Orudzhev, E., & Alizade, A. (2021). Cointegration analysis of the impact of Azerbaijan and Ukraine GDPs on the trade turnover between these countries. *Journal of International Studies, 14*(3), 274-290. doi:10.14254/2071-8330.2021/14-3/18

Journal of International Studies



*Scientific Papers*

# Cointegration analysis of the impact of Azerbaijan and Ukraine GDPs on the trade turnover between these countries

**Elshar Orudzhev**
*Department of Mathematical Economy,*
*Baku State University (BSU),*
*Azerbaijan*
*elsharorucov63@mail.ru*
*ORCID 0000-0002-6985-1407*

**Arzu Alizade**
*Department of World Economy,*
*Baku State University (BSU),*
*Azerbaijan*
*arzu.alizade.98@mail.ru*
*ORCID 0000-0002-0237-356X*

**Abstract**. This article studies the integration processes between Azerbaijan and Ukraine by using the indicators of the integratedness of the GDPs of these countries and of the trade turnover between them. The annual data from 1994 to 2018 are studied as the period of monitoring. All the studied time series are non-stationary, and in passing to the time series of differences, they retain only the information corresponding to short-term changes in their dynamics; while information about long-term changes in the process, contained in those levels of variables that are lost in the transition to differences, is lost. Therefore, problems of correct modelling of the corresponding time series, of which components lead to departure from stationarity, arise. The article uses the econometric methodology of the gravity modelling of the correlation between non-stationary time series. In the modelling, econometric methods, all the necessary step-by-step statistical procedures to determine the order of integratedness of the non-stationary time series, to identify the assessment of the parameters of the model and to check its adequacy and the accuracy of short-term and long-term predicted values are correctly used by applying Excel tools and the Eviews package. The departure of empirical tests from the trend is analyzed. The constructed dynamic analogue of the gravity model enables to qualitatively predict the status of integration of the foreign trade of the studied two countries. Based on the constructed model, econometrically sound recommendations that enable a dynamic analysis of effective regulation of the export and import transactions

**Received:**
August, 2020
**1st Revision:**
February, 2021
**Accepted:**
September, 2021

DOI:
10.14254/2071-8330.2021/14-3/18

between these countries by the governments to balance the mutual trade have been developed.

**Keywords:** cointegration, analogue of the gravity model, error correction mechanism, Johansen tests, dispersion decomposition, impulse response function, GDP, trade turnover, Ukraine, Azerbaijan

**JEL Classification:** C000, C010, C020, C100, C530, C590

## 1. INTRODUCTION

The article is dedicated to the research of trade cointegratedness processes of foreign economic activity between Azerbaijan and Ukraine. By cointegratedness processes here we mean that the corresponding realizations of the non-stationary time series of the integratedness indicators of these countries are cointegrated up to a certain order of differences (Verbeek, 2012). For the assessment of integration processes criteria for the integratedness of trade markets, the scale of cross-border flows of goods, services, capital, etc. are widely used. If there is a convergence of indicators in a promising time period, then we can assume that the integratedness processes are effective. The problem of developing trade and economic integration of Azerbaijan with Ukraine doesn't lose its relevance thus far. There is a huge unused potential for the comprehensive development of Ukrainian-Azerbaijani trade and economic relations. Despite the fact that over the past two years, the trade turnover between these countries has had positive trends, the absolute figures are unsatisfactory based on the potential of mutual trade. It should be noted that Ukraine is one of the main partners of Azerbaijan. It ranks second in the total trade in the post-soviet area, after Russia. In 2015, in terms of the volume of trade in goods and services with Ukraine, Azerbaijan ranked fifth among the CIS countries, after Russia, Belarus, Kazakhstan and Moldova. In connection with the deterioration of Russian-Ukrainian relations and the difficult geopolitical in the Donbass region, after a threefold decrease in the volume of trade between Ukraine and Azerbaijan in 2014-2016, from 979 million USD to 321 million USD, in 2018 already this turnover increased to approximately 360 million USD. The decrease in commodity turnover is primarily due to the fact that in the Donbass, the industrial center of Ukraine, which traditionally supplied metal products to Azerbaijan, due to the ongoing military conflicts the factories worked intermittently. Another reason is a number of restrictions imposed by Russia on the transit of Ukrainian products through its territory after Ukraine ratified the agreement on the free trade zones with the EU. We should state that trade in goods between Azerbaijan and Ukraine in 2010 amounted to about 1 billion USD. Until 2010, the trade balance in bilateral relations was invariably in favor of Ukraine. It is necessary to return the lost indicators at an accelerated pace, and then bring the trade cooperation to a new level. From the statistical data, it turns out that if Azerbaijan's foreign trade turnover with Ukraine was only 350 mln USD in 2006 (with a specific weight of 3.1%), then this figure was 1 billion 354 mln USD in 2010 (with a specific weight of 4.8%). The specific weight of Ukraine in the import of Azerbaijan was 6% in 2006. The amount of goods imported from Ukraine in monetary terms increased from 317.5 mln USD to 465.6 mln USD in 2006, with a specific weight of 7.1% in 2010. The specific weight of Ukraine in the export of the republic of Azerbaijan was only 0.6% in 2006. Due to the expansion of cooperation, in 2010 the export of Azerbaijan to Ukraine with a specific weight of 4.2% took the first place among the CIS republics. It is necessary to return the lost indicators at an accelerated pace, and then bring trade cooperation to a new level. Today Azerbaijan's export to Ukraine is largely formed by the energy carriers.

The export of crude oil from Azerbaijan to Ukraine is mainly supplier to the Kremenchug refinery. In addition to crude oil, Azerbaijan also supplies aviation kerosene, motor oils, some types of diesel fuel, petroleum coke, refrigeration compressors, etc. To Ukraine. In addition, fruits and vegetables, juices, canned food, soft drinks, etc. are imported from Azerbaijan to Ukraine. At the same time, Ukraine supplies to Azerbaijan metals and metal products, electric machines, meat, dairy and confectionery products, drinks, etc. In the structure of Ukrainian exports to Azerbaijan, the share of ferrous metallurgy and other non-precious metals is significant. These supplies were mainly from the Ilyich Iron and Steel Works of Mariupol, ArcelorMittal Kryvyi Rih and from the factories operating mainly in Donetsk and Luhansk regions. It is necessary to diversify trade and economic relations between these countries in all the spheres of the economy, including tourism, international transport and logistics activities, one of the priority areas of which is the projects of the east-west and north-south transport corridors as well as the Odessa-Brody project which opens up new opportunities for the development of Ukrainian economy. It is important to further strengthen the trade, economic and investment components of the bilateral cooperation, in particular, through practical implementation of investment projects in Ukraine with the participation of Azerbaijani business and vice versa. It is also necessary to provide more favorable trade regimes to each other (revision of transport and customs tariffs) in the context of the global shocks associated with the coronavirus (COVID-19), and closer inter-country economic cooperation in the non-oil sector. The possibilities of mutual complementary cooperation in the aviation and space spheres should also be considered, taking into account the course of Azerbaijan towards the development of these areas and the scientific potential available in Ukraine.

To assess the prospects for expanding mutually beneficial factors in trade, economic, fuel and energy and transport spheres, a highly relevant task is to conduct an econometric co-integration analysis of the mutual influence of the corresponding aggregated indicators of foreign trade of the two strategic partners.

