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JOHANSEN'S COINTEGRATION ANALYSIS OF SOME FACTORS OF ECONOMIC GROWTH AND EXPORTS OF PRODUCTS FROM THE REPUBLIC OF AZERBAIJAN TO UKRAINE

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Johansen's Cointegration Analysis of Some Factors of Economic Growth and Exports of Products from the Republic of Azerbaijan to Ukraine

In the present paper, a Johansen's cointegration analysis is carried out considering the volume of exports from Azerbaijan to Ukraine, GDP per capita of Ukraine, the openness of the economy of Ukraine and the economically active population of Azerbaijan for the period 1996-2022, also a comparative analysis of the above indicators is carried out, the characteristics of joint short-term and long-term movements are determined. In the course of research the author used the methodology of modified gravitational modeling, the econometric methodology of time series analysis, including tests for checking stationarity, the extended Dickey-Fuller test, the Granger test for the detection of causality, determining the cointegration dependence using the Johansen's test, a Vector Error Correction Model (VECM) has been built. First, a basic modified model of gravity has been built, and the statistical adequacy of this model has been checked. A comparative analysis of two regression models was carried out after the inclusion of the trend component in one of them. The dynamic structure of regression residuals was studied and the test for heteroscedasticity and autocorrelation was carried out. It is shown that the most suitable specification for cointegration is the quadratic trend in the initial levels with a linear trend in cointegration relationships, which has led to the emergence of two cointegration vectors. As a result of the completed analysis, two cointegration relationships are obtained. The results of the impulse response functions, decomposition of dispersions and the VECM model in the form of combinations of two cointegrating vectors with the expected signs of the adjustment integers showed that the economic indicators used in the analysis for the specified period maintain cointegration in the long term with the not stable equilibrium joint movements of the factors under study.

Keywords: *cointegration, cointegrating vectors, error correction models, gravitational method, impulse response function.*

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Алізаде А. Р. Коінтеграційний аналіз Йохансена деяких факторів економічного зростання та експорту продукції з Азербайджанської Республіки в Україну

У цій роботі проведено коінтеграційний аналіз Йохансена між обсягом експорту з Азербайджану в Україну, ВВП на душу населення України, відкритістю економіки України та економічно активним населення Азербайджану за період 1996–2022 років, порівняльний аналіз вищезазначених показників, визначено характеристики спільних короткострокових і довгострокових рухів. У цьому дослідженні використано методологію модифікованого гравітаційного моделювання, економетричну методологію аналізу часових рядів, включаючи тести на перевірку стаціонарності за допомогою розширеного тесту Дікі-Фуллера, виявлення причинно-наслідкових зв'язків тестом Грейнджера і коінтеграційної залежності за допомогою тесту Йохансена на коінтеграцію, а також побудову векторної моделі корекції помилок (VECM). Спочатку було побудовано базову модифіковану модель гравітації, перевірено статистичну адекватність цієї моделі. Проведено порівняльний аналіз двох моделей регресії після включення в одну з них трендової складової. Вивчено динамічну структуру залишків регресії та здійснено перевірку на гетероскедастичність та автокореляцію. Показано, що найбільш підходящою специфікацією для коінтеграції є квадратична тенденція в початкових рівнях з лінійною тенденцією в коінтеграційних співвідношеннях, що призвело до виникнення двох векторів коінтеграції. В результаті проведеного аналізу отримані два коінтеграційних співвідношення. Результати функцій імпульсного відгуку, розкладання дисперсій та моделі VECM у вигляді комбінацій двох коінтегруючих векторів з очікуваними знаками множників пристосування показали, що економічні показники, використовувані в аналізі за вказаний період, зберігають коінтеграцію в довгостроковій перспективі з нестабільно рівноважними спільними рухами досліджуваних факторів.

Ключові слова: *коінтеграція, коінтегруючі вектори, моделі корекції помилок, гравітаційний метод, функція імпульсного відгуку.*

Рис.: *8.* ***Табл.:*** *12.* ***Формул:*** *14.* ***Бібл.:*** *17.*

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Introduction. The analysis of trade relations between Ukraine and Azerbaijan is important not only from the standpoint of economic well-being, but also from the political and geostrategic points of view. The two countries have unique economic, geographical, and cultural characteristics. Located at the crossroads of Europe and Asia, Azerbaijan is a country rich in natural resources such as crude oil and natural gas. Ukraine, in turn, occupies a strategically important position on the map of Europe, possessing a developed industrial sector and significant agrarian resources.

In the context of today's staggering globalization challenges and changing global economic conditions, the ongoing war between Russia and Ukraine and the disruptions of regional and international logistic chains, economic uncertainty caused by it, the two countries are looking for new ways to overcome lost opportunities to strengthen and expand their foreign trade, economic and humanitarian ties.

In the current situation, it is relevant to conduct an in-depth analysis of trade flows, namely exports, between Azerbaijan and Ukraine using gravitational model approaches. These models make it possible to assess the impact of various factors, such as the economic size of the country, geographical distance, economic development, the openness of the economy, the size of the economically active population, trade policies and others, the intensity of trade between the two countries. The GDP per capita of Ukraine is taken as an indicator of economic development, as an important economic indicator, used to assess the average level of economic well-being of the population in a country and is calculated as the total volume of goods and services produced in the country (GDP) divided by the population of the country. Countries with high GDP per capita tend to have better infrastructure, better education and health care, and this indicator appears useful when comparing the performance of different countries' economies. This indicator also shows how productively resources are exerted in the economy. Another indicator that comes in view is the factor of openness of the country's economy, showing the difference in trade between countries and economies. This factor plays a central role in the sustainable and long-term economic development of the country, which is an important component of the assessment of sovereign risk in crisis situations. Changes in the openness of the economy lead to changes in the ratio and strength of influence on the national economy on the part of the external and internal factors that cause either an economic growth or a decline. Despite the positive aspects of economic openness, Ukraine, being one of these countries, faces a number of challenges such as the instability of the domestic political and military situation, as well as the impact of global economic and political factors related to the sanctions of Western countries led by the United States against Russia and the consequences of Russia's anti-sanctions measures. However, Ukraine has domestic industrial raw materials and human potential, and external financial support to further strengthen its economic position through the improvement of the investment climate on the part of Western countries after the end of the war, the restoration of destroyed land and sea transport, energy, industrial infrastructure and the modernization of infrastructure outside the zones of hostilities, also the development of human capital, which has a positive and significant impact on both the long-term and short-term economic growth. Such a time series as the economic activity of the population is also considered as an indicator of development.

Analysis of recent publications. There are very few published works devoted to the study of trade, economic and humanitarian relations between Ukraine and the Republic of Azerbaijan. There are some works in which the current state of the economy of both Ukraine and Azerbaijan are analyzed and the impact of the military conflict between Russia and Ukraine on the socioeconomic development of the latter country, as well as the consequences for Ukrainian-Azerbaijani trade and economic relations in the context of blocked logistics are examined. In particular, the paper [1] builds a mathematically and statistically correct dynamic analogue of the gravitational model of trade flows between Ukraine and Azerbaijan depending on the GDP of these countries, that enables to a dynamic analysis of the effective State regulation of export and import operations between the indicated countries to balance mutual trade. For example, in 2022, Ukraine had a trade deficit with Azerbaijan of $98169.200. It is necessary to further proceed with the analysis of such a model with the addition of subsequent years searching for ways to reduce the trade deficit. The paper [2] determines that the economic consequences of modern military conflicts, along with other macroeconomic factors, quantitatively and qualitatively affect changes in GDP per capita. The articles [3-5] analyze the current state of the economy of Ukraine, study in detail the issues of foreign trade relations of Ukraine, the dynamics of export-import operations of this country with raw materials, analyze the structure of exports and imports. The work [6] is related to the study of Ukrainian-Azerbaijani trade and economic cooperation, the main risks and threats limiting the expansion of trade between the two countries are noted. The article [7] provides a comparative analysis of the methods of economic-statistical and managerial analysis, which can serve as an instrument in considering the impact of the economic asymmetry of partner countries on the efficiency of their trade and economic integration. In the next paper [8] with a more thorough comparison with the work [1], a new specification of the model of dependence between the

GDP of Azerbaijan and trade turnover with Ukraine in addition to Georgia is determined.

Another paper [9] shows that the conclusions [6] do not correspond to reality, and it is also proved that the convergence of economies in terms of income and the reduction of existing gaps in the face of geopolitical and economic uncertainty, the ongoing war and the resulting breaks in the logistics chain are difficult to implement. Yet another paper [10] analyzes the consequences of sanctions against Russia for post-Soviet partner countries.

Aim of the study and the methodology. The aim of this study is to conduct a time series analysis, a comparative analysis of the aforementioned data, to determine the characteristics of joint short-term and long-term movements (convergence or divergence in the very nature of behavior), as well as undertake an in-depth cointegration analysis of trade flows, namely exports, between Azerbaijan and Ukraine using modified gravitational models.

The author applies the methodology of modified gravitational modeling [1; 8; 9]. The main idea behind the approach of the gravitational model of trade is foreign trade turnover that is directly dependent on the economic potential of the trading countries and inversely dependent on the distance between them. It is the size of the economy that determines supply and demand, and the distance between partners is important in terms of the costs of trade in goods, which increase proportionate with the distance between countries. Building of a gravitational model makes it possible to determine the dependence of the unidirectional foreign trade flow on the parameter of the internal economic status of both the exporting and importing countries.

In addition, an econometric methodology for time series analysis was also used, including tests for checking stationarity using the extended Dickey-Fuller test, identifying causal relationships using the Granger test, as well as identifying cointegration dependence with the Johansen's cointegration test [11; 12] and building a Vector Error Correction Model (VECM).

Main results. This study presents the results of the evaluation of the equation of gravity, which includes the following determinants: the volume of exports from Azerbaijan in Ukraine, GDP per capita of Ukraine, the openness of the Ukrainian economy and the economically active population of Azerbaijan. At this, the multiplicative graded relation is considered as an initial dependence:

$$y_t = \alpha_0 x_{t1}^{\alpha_1} x_{t2}^{\alpha_2} x_{t3}^{\alpha_3} d^{\alpha_4} e^{\varepsilon_t},\ t = \overline{1,26}. \qquad (1)$$

showing the dependence of the factor of exports from the Republic of Azerbaijan in Ukraine, denoted by y_t (unit of measurement - thousand US dollars), on the factor x_{t1}, which is GDP per capita of Ukraine (unit of measurement - thousand US dollars) and the factor x_{t2}, which means the openness of the economy of Ukraine (unit of measurement - percentage), as well as on the factor x_{t3}, denoting the economically active population of Azerbaijan (unit of measurement - thousand people) with a random member ε_t, which includes the total influence of all factors not taken into account in the model, measurement errors and the geographical distance d (in thousand kilometers) between Baku and Kyiv. In this formula, α_0 is free term, α_1, α_2, α_3, α_4 are constant numbers. Here, the main factor elements are combined by the multiplication operation. It is assumed that $\alpha_1 > 0$, $\alpha_2 > 0$, $\alpha_3 > 0$, $\alpha_4 > 0$.

Based on this, after the appropriate designations of the system $\{lny_t, lnx_{t1}, lnx_{t2}, lnx_{t3}\}$ through the elements of the system {LN(EXPAZ_UKR), LN(GDP_UKR), LN(EC_OPENNES_UKR), LN(EC_POP_AZ)} as well as a comparative analysis with the available publications [13, 14], the basic modified model of gravity can be presented as follows:

$$\begin{aligned} LN(EXPAZ\_UKR) = \alpha + \alpha_1 LN(GDP\_UKR) + \\ + \alpha_2 LN(EC\_OPENNES\_UKR) + \\ \alpha_3 LN(EC\_POP\_AZ) + \varepsilon_t, \end{aligned} \qquad (2)$$

where $d = ln\alpha_0 + \alpha_4 lnd$, d=2,233 thousand km, $\alpha_4 = 2$.

We have three unknown parameters that need to be assessed from 26 observations for the period 1996-2022 [15; 16].

Initially, this model also included the indicator of openness of the economy of Azerbaijan as an exogenous factor, but due to the fact that a discrepancy in the order of stationarity of this variable (stationary at the initial levels) with others was detected, this indicator was excluded from the model and was not considered.

The variable GDP per capita of Azerbaijan was also excluded from consideration. Due to a smaller number of observations, this time series was nonstationary both at the initial levels and in the differences.

First, let's conduct a visual analysis of each indicator. The export graph is shown in Figure 1.

As can be seen from the presented graph for the export variable, from 1996 to 2007 the dynamics of exports were unstable and fluctuating, combining annual periods of growth and recession. During this period, the main export item from Azerbaijan to Ukraine was crude oil and petroleum products. Azerbaijan was actively increasing oil production and looking for new markets, including Ukraine. Exports of vegetables, fruits, nuts and other agricultural products also occupied a significant place. Along with this, Azerbaijan began to export chemical products to Ukraine, including fertilizers and chemicals. Over these 10 years, export volumes between the two partners can be said to have remained at the same level. If in 1996 exports amounted to $30.2 million, where 42.3% of them accounted for refined oil, 6.53% for valves and almost 4% for air conditioners, then in 2007 with a turnover of $31 million, the top three exported goods were the same refined oil, but in the amount of 39.5%, polyethylene - 14.6% and fruit juices in the amount of 6.65 % [17].

From 2008 to 2011, there was a significant increase in export volumes by 5 times, or from $175 million to $912 million. The main export item is mineral products, accounting for almost 80% of exports in 2008 and 96% in 2011, generating revenues of more than $850 million. Exports of polyethylene during this period decreased by almost 5 times, and exports of fruits and vegetables, on the contrary, increased up to $5.27 million. In addition, the export of air transport (airplanes, helicopters/spacecraft) amounted to $8.52 million, becoming one of the profitable export items.

The next 4 years, starting from 2011, are characterized by a sharp decline in export volumes from $912 million to $25.3 million in 2015. Compared to 2011, in 2012, the volume of Azerbaijan's exports to the Ukraine decreased by more than

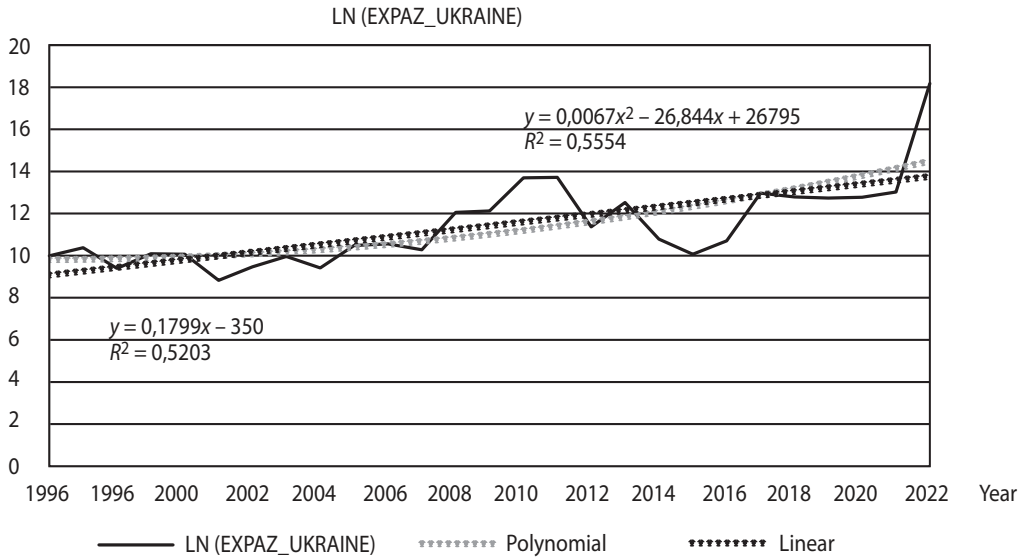

Fig. 1. Dynamics of exports of products from the Republic of Azerbaijan to Ukraine

Source: developed by the author

8 times and reached the size of only $105 million, which is almost three times less than in 2013, while mineral products remained the main export item, e. g. refined oil, accounting for 81.5% (almost $240 million) and the increased production of foods up to $23.7 million, including such items as tea ($441 thousand), nuts ($126 thousand), as well as packaging materials up to almost $4.5 million. From 2013 to 2015, export volumes fell by more than 11 times, reaching the lowest level of $25.3 million over the past 10 years. Over these two years, Azerbaijan has reduced the supply of refined oil by almost 30 times (to $8 million), and foods by almost 3 times.

Since 2015, it is possible to trace the upward trend in the export commodity flow. Exports increased to $44.8 million in 2016, where polymer shipments accounted for almost 20% of total exports and mineral and food supplies were reduced: an almost 10-fold increase up to $429 million was observed in 2017, with mineral products worth $377 million exported, more than $7 million worth of polyethylene and almost $6.5 million worth of food products and other goods such as machinery, equipment, etc. Over the past 5 years, Azerbaijan has significantly increased its export capacity, reaching $363 million.

The trend curve is expressed by a quadratic equation and indicates an overall increase in exports, despite temporary declines. The coefficient of determination R^2 = 0,55 shows a moderate correspondence of the trend curve to the data, which indicates the presence of other factors affecting exports in the short term.

Graphical representations of the dynamics of the development of exogenous variables are presented in the Figures 2, 3, 4.

Figure 2 shows that Ukraine's GDP per capita is gradually increasing with some fluctuations. By the year 2000, the indicator showed stable growth, which indicates the recovery of the economy after the crisis of the early 1990s. Over the next 8 years, GDP growth appears more significant, driven by economic reforms and export growth, particularly in metals and agricultural products. In 2009, there was a sharp decline in GDP per capita due to the global financial crisis, which had a negative impact on the Ukrainian economy. In 2010-2013, GDP per capita recovered and continued to grow, albeit less intensively than in previous years. A significant drop in 2014-2015 is explained by the political crisis, the annexation of Crimea by Russia and the outbreak of the conflict in eastern Ukraine. In the following years, a gradual recovery in GDP per capita can be observed, but at a more moderate pace. Despite the impact of the COVID-19 pandemic, the overall trend continues to be positive. The graph also shows a trend curve expressed by a quadratic equation, and shows that despite fluctuations, the long-term trend is upward. The value of the coefficient of determination R^2 = 0,78 indicates a good fit of the trend curve model to the data.

The economic openness of Ukraine's economy demonstrates different phases, reflecting the influence of both internal and external factors. Based on the presented graph, the following conclusions can be drawn. The years 1996-2000 were characterized by a decrease in the openness of the economy associated with the transition period after the collapse of the USSR, economic difficulties and the need for structural reforms. A significant increase in the openness of the economy can be traced in the period from 2001 to 2010, which is explained by the improvement of foreign economic relations, integration into the global economy and growth in exports, after which there is a sharp decrease in the openness of the economy, the cause of which is the consequences of the global financial crisis, which negatively affected foreign economic activity. Attention should also be paid to the impact of the political crisis in the country in 2014-2015, which reduced trade flows. In 2017, there is a sharp increase in this economic indicator with adaptation to new economic conditions. The last 5 years have been characterized by a downward trend in the openness of the economy, which accounted for the COVID-19 pandemic, the decline in international trade and economic instability.

Azerbaijan, like many post-Soviet countries, was in a state of economic transition from planned economy to market

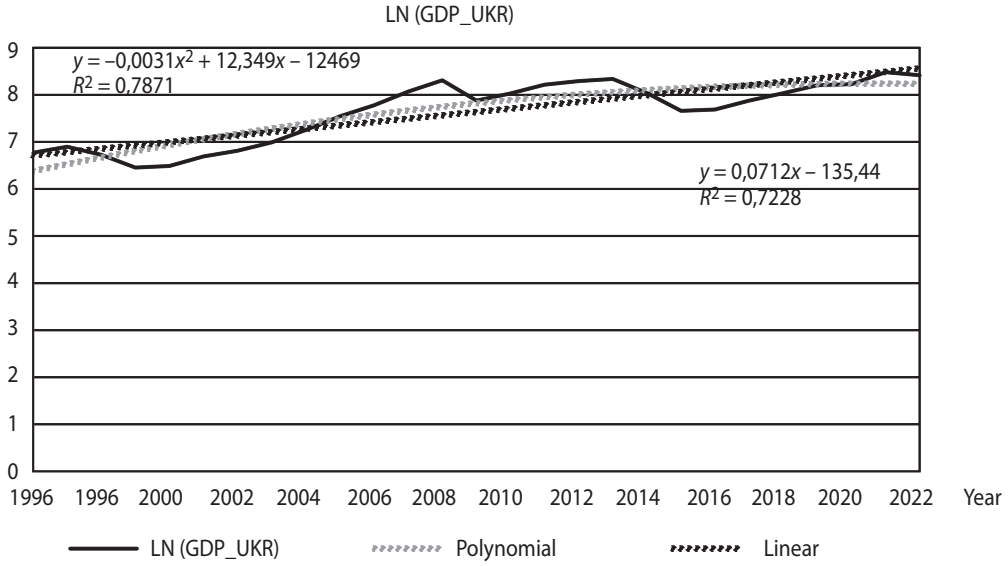

Fig. 2. Dynamics of GDP per capita of Ukraine

Source: developed by the author

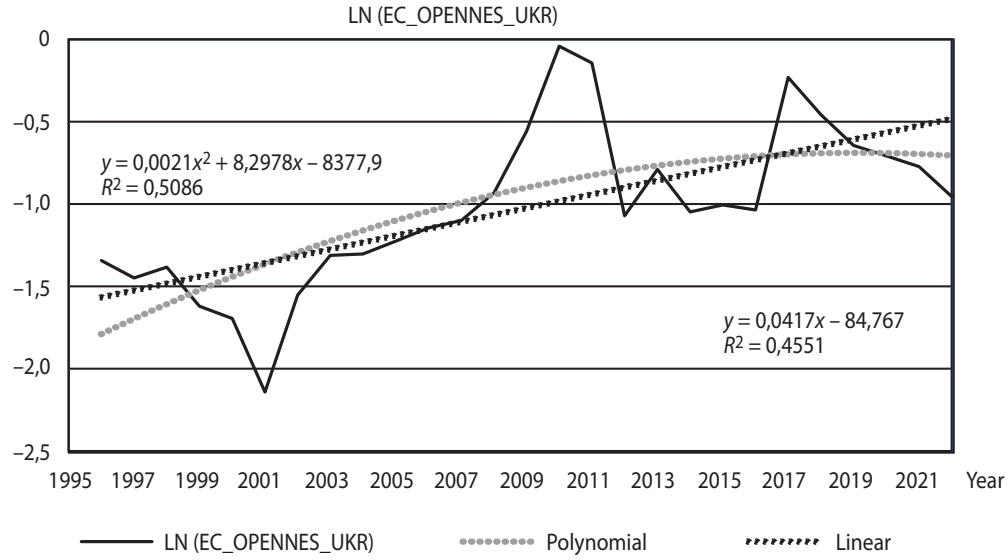

Fig. 3. Dynamics of the indicator of openness of the economy of Ukraine

Source: developed by the author

in the period of 1990-2000. In the early 1990s, the economy of Azerbaijan was destabilized, which affected the employment of the population. In the late 1990s, oil production began to develop, which had a positive effect on both the economy and employment.

As can be seen from the graph, over the next 7 years, thanks to the oil sector and foreign investment, Azerbaijan's economy began to grow rapidly, which contributed to an increase in the number of jobs, especially in the oil industry and related sectors. Along with the oil sector, agriculture and construction also played an important role in the country's economy.

Since 2007, there has been a rapid trend of growth in the number of economically active population of the Republic of Azerbaijan due to the diversification of the economy, the introduction of social programs, as well as the demographic growth of the population. As with the rest of the world, the pandemic had a significant impact on the economy and labor market in 2019. Temporary closures of enterprises and quarantine measures have led to an increase in unemployment. However, starting from 2020, you can again notice an upward trend in EAN.

As can be seen from graphs 1, 2, 3, 4, the quadratic trend is more preferable for further purposeful study.

Descriptive statistics are presented in Table 1.

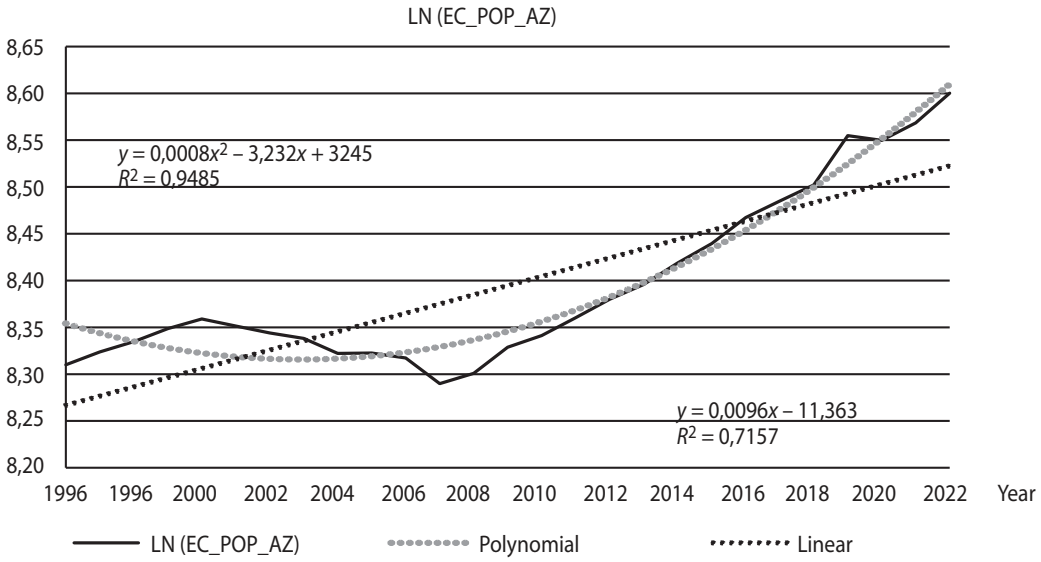

Fig. 4. Dynamics of economically active population of Azerbaijan

Source: developed by the author

The results of checking the presence of a correlation between the variables are presented in the form of a correlation matrix in the Table 2. It can be seen from the table that there is a close correlation between the factor pairs LN(EXPAZ_UKR) and LN(GDP_UKR), where $r_{yx_1} = 0,71$, and for the rest of the pairs LN(EXPAZ_UKR) and LN(EC_OPENNES_UKR), as well as LN(EXPAZ_UKR) and LN(EC_POP_AZ) there is a noticeable relationship at $r_{yx_2} = 0,68$, $r_{yx_3} = 0,64$ respectively.

Using the Eviews 12 software package, the further models were built, presented in Tables 3, 4, as follows.

As can be seen from Tables 3 and 4, after trend was included in the equation, it became more qualitative and the coefficient of determination increased from 0.66 to 0.73, that is, 73% of the endogenous variable is explained by the selected exogenous variables. Formally, the models look in the following way:

$$\begin{aligned} LN(EXPAZ\_UKR) = {} & 0.803443660732 * LN(GDP\_UKR) + \\ & + 1.35923922185 * LN(EC\_OPENNES\_UKR) + \\ & + 8.10125077863 * LN(EC\_POP\_AZ) - 61.3267782584. \end{aligned} \quad (3)$$

$$\begin{aligned} LN(EXPAZ\_UKR) = {} & 2.65486277008 * LN(GDP\_UKR) + \\ & + 1.72329780839 * LN(EC\_OPENNES\_UKR) + \\ & + 22.6916556907 * LN(EC\_POP\_AZ) - \\ & - 0.30416963048 * ® TREND - 193.621000538. \end{aligned} \quad (4)$$

Table 1

Descriptive statistics

	LN(EXPAZ_UKR)	LN(GDP_UKR)	LN(EC_OPENNES_UKR)	LN(EC_POP_AZ)
Mean	11.42366	7.637645	-1.024823	8.394629
Median	10.70110	7.877900	-1.048201	8.351403
Maximum	18.18142	8.482156	-0.041863	8.600220
Minimum	8.830689	6.454818	-2.141704	8.289856
Std. Dev.	1.979617	0.664889	0.490429	0.092269
Skewness	1.464833	-0.505378	0.090226	0.941933
Kurtosis	5.930696	1.769713	2.870689	2.536004
Jarque-Bera	19.31841	2.852138	0.055445	4.234775
Probability	0.000064	0.240252	0.972658	0.120346
Sum	308.4387	206.2164	-27.67022	226.6550
Sum Sq. Dev.	101.8910	11.49402	6.253529	0.221355

Source: developed by the author

Table 2

Correlation matrix

	LN(EXPAZ_ UKR)	LN(GDP_ UKR)	LN(EC_OPENNES_ UKR)	LN(EC_POP_ AZ)
LN(EXPAZ_UKR)	1	0.71	0.68	0.64
LN(GDP_UKR)	0.71	1	0.75	0.50
LN(EC_OPENNES_UKR)	0.68	0.75	1	0.38
LN(EC_POP_AZ)	0.64	0.50	0.38	1

Source: developed by the author

Table 3

Regression model

Dependent Variable: LN(EXPAZ_UKR)				
Method: Least Squares				
Sample: 1996 2022				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN(GDP_UKR)	0.803444	0.588034	1.366322	0.1850
LN(EC_OPENNES_UKR)	1.359239	0.742918	1.829596	0.0803
LN(EC_POP_AZ)	8.101251	2.995710	2.704284	0.0127
C	-61.32678	23.99978	-2.555306	0.0177
R-squared	0.668134	Mean dependent var		11.42366
Adjusted R-squared	0.624847	S.D. dependent var		1.979617
S.E. of regression	1.212510	Akaike info criterion		3.359215
Sum squared resid	33.81414	Schwarz criterion		3.551191
Log likelihood	-41.34941	Hannan-Quinn criter.		3.416300
F-statistic	15.43504	Durbin-Watson stat		1.144860
Prob(F-statistic)	0.000010			

Source: developed by the author

Table 4

Regression model with trend

Dependent Variable: LN(EXPAZ_UKR)				
Method: Least Squares				
Sample: 1996 2022				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LN(GDP_UKR)	2.654863	0.952766	2.786478	0.0108
LN(EC_OPENNES_UKR)	1.723298	0.696354	2.474744	0.0215
LN(EC_POP_AZ)	22.69166	6.777600	3.348037	0.0029
@TREND	-0.304170	0.129254	-2.353278	0.0280
C	-193.6210	60.34422	-3.208609	0.0040
R-squared	0.734873	Mean dependent var		11.42366
Adjusted R-squared	0.686668	S.D. dependent var		1.979617
S.E. of regression	1.108112	Akaike info criterion		3.208768
Sum squared resid	27.01406	Schwarz criterion		3.448738
Log likelihood	-38.31837	Hannan-Quinn criter.		3.280124
F-statistic	15.24477	Durbin-Watson stat		1.368021
Prob(F-statistic)	0.000004			

Source: developed by the author

If in the model (3) only the variable LN(GDP_UKR) was statistically insignificant at the 5% significance level, then in the model (4) after including the trend variable, all selected variables are statistically significant at the 5% significance level.

To check the significance of the constructed models (3), (4), the observed and critical values of the Fisher criterion are calculated. For the model (3), these values at the significance level of 5% and degrees of freedom $k_1 = 3$, $k_2 = 22$ are 15.43504 and 3.05, respectively.

Since 15.43504>3.05, the model (3) is considered statistically significant. The observed and critical values of the Fisher criterion are 15.24477 and 2.84 at the significance level of 5% and degrees of freedom $k_1 = 4$ and $k_2 = 21$, for the model (4). Given that 15.24477>2.84, this model is also considered statistically significant.

The autocorrelation check was carried out using the Durbin-Watson D statistics.

For the model (3) and the number of observations 26, the number of explanatory variables 3 and the given significance level of 0.05, critical values d_{lower} = 1,113 and d_{upper} = 1,652, that divide the segment [0,4] into five parts, the observed value $d_{observer}$ = 1,144 was found. Given that $d_{observer} > d_{lower}$, the observed value falls within the zone of uncertainty. For the model (4), according to the table of critical values of D statistics for the number of observations 26, the number of explanatory variables 4 and the given significance level of 0.05 of the values d_{lower} = 1,062 and d_{upper} = 1,759, dividing the segment [0,4] into five parts, the observed value of $d_{observer}$ = 1,368 is obtained. Since $d_{observer} > d_{lower}$, the observed value also falls into the zone of uncertainty.

The CUSUM test confirmed that the regression residuals have a dynamically stable structure. The test is based on the calculation of the accumulated sums of recursive residuals and the accumulated sums of squares of recursive residuals and the evaluation of the corresponