Brent crude oil price from 1976 to 2022. Empowering people with data. [Электрон. ресурс] // Сайт statista.com. 2023. Режим доступа: https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/.

27. Dickey D.A., Fuller W.A. Distribution of Estimators for Autoregressive Time Series with a Unit Root [Электрон. ресурс] // Journal of the American Statistical Association. 1979. № 74. С. 427–431. Режим доступа: https://www.jstor.org/stable/2286348. DOI: 10.2307/2286348.

28. Granger Clive, WJ. Time Series Analysis, Cointegration, and Applications [Электрон. ресурс] // American Economic Review. 2004. № 94 (3). С. 421-425. DOI: 10.1257/0002828041464669. Режим доступа: https://www.aeaweb.org/articles?id=10.1257/0002828041464669.

29. Конторович Г.Г. Лекции: Анализ временных рядов [Электрон. ресурс] // Экономический журнал Высшей школы экономики. 2003. №. 1(7). С. 79–103. Режим доступа: https://ej.hse.ru/en/2003-7-1/26547295.html.

30. Johansen S., Juselius K. Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money // Oxford Bulletin of Economics and Statistics. 1990. № 52. С. 169–210.

Сведения об авторе

Айюбова Натаван Солтан
К.э.н., доцент Бакинский Государственный Университет, Факультет Математической Экономики, Баку, Азербайджан
Эл. почта: nayyubova50@gmail.com

Information about the author

Ayyubova Natavan Soltan
Cand. Sci. (Economics), Associate Professor Baku State University, Department of Mathematical Economics, Baku, Azerbaijan
E-mail: nayyubova50@gmail.com