Here, the studied integration processes between Azerbaijan and Ukraine are considered by using the indicators of Azerbaijan's GDP and the trade turnover of this country with Ukraine. These indicators are the most significant variables for analyzing the dynamics of mutual trade turnover in the environment of inter-country cooperation and for assessing the impact of the mutual trade on their inclusive growth. The nominal data with the unit of measurement in thousands USD was used while the monitored period is from 1994 to 2018. The major data sources have been the Statistical Committee of the Republic of Azerbaijan and the World Bank (www.stat.gov.az; www.worldbank.com).

## 2. ANALYSIS OF RECENT PUBLICATIONS.

In recent years, a number of articles have been published devoted to the study of integration processes in the Common Free Market Zone (Russia, Belarus and Kazakhstan), in the EAEU, between individual and groups of post-Soviet countries, taking into account their regional characteristics in the process of the transformation of the economies (Andronova, 2012; Pylin, 2015; Orudzhev & Huseynova, 2019; Orudzhev & Huseynova, 2020). In these articles, as a result of the study of indicators of mutual trade by methods of comprehensive economic and statistical analysis, trends in the development of trade and economic cooperation of the studied countries are brought to light, and the main directions for improving the integrated economic processes are identified. In particular, in (Orudzhev & Huseynova, 2019) the cointegration ratios of the mutual influences of Azerbaijan's GDP and the balance of export-import operations of Russia and Belarus are found. Due to the heterogeneity of the time series in (Orudzhev & Huseynova, 2019), the predicted errors of the trend regression models turned out to be high. The cointegration analysis of Azerbaijan's trade relations with the main members of the EAEU is studied in (Orudzhev & Huseynova, 2020). As a result of the obtained quantitative estimates of the dispersion of the GDP aggregate of Azerbaijan's economic development, the positive impact on economic growth of the foreign trade with these countries, which are characterized by regional disproportions in economic development, is determined. And in Article (Golovan, 2012), the dynamics of the structure of Ukraine's foreign trade from 2005 to 2011 is analyzed. It establishes relationship between the geographical structure of the foreign trade both with external debt and the unfavorable commodity structure of Ukraine's foreign trade. Studies (Kharlamova & Vertelieva, 2013) are devoted to the statistical analysis of the international competitiveness of Ukraine and 29 states (the analysis doesn't include Azerbaijan) based on data from 2004 to 2013. Clusters of countries are identified by the level of their relative national competitiveness. Article (Chebotareva & Fayzulina, 2016) provides a description of the main trends in the development of Ukraine's foreign trade, the geographical structure of exports and imports of goods, and a correlation analysis of the impact of exports and imports on the formation of Ukraine's GDP. It is stated that the main partner, both in import and export, for many years has been Russia, the economic and political relations with which are currently going through hard times. Trade wars, conflicts in the east of Ukraine forced the participants of the foreign economic activities, both Ukraine and Russia, to look for trading partners in other countries. The authors of Article (Moroz et al., 2017) studied the current state and prospects of the trade relations between Ukraine and the Visegrad countries. Corresponding econometric models of trade flows between Ukraine and these countries are built. In (Frolov & Savytska, 2016), the cause and effect relationships between the components of the region's foreign trade turnover and indicators that characterize the economic situation of the region, the country and the world are studied. The export of the Sumy region is analyzed as an example. In Article (Kalyuzhna, 2020) a retrospective analysis of Ukraine's foreign trade in goods in the context of deepening interstate economic contradictions is carried out. An empirical analysis of the absolute indicators (the volume of the trade turnover in general and with individual groups of countries) and relative indicators (the share of trade with individual groups of countries in the overall structure of the trade turnover) of Ukraine's foreign trade in goods with the countries of the European Union and the CIS is carried out. This work doesn't study the trade in goods with Azerbaijan. And in Article (Orudzhev & Alizade, 2020) using the posteriori approach, in case the total number of factors influencing Azerbaijan's GDP is significant, an econometric analysis is carried out from a variety of insignificant factors. Here, the cause and effect relationship with only one element of this set (with the trade turnover of Ukraine) is studied. Estimates of the parameters of the econometric model are found, after which, using the error correction model, qualitative dynamic statistical characteristics are determined. It is also possible to build a similar model for Ukraine's GDP in the context of the trade turnover with Azerbaijan and compare the corresponding model options for the entire range of characteristics of their quality for the purposes of forecasting. Using the reverse transformation, we can state that the quantitative correlations found in (Orudzhev & Alizade, 2020) make it possible to build a dynamic model of long-term relationship and predict the performance of the main factors. In this case, exports and imports depend on the aggregate macroeconomic indicators of both countries, primarily on the size of their economies, which are traditionally characterized by the gross domestic product, gross capital formation, imports and exports, and possible dependence on some other factors.

## 3. METHODOLOGY

The article uses an econometric methodology for studying the statistical relationship between multidimensional non-stationary time series, including Engle – Granger and Johansen cointegration tests, research of Granger causality, responses to shock (Hall, 1992). Based on the vector error correction model (VECM), and performing decomposition of the residual variance of forecast errors. For the theoretical analysis of modeling calculations, we used the methods of multivariate statistical analysis (Verbeek,2012), necessary for constructing multidimensional data models (multivariate analysis of dispersion, multivariate correlation and regression analysis, statistical hypotheses in the analysis of multivariate data), fourdimensional vector models of auto-regression and co-integration in these models, approaches of modern economic and mathematical modeling (Verbeek, 2012), and application packages Excel (Kenneth & Carey, 2010) and EViews (Johnson, 2015).

## 4. THE MAIN RESULTS OF THE RESEARCH

In this article, the forecast of the relationship between the integratedness indicators of the GDP of Azerbaijan and Ukraine and trade turnover between these countries is carried out by the method of logarithmic approximation of the actual data with subsequent extrapolation. In this case, the multiplicative-power relation is considered as the initial dependence:

$$y_t = \alpha_0\, x_{t1}^{\alpha_1} x_{t2}^{\alpha_2} d^{\alpha_3}, t = \underline{1,25}. \tag{1}$$

Models of the dependence of the trade turnover $y_t$ between Azerbaijan and Ukraine on the factor $x_{t1}$, representing the GDP of Azerbaijan and the factor $x_{t2}$, representing the GDP of Ukraine, with a random term $\varepsilon_t$, which includes the total influence of all factors not accounted for in the model, measurement errors and geographic distance *d* (in thousand kilometers) between Baku and Kiev. $\alpha_0$- free member, $\alpha_1, \alpha_2, \alpha_3$- constant number in this formula. Here the main factorial elements are combined by the multiplication operation.It's assumed that, $\alpha_1 > 0, \alpha_2 > 0, \alpha_3 < 0$.

Marks of constant values correspond to the assumptions about the directions of influence of GDP and distance on the trade flow of the gravity model (Tinbergen, 1962), which is based on the assumption that the volume of trade in goods between two countries is directly proportional to the capacity of their markets and inversely proportional to the barriers between them. At the same time, the capacity of markets is determined by the size of the GDP of trading partners, and the impact of barriers is approximated by the geographical distance between countries.

As a direct proportionality, we can use the population size, area of countries, GDP per capita. However, here, as factors influencing the trade turnover between Ukraine and Azerbaijan, the main macroeconomic indicators GDP and the size of the economies of these countries are selected. But the results obtained in this work are transferred to the case including these factors in the model without significant changes. Various modifications of the gravity model for a certain type of product between two or more countries are constructed in (Dankevych, Pyvovar & Dankevych, 2020)

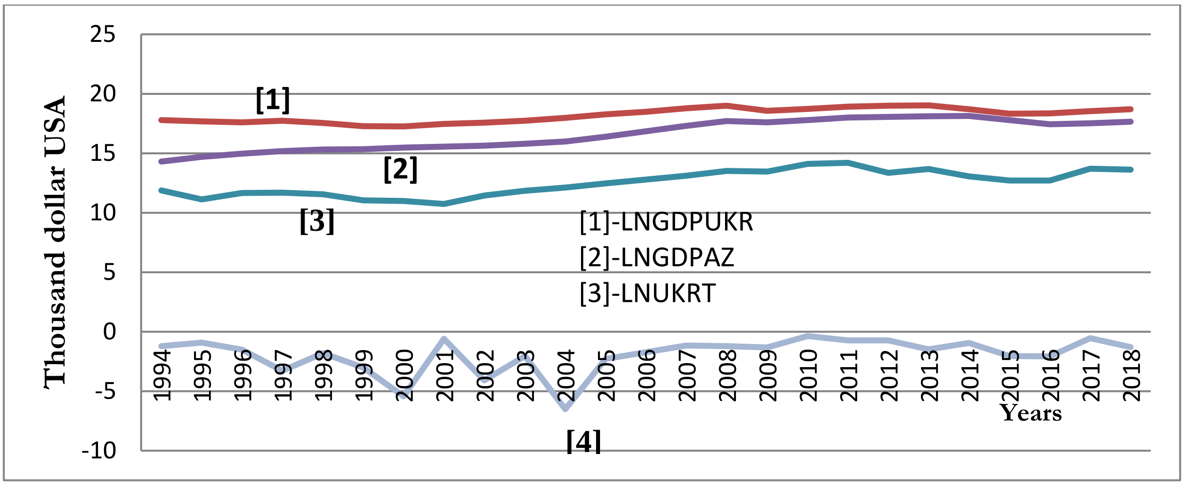
It should also be noted that the specifications of models of foreign trade flows for sea, rail, road and pipeline transportation are evaluated separately. The structure of transportation costs can include other components, including the costs for coping with administrative barriers (customs procedures), membership in currency and trade unions, and exchange rate volatility. We only study the above mentioned dependence in this work.

The regression equation is linear with respect to the logarithms of the original variables, the model is double logarithmic.

The power exponents of the factors of the model of this paper are estimates of the partial elasticity of the effective factor with respect to causal factors.

The studied time series will be transformed into logarithmic ones. This transformation makes it possible to more clearly represent the relationship between the indicators under consideration. The first differences of the logarithms are an approximation of the growth rates of the corresponding variables.

Dynamic data descriptions from (www.stat.gov.az; www.worldbank.com) and descriptive statistics on the logarithms of variables are shown in Graph 1 and Table 1:




**Graph 1. Dynamic descriptions of data**

*Source*: The results of procedures realized in MS EXCEL 2010 software package insert /Charts group/Line with Markers

Table 1

Descriptive statistics on the logarithms of variables

| | LNUKRT | LNGDPAZ | LNGDPUKR | LNRESIDS |
|---|---|---|---|---|
| Mean | 12.50237 | 16.58730 | 18.20031 | -1.928520 |
| Median | 12.71052 | 16.85922 | 18.32671 | -1.480693 |
| Maximum | 14.19880 | 18.13612 | 19.02669 | -0.362492 |
| Minimum | 10.74011 | 14.30366 | 17.25791 | -6.508979 |
| Std. Dev. | 1.057384 | 1.261864 | 0.590442 | 1.513119 |
| Skewness | -0.060990 | -0.238608 | -0.121725 | -1.674268 |
| Kurtosis | 1.725032 | 1.529524 | 1.570301 | 5.268172 |
| Jarque-Bera | 1.708773 | 2.489621 | 2.190944 | 17.03886 |
| Probability | 0.425544 | 0.287995 | 0.334382 | 0.000200 |
| Sum | 312.5592 | 414.6826 | 455.0076 | -48.21301 |
| Sum Sq. Dev. | 26.83344 | 38.21520 | 8.366930 | 54.94867 |
| Observations | 25 | 25 | 25 | 25 |

*Source*: The results of procedures realized in EViews 8 software package As Group/View/Descriptive statistics/Common sample

Graph 1 visually comparing the dynamics of the logarithms of the studied variables over the considered period. It can show no sharp structural shifts in either the constant or trend of the equation.

From table 1, it appears that the elements of the 2nd, 3rd, 4th columns have a slight left-sided asymmetric of the empirical curves relative to the theoretical; for the element of the 5th column, the vertex is shifted to the left significantly. Kurtosis for elements of the 2nd, 3rd, 4th columns appears that observe a slight peaking of the empirical curve; for the 5th column, elements of this value increase approximately three times, which leads to a significant deviation of the empirical distribution of residuals from the normal one.

On the assumption of comparative analysis with the results of work (Orudzhev & Alizade, 2020), Graph 1 and Table 1, it can be assumed that the dependence of the logarithm of Azerbaijan's foreign trade turnover with Ukraine on the logarithms of GDP of these countries are described by the following linear regression model.

$$lny_t = \alpha_{00} + \alpha_1 lnx_{t1} + \alpha_2 lnx_{t2} + ln\varepsilon_t, t = \underline{1,25} \quad (2)$$

$y_t$,$y_t, x_{1t}, x_{2t}, x_{3t}$ $x_{t1}, x_{t2}$-relevant factors, $\alpha_{00} = ln\alpha_0 + \alpha_3 lnd$, $\alpha_1$, $\alpha_2\alpha_0, \alpha_1, \alpha_2, \alpha_3$-unknown model parameters; $\varepsilon$ – a random member, that includes the total influence of all factors unaccounted for in the model, measurement errors.

For definiteness d=2,233 thousand km, $\alpha_3 = -2$. Transformation (1) into (2) leads to the transformation of random deviations $\varepsilon_t$ into $ln\varepsilon_t$. The use of the least squares method (LSM) in (2) to find parameter estimates requires the deviations $\nu_t = ln\varepsilon_t$ to satisfy the LSM assumptions: $\nu_t \sim N(0, \sigma^2)$, i.e. $\nu_t$ must obey normal distribution with zero mathematical expectation and finite variance $\sigma^2$. This is possible only in the case of a logarithmic normal distribution of random variable $\varepsilon_t$ with a mathematical expectation.

$$M(\varepsilon_t) = e^{\frac{\sigma^2}{2}} \text{ and dispersion } D(\varepsilon_t) = e^{\sigma^2}(e^{\sigma^2} - 1).$$

The Multiple Regression Model estimated by the Least Squares method, built by using the Eviews package, is presented in Table 2.

Table 2

Estimated multiple regression model with logarithms of variables

| | | | | |
|---|---|---|---|---|
| Dependent Variable: LNUKRT | | | | |
| Method: Least Squares | | | | |
| Date:14.07.20 Time: 15:17 | | | | |
| Sample:1994 – 2018<br>Included observations: 25 | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| LNGDPAZ | 0.139474 | 0.135355 | 1.030433 | 0.3145 |
| LNGDPUKR | 1.413870 | 0.308301 | 4.586001 | 0.0002 |
| LNRESİDS | 0.011772 | 0.055296 | 0.212883 | 0.8335 |
| C | -15.52129 | 3.799718 | -4.084854 | 0.0005 |
| R-squared | 0.904768 | Mean dependent var | | 12.50237 |
| Adjusted R-squared | 0.891163 | S.D. dependent var | | 1.057384 |
| S.E. of regression | 0.348835 | Akaike info criterion | | 0.877210 |
| Sum squared resid | 2.555401 | Schwarz criterion | | 1.072230 |
| Log likelihood | -6.965128 | Hannan-Quinn criter. | | 0.931301 |
| F-statistic | 66.50474 | Durbin-Watson stat | | 1.530174 |
| Prob(F-statistic) | 0.000000 | | | |

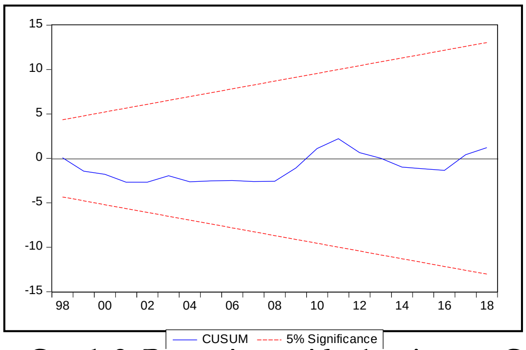
*Source*: The results of procedures realized in EViews 8 software package
Open/ As Equation / Estimate Equation Method LS – Least Squares (NLS and ARMA)

and has the following formal form:

LNUKRT = 0.13947443961*LNGDPAZ+ 1.4138696781*LNGDPUKR +
0.011771574448*LNRESİDS - 15.5212948644 (3)

The estimates obtained confirm the theoretical assumptions regarding the signs of the coefficients for the GDP variables of both states. In accordance with the hypothesis Put forward,the coefficient for direct transportation costs turned out to be negative, i.e. The power of d, which we have taken equal to -2. As shown from the results obtained in Table 2, for the general formal model is the most accurate, the coefficient of determination turned out to be high 90%.

Let's review other predictive characteristics of the model based on CUSUM tests. These tests are based on calculating the accumulated sums of recursive residuals and accumulated sums of squares of recursive residuals and evaluating the corresponding equations. The test results are diagrams of the dynamics of these values and 95% confidence intervals for them. If the recursive estimates of the residuals go beyond the critical boundaries, then this indicates the instability of the model parameters. Test results for model (3) are described in Graph 2 and 3. The location of the blue line between the red lines in Graph 2 means that the hypothesis $H_0$- about the stability of the parameters is accepted, and if the blue line intersects with the red ones, then the hypothesis $H_0$_is rejected in favor of the alternative hypothesis, $H_a$ - about the instability of the parameters relative to the length of the time interval. Graph 3 shows that recursive estimates of residuals (CUSUM) and squares of recursive estimates of residuals (CUSUM of Squares) do not go beyond 95% confidence intervals, which once again confirms the high predictive capabilities of the developed model (3). Thus, the prognostic tests carried out showed that model (3) is stable, correctly specified, and has stable prognostic characteristics.





**Graph 2. Recursive residual estimates Graph 3. Standardized residual estimates**

*Source*: The results of procedures realized Source: The results of procedures realized in EViews 8 software package in EViews 8 software package View /Stability diagnostics/Recursive View/Actual, Fitted, Residual /Standardized Estimates (OLS test)/CUSUM test residuals

Let us pay attention to the correlation coefficients between the factors represented by the correlation matrix of Table 3:

Table 3

Correlation matrix

| | LNUKRT | LNGDPAZ | LNGDPUKR |
|---|---|---|---|
| LNUKR T | 1.000000 | 0.887882 | 0.948657 |
| LNGDPAZ | 0.887882 | 1.000000 | 0.905568 |
| LNGDPUKR | 0.948657 | 0.905568 | 1.000000 |

*Source*: The results of procedures realized in EViews 8 software package
As Group/View / Covariance analyses/Correlation

A qualitative assessment of the tightness of the relationship between factors is revealed on the Chaddock scale. Based on this scale, if the value of an element of this matrix is between 0.5 and 0.7, then the tightness of the relationship between the corresponding factors is considered noticeable, and if the value of the element is in the range (0.7; 0.9), then the tightness of the relationship of the respective pairs is accepted as high.

To check the significance of the constructed model (3), the observed and critical values of the Fisher criterion are calculated. These values are respectively equal to 66.5 and 3.44 at the significance level of 5% and degrees of freedom $k_1 = 2, k_2 = 22к_2 = 21$. Due to the fact 66.5 >3.44, the model according to this criterion is considered significant. Estimation of coefficients for LNGDPAZ and LNRESIDS according to t-statistics at a significance level of 0.05 can be considered insignificant.

The autocorrelation was verified by using Darbin-Watson d-statistics. From the table of critical values of d-statistics for the number of observations 25, the number of explanatory variables 2 and the given significance level of 0.05, the values of $d_{low} = 1{,}21$ и $d_{up} = 1{,}55$, which divide interval [0,4] into five areas, found the observed value $d_{obser} = 1{,}53$. $d_{набл} = 1{,}08$. As $1{,}21 < d_{obser}$ =1,53< 1,55. The observed value has an uncertainty value, nothing can be said about the presence of autocorrelations using the Durbin-Watson test.

Now we consider the problem of the presence of heteroscedasticity. Heteroscedasticity leads to the fact that estimates of the regression coefficients aren't effective, and variances of the distributions of the coefficient estimates increase. The heteroscedasticity of the residuals was verified by White test and the results are presented in Table 4.

The value $nR^2 = Obs * R - squared$,where $n = 25, R^2$- the coefficient of determination for the auxiliary regression of the squares of residuals for all repressors, their squares, pair wise products and a constant, equal 5.563891, and this value almost coincides with the $\chi^2_{0,35}(5)$ =5,563807. The corresponding P-value is greater than 0.05, i.e. the null hypothesis about the homoscedasticity of the random term needn't be rejected.

Table 4

Results of White test for heteroscedasticity

| | | | |
|---|---|---|---|
| F-statistics | 1.087810 | Probability F (5,19) | 0.3988 |
| Obs* determination coefficient | 5.563891 | Prob. Chi-Square (5) | 0.3510 |

*Source*: The results of procedures realized in EViews 8 software package
View /Residual diagnostics/Hetroskedasticity test/White test

The stationarity of the time series of the modeling variables was verified by using the advanced Dickey-Fuller Test. Testing results showed that the initial series and their first differences aren't stationary, and second-order difference operators are stationary. The test results are provided in Table 5.

Table 5

Result of dickey-fuller test

| Variables | Statistic Criteria | Critical value 1% | Critical value 5% | Critical value 10% | Prob. |
|---|---|---|---|---|---|
| Second differences | | | | | |
| LNUKRT | -8.159048 | -4.440739 | -3.632896 | -3.254671 | 0.0000 |
| LNGDPUKR | -5.371924 | -4.440739 | -3.632896 | -3.254671 | 0.0014 |
| LNGDPAZ | -4.615559 | -4.440739 | -3.632896 | -3.254671 | 0.0070 |
| LNRESIDS | -4.881168 | -4.532598 | -3.673616 | -3.277364 | 0.0051 |

*Source*: The results of procedures realized in EViews 8 software package View /Unit root test/Augmented Dickey – Fuller/2nd difference/Intercept and trend, m=1,2,3,4,5 lags

The verification of the causal relationships between the factors for lag values m = 1, 2, 3, 4 was carried out through the Granger Test. The Granger Causality Test, with the exception of one directions, confirmed the presence of a two-way causal relationship, which indicates the existence of a third variable, which is the real cause of the change in the two considered variables. Only for lag m = 4, the causal relationships between ΔLNGDPAZ and ΔLNUKRT is opposite. Here, Δ denotes the difference operator of the corresponding variable.

Previously we have created a formal model with a trend component. The coefficient of determination approximately coincides with this coefficient of the model (1). However, other statistics are low-meaning. Therefore, we keep the initial model (1).

The results of the above tests appear that the estimates of the regression coefficients are poor. The reason for this is the nonstationarity of the studied series. Engle-Granger and Johansen's cointegration approach is the correct mathematical description of the series. This approach can be applied to create an error correction model if the time series included in the model are nonstationary but integratedness of the same order. To check cointegration, we should analyze the need to include a constant or a constant and linear trend in the model and check the model's adequacy using Student's t-tests, Fisher's, and other statistics. We will accept possible variants of 5 hypotheses to apply the appropriate test procedures $H_2(r)$, $H_1^*(r)$, $H_1(r)$, $H^*(r)$, $H(r)$– the data don't have a deterministic trend, the cointegration equation contains neither a trend nor a free term; $H_1^*(r)$ – the data don't have a deterministic trend, the cointegration relation contains a free term and doesn't contain a trend; $H_1(r)$ – the data contains a deterministic trend, the cointegration equation contains a free term and doesn't contain a trend; $H^*(r)$ – the data have a deterministic linear trend, the cointegration relation has both a trend and a free term; $H(r)$ – the data contain a deterministic quadratic trend, cointegration equation contains a trend and a free term.

The Engle-Granger and Johansen testing results are presented in Tables 6, 6.1 and 6.2:

Table 6

Results of tests of Engle-Granger and Johansen for cointegration by logarithms of variables

| | | | | | |
|---|---|---|---|---|---|
| Date 14/07/20 Time: 17:35 | | | | | |
| Sample: 1994-2018 | | | | | |
| Included observations: 20 | | | | | |
| Series: ΔLNUKRT ΔLNGDPAZ ΔLNGDPUKR | | | | | |
| Selected (0.01 level*) Number of Cointegrating Relations by Model | | | | | |
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Test Type | $H_2(r)$ | $H_1^*(r)$ | $H_1(r)$ | $H^*(r)$ | $H(r)$ |
| Trace | 3 | 2 | 3 | 1 | 3 |
| Max-Eig | 3 | 1 | 3 | 1 | 1 |
| Information Criteria by Rank and Model | | | | | |
| Data Trend: | None | None | Linear | Linear | Quadratic |
| Rank or No. of CEs | $H_2(r)$ | $H_1^*(r)$ | $H_1(r)$ | $H^*(r)$ | $H(r)$ |
| | Log Likelihood by Rank (rows) and Model (columns) | | | | |
| 0 | -24.24897 | -24.24897 | -24.20618 | -24.20618 | -23.99838 |
| 1 | -2.270148 | -2.172438 | -2.135090 | -2.117768 | -2.054350 |
| 2 | 7.508518 | 7.663538 | 7.668070 | 7.691298 | 7.754099 |
| 3 | 13.10042 | 13.30656 | 13.30656 | 13.33109 | 13.33109 |
| | Akaike Information Criteria by Rank (rows) and Model (columns) | | | | |
| 0 | 3.324897 | 3.324897 | 3.620618 | 3.620618 | 3.899838 |
| 1 | 1.727015 | 1.817244 | 2.013509 | 2.111777 | 2.305435 |
| 2 | 1.349148* | 1.533646 | 1.633193 | 1.830870 | 1.924590 |
| 3 | 1.389958 | 1.669344 | 1.669344 | 1.966891 | 1.966891 |
| | Schwarz Information Criteria by Rank (rows) and Model (columns | | | | |
| 0 | 3.772977 | 3.772977 | 4.218058 | 4.218058 | 4.646637 |
| 1 | 2.473814 | 2.613830 | 2.909668 | 3.057722 | 3.350954 |
| 2 | 2.394667* | 2.678738 | 2.828072 | 3.125322 | 3.268829 |
| 3 | 2.734197 | 3.162942 | 3.162942 | 3.609849 | 3.609849 |

*Source*: The results of procedures realized in EViews 8 software package

View /Cointegration test/Johansen system cointegration test /Summarize all 5 sets assumption

Table 6.1

Result test of Max-Eigenvalue

| Hypothesis | Alternative hypothesis | Max-Eigenvalue statistics | Critical value 1% | Prob. |
|---|---|---|---|---|
| $H_0$:r=0* | $H_A$:r >0 | 44.17683 | 30.83396 | 0.0001 |
| $H_0$:r=1 | $H_A$:r >1 | 19.61813 | 23.97534 | 0.0463 |
| $H_0$:r=2 | $H_A$:r >2 | 11.27959 | 16.55386 | 0.0798 |

*Source*: The results of procedures realized in EViews 8 software package
View /Cointegration test/Johansen system cointegration test /İntercept and trend in CE

Table 6.2

Result of Trace test

| Hypothesis | Alternative hypothesis | Trace statistics | Critical value 1% | Prob. |
|---|---|---|---|---|
| $H_0$:r=0* | $H_A$:r >0 | 75.07456 | 49.36275 | 0.0000 |
| $H_0$:r=1 | $H_A$:r >1 | 30.89772 | 31.15385 | 0.0109 |
| $H_0$:r=2 | $H_A$:r >2 | 11.27959 | 16.55386 | 0.0798 |

*Source*: The results of procedures realized in EViews 8 software package
View /Cointegration test/Johansen system cointegration test /İntercept and trend in CE

The results of the Trace, Max-Eigenvalue tests are the same only for the $H^*(r)$ variant from table 6. In the case of $H^*(r)$ the information criteria of Akaike and Schwarz have low values of 1.830870 and 3.057722, respectively. The last two tables shown the number of cointegration vectors in the series of dynamics, we first tested the null hypothesis that there are no cointegration vectors, i.e. r = 0, there is one such vector against the alternative hypothesis. We rejected the null hypothesis, since the calculated values were more than the critical values, from where we came to the conclusion that there is one vector of cointegration. Then we tested the hypothesis, there is one vector against the alternative hypothesis that there are two cointegration vectors. Here, we accepted the null hypothesis because calculated criteria are less than the critical values. The same is true in the case of the alternative hypothesis of three and four vectors. Thus, we concluded that there is one vector of cointegration.

The Engle-Granger and Johansen Tests showed that all variables are cointegratedness, which confirms their long-term relationship and the authenticity of the correlation. Given the informational criteria of Akaike and Schwartz, it was found out that the best one was the lag equal to 2. One cointegration relation is obtained with the degree of integration of the second order and the cointegration rank equal to 1.

According to (Verbeek, 2012), the system of integratedness order 2 and cointegratedness series can be represented in the form of a vector error correction model (VECM) with a lag of 2 and a rank of 1, which expresses the long-term equilibrium relationship of variables and authenticity. Their correlation, which makes it possible to measure deviations from equilibrium in the event of shocks and the speed of its recovery. The following error correction equation was found for the second order differences of the logarithmic values of Azerbaijan's GDP by following procedures of the Eviews program,

$$\Delta (\Delta \text{LNUKRT}) = 0.0355603015521*(\Delta \text{LNUKRT}(-1) - 3.1870061501* \Delta \text{LNGDPAZ}(-1) - 2.39804627923* \Delta \text{LNGDPUKR}(-1) + 0.831686150061* \Delta \text{LNRESIDS}(-1) - 0.202025767492) - 1.12183480279* \Delta (\Delta \text{LNUKRT}(-1)) - 0.265731742651* \Delta (\Delta \text{LNUKRT}(-2)) - 1.91013865615* \Delta (\Delta \text{LNGDPAZ}(-1)) - 2.66911616438* \Delta (\Delta \text{LNGDPAZ}(-2)) + 0.68045831886* \Delta (\Delta \text{LNGDPUKR}(-1)) + 0.443920173228* \Delta (\Delta \text{LNGDPUKR}(-2)) + 0.0179318911639* \Delta (\Delta \text{LNRESIDS}(-1)) + +0.0349766890005* \Delta (\Delta \text{LNRESIDS}(-2)) + 0.0751422282878 \quad (4)$$

Where $\Delta(\cdot) = \Delta_t(\cdot);\ \Delta(-i) = \Delta_{t-i}(\cdot),\ t = \underline{1,3}$, "·" the corresponding variable is indicated.

When we implementing the Granger causality test, we showed that there are feedbacks between variables. It is easy to obtain error correction models for the remaining variables by using Eviews software procedures, following similar procedures:

Δ(Δ LNGDPAZ )= 0.129695443071*( Δ LNUKRT (-1) - 3.1870061501* Δ (Δ LNGDPAZ (-1) - 2.39804627923* Δ LNGDPUKR (-1) + 0.831686150061* Δ LNRESIDS (-1) - 0.202025767492 ) - 0.141834541652* Δ (Δ LNUKRT (-1)) - 0.0833088402909* Δ (Δ LNUKRT (-2)) - 0.441538690404* Δ (Δ LNGDPAZ (-1)) - 0.755478401528* Δ (Δ LNGDPAZ (-2)) + 0.3237492508* Δ (Δ LNGDPUKR (-1)) + 0.34419371965* Δ (Δ LNGDPUKR (-2)) - 0.0774495416136* Δ (Δ LNRESIDS (-1)) - 0.0234505524657* * Δ (Δ LNRESIDS (-2)) + 0.0371313594229 (5)

Δ (ΔLNGDPUKR) = 0.281005895234*( (-1) - 3.1870061501* Δ LNGDPAZ (-1) - 2.39804627923* Δ LNGDPUKR (-1) + 0.831686150061* Δ LNRESIDS (-1) - 0.202025767492 ) - 0.285248125451* Δ (Δ LNUKRT (-1)) - 0.148058177738* Δ (Δ LNUKRT (-2)) + 0.143862237724* Δ (Δ LNGDPAZ (-1)) + 0.230600836987* Δ (Δ LNGDPAZ (-2)) + 0.105303313039* Δ (Δ LNGDPUKR) (-1)) - 0.1312986001* Δ(Δ LNGDPUKR (-2)) - 0.187035333378* Δ (Δ LNRESIDS (-1)) - 0.0791985748849* * Δ (Δ LNRESIDS (-2)) + 0.059546588866 (6)

Model (4), (5), (6) are statistically correct, since the previous stages of construction ensure that its variables are stationary.

The adequacy of the constructed error model (4), (5), (6) is estimated based on the results of the general analysis of residuals (errors) of the three regression equations. LM (VAR Residual Serial Correlation LM Test) - testing the hypothesis of serial correlations; Jarque-Bera test using of the joint normal distribution of random errors; White heteroscedasticity test: No Cross Terms - about the constancy of the dispersion of the residuals. Equivalent forms of criteria were used for make a decision, which are a comparison of the conditions for the significance of ε and P-values that are indicated in the columns of Prob. in the evaluation window of the test tables 7,8,9.

Table 7

VAR Residual Serial Correlation LM Test

| Null hypothesis: no consistent correlation with lag h | | |
|---|---|---|
| Date: 14.07.20 Time: 18:26 | | |
| Sample: 1994 2018 | | |
| Included observations: 21 | | |
| Lags | LM-Stat | Probability |
| 1 | 9.099665 | 0.4281 |
| 2 | 9.692784 | 0.3759 |

*Source*: The results of procedures realized in EViews 8 software package Var/View/Residual tests/ Auto correlation LM

Table 8

VAR Residual Normality Test

| | | | | |
|---|---|---|---|---|
| Orthogonalization: Khaletsky (Lutkepohl) | | | | |
| Null hypothesis: residuals are multidimensional normally | | | | |
| Date: 14/07/20 Time : 19:45 | | | | |
| Sample: 1994 2018 | | | | |
| Included observations:21 | | | | |
| Components | Skewness | Chi-square | df | Probability |
| 1 | -0.323396 | 0.366047 | 1 | 0.5452 |
| 2 | -0.640859 | 1.437450 | 1 | 0.2306 |
| 3 | 0.088869 | 0.027642 | 1 | 0.8680 |
| Joint | | 1.831139 | 3 | 0.6082 |
| Components | Kurtosis | Chi-square | df | Probability |
| 1 | 2.582207 | 0.152732 | 1 | 0.6959 |
| 2 | 3.743534 | 0.483738 | 1 | 0.4867 |
| 3 | 2.959332 | 0.001447 | 1 | 0.9697 |
| Joint | | 0.637917 | 3 | 0.8877 |
| Components | Jarque-Bera | df | Probability | |
| 1 | 0.518779 | 2 | 0.7715 | |
| 2 | 1.921188 | 2 | 0.3827 | |
| 3 | 0.029089 | 2 | 0.9856 | |
| Joint | 2.469056 | 6 | 0.8719 | |

*Source*: The results of procedures realized in EViews 8 software package
Var/View/Residual tests/Normality test

Table 9

White test for heteroscedasticity: No Cross Terms

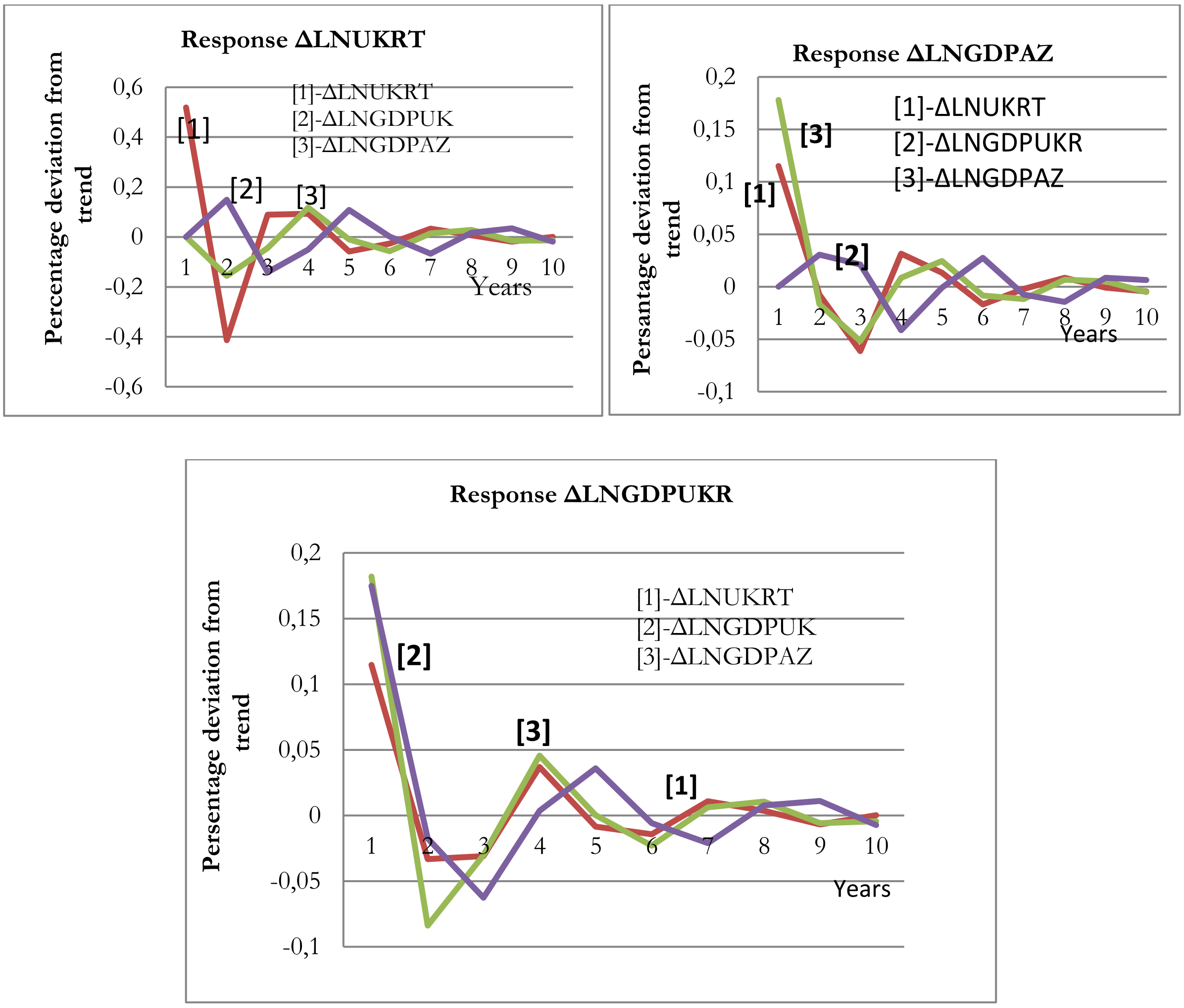
| | | | | | |
|---|---|---|---|---|---|
| Date: 14/07/20 Time: 20:15 | | | | | |
| Sample: 1994 2018 | | | | | |
| Included observations:21 | | | | | |
| Joint test: | | | | | |
| Chi-square | df | Probability | | | |
| 75.69128 | 72 | 0.3602 | | | |
| Dependent | Determination coefficient | F(12,8) | Probability | Chi-square (12) | Probability |
| res1*res1 | 0.895876 | 5.735936 | 0.0096 | 18.81339 | 0.0931 |
| res2*res2 | 0.230033 | 0.199171 | 0.9935 | 4.830694 | 0.9634 |
| res3*res3 | 0.176262 | 0.142652 | 0.9985 | 3.701503 | 0.9882 |
| res2*res1 | 0.588175 | 0.952146 | 0.5469 | 12.35168 | 0.4179 |
| res3*res1 | 0.499298 | 0.664798 | 0.7475 | 10.48526 | 0.5735 |
| res3*res2 | 0.232051 | 0.201447 | 0.9932 | 4.873076 | 0.9621 |

*Source*: The results of procedures realized in EViews 8 software package
Var/View/Residual tests/ White test for heteroscedasticity: No Cross Terms

Table 8 shows that skewness is close to zero (-0.640859) and kurtosis is close to three (3.743534), which better smoothes out the empirical distribution of the residuals of the deviation from the normal, rather than the corresponding values (-1.674268) and (5.268172) from table 1.

We can conclude that the null hypotheses based on the results of estimations of tables 7, 8, 9: about the mutual independence of the residuals; the normal joint distribution of random errors; on the constancy of the variance of errors at the 5% level do not deviate and the constructed system of error models (4), (5), (6) are adequate.

For a fully informative study, in addition to the Granger causality test, it's necessary to analyze the response of impulse functions. These functions represent a median estimate with 90% confidence interval of the endogenous variable for the positive shock of one standard deviation of the exogenous variable and shows the time of return to the equilibrium trajectory. The confidence intervals were obtained by bootstrapping with 100 replications, as described in (Hall, 1992). The test results for 10 year time horizons are described in Graph 4:

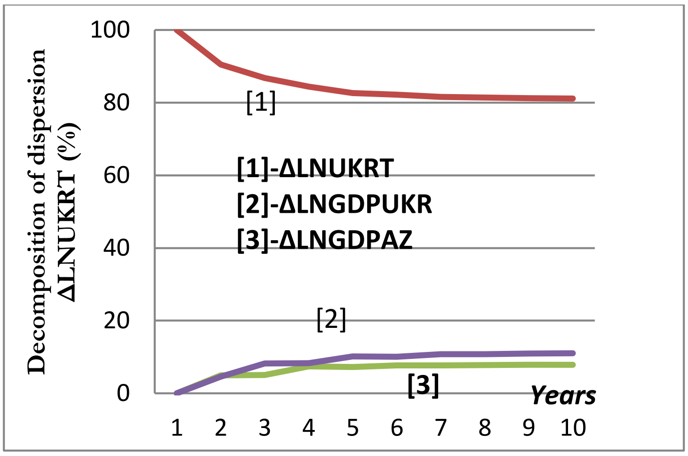


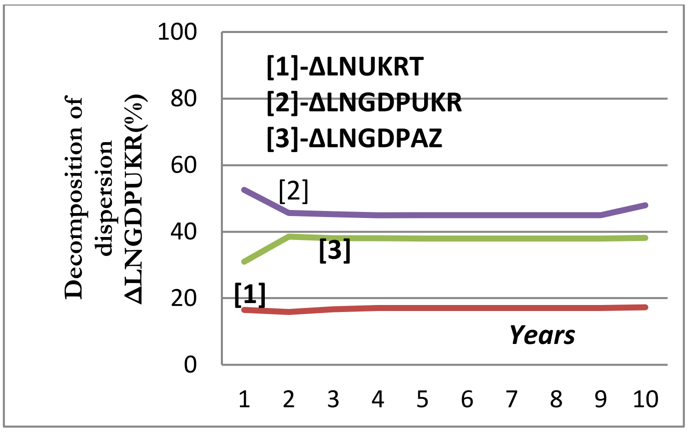

**Graph 4. Reactions of impulse response functions**

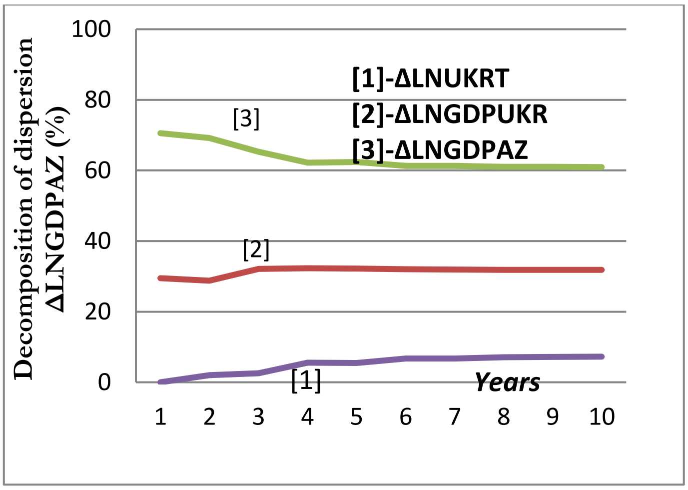
*Source*: The results of procedures realized in EViews 8 software package Var/View/impulse response/table and MS Excel 2010 insert /Charts group/Line with Markers

Graph 4 shows that the response of the variables to a deviation from the general stochastic trend isn't the same. In response to shocks, the endogenous variable travels its part of the path to equilibrium.

To study the influence of exogenous variables on the endogenous variable according to data for the last 10 years, an econometric method of decomposition of the variances of forecast errors is used, which determines the contribution of changes in this variable to the own variance of the forecast. errors and variance of other variables. The verification results of the relevant tests are shown in Graph 5:




**Graph 5. Decompositions of forecast error variances**

*Source*: The results of procedures realized in EViews 8 software package Var/View/Variance decompasitions /table and MS Excel 2010 insert /Charts group/Line with Markers

## 5. CONCLUSIONS

The conducted cointegration analysis of the mutual influence of the GDPs Azerbaijan and country's trade with Ukraine allows us to formulate a number of conclusions:

1. The results of the lagged dependencies show that the constructed cointegration relations formed from the difference operators of the second order of the effective logarithm values of the initial variables, can be considered significant. The inclusion in models (4), (5), (6) of the parameters of auto-regression and a moving average of the second order has an economic interpretation that the foreign trade between Ukraine and Azerbaijan is significantly influenced by the states themselves, trying to bring the foreign trade balance as close as possible to the possible minimum, therefore, during each year, volumes of the foreign trade between these countries are adjusted depending on the values in previous periods.

2. The constructed vector model of error correction with two components allows us to evaluate the quantitative characteristics of the short-term and long-term dynamics of the relationship between the studied indicators. In particular, estimates of lag parameters are provided and the speeds of convergence to the equilibrium trajectory are determined. Deviations from equilibrium trajectories in previous time periods are restored in subsequent time periods.

3. The long-term equilibrium relationship is stable in that, if broken in the short-term periods, it is restored. Combining the statistical long-term and dynamic short-term relationships between the variables in one line, we can measure the deviations from the equilibrium in the event of shocks and the rate of its recovery by using relations (5) and (6).

4. The contributions to the variance of forecast errors of changes in the own dispersion of the effective factor and variance of the causal factor is determined.

5. The trade simulation using the above methodology allows forecasting trade flows. The introduction of tools for studying the dynamics of the causality of the GDP of both countries of the trade turnover between them on the basis of the proposed method for monitoring unsteady time series will allow us to determine the strategy of stabilization of export-import operations, the real state of the trade relations in the current period and to obtain adequate forecasts for the development of economic cooperation in the future. The estimates obtained from correction mechanisms (4), (5), (6) make it possible to carry out dynamic analyses for effective government regulation of export-import operations between the two countries to balance the trade and improve corresponding inclusive parameters of long-term sustainable economic growth of these states. It is very important for the respective foreign trade regulatory bodies of both countries to conduct monitoring using methodology of the system of vector error correction model (4), (5), (6). It is enough carry out monitoring on an annual basis after the release of official information on the results of the reporting year.

## REFERENCES

Andronova, I.V. (2012*)*. Evolution of integration processes in the post-Soviet space. *Bulletin of RUDN University, Series Economics*, 5, 72-81.

Chebotareva N.N., & Fayzulina, Yu. V. (2016). Analysis of export and import of goods and services in Ukraine. *Network journal "Scientific Result". Series "Economic Research"*, 2, 1(7),.57-63.

Dankevych, V.Y., Pyvovar, P.V., & Dankevych, Y.M. (2020). The impact of World Trade Liberalization on the Development of Domestic Brewing Companies. *The Problems of economy*, 1(43), 59-67.

Frolov, S.M., & Savytska, O.I. (2016). Research of Causal Relations between Components of foreign Trade and Economic Performance of the Region Country and World. *The Problems of economy,* 1, 282-288.

Golovan, D.V. (2012). Dynamics of the structure of foreign trade and the international strategy of economic development of Ukraine. *Economy and management of machinery and equipment enterprises: problems of theory and practice,* 3(19), 98-205.

Hall, P. (1992). On Bootstrap Confidence Intervals in Nonparametric Regression. *Annals of Statistics* 20(2), 695-711.

Johnson, R. R. (2015). *A Guide to Using Eviews with Using Econometrics: A Practical Guide* University of San Diego.

Kalyuzhna, N. G. (2020). International Trade Integration of Ukraine in the context of Deepening Interstate Conflict. *The Problems of economy* 1(43), 27-35.

Kharlamova, G., & Vertelieva, O. (2013). The International Competitiveness of Countries: Economic-Mathematical Approach*, Economics & Sociology,* 6(2), 39-52.

Kenneth, N. B., & Carey, P. (2010). *Data Analysis with Microsoft Excel*: Updated for Office 2007, Third Edition, p. 613, ISBN-13: 978-0-495-39178-4, Cengage Learning products are represented in Canada by Nelson Education, Ltd.

Moroz, S., Nagyova, L., Bilan, Yu., Horska, E., & Polakova, Z. (2017). The current state and prospects pf trade relations between Ukraine and the European Union: The Visegard vector *Economic Annals*-XXI, 163(1-2(1)), 14-21.

Orudzhev E.G., & Huseynova S.M. (2019). The cointegration relations between Azerbaijan's GDP and the balances of the trade relations of Russia and Belarus. *Journal of Contemporary Applied Mathematics*, 9(2), 73-92.

Orudzhev, E. G., & Huseynova, S. M. (2020*).* About one cointegration issue of trade relations Azerbaijan, Russia, Belarus. *Journal of Advanced Research in Dynamical and Control Systems (JARDCS),* 12(6), 1385-1394.

Orudzhev, E.G., & Alizade, A.R. (2020). Cointegration of Trade and Economic Relations between Azerbaijan and Ukraine. *Journal of Contemporary Applied Mathematics*, 2, 83-97. http://journalcam.com/wp-content/uploads/2020/05/100110.pdf

Pylin, A.G. (2015). Foreign economic relations of Azerbaijan in the context of regional integration. *Problems of the post-Soviet space* https://www.postsovietarea.com/jour

Tinbergen, J. (1962). An Analysis of World Trade Flows. // *Shaping the World Economy. Suggestions for an International Economic Policy. Appendix VI*. – New-York: The Twentieth Century Fund, 262-293.

Verbeek, M. (2012). *A Guide to Modern Econometrics*. John Wiley & Sons p. 386

www.stat.gov.az (08.07.2020)

www.worldbank.com (08.07.2020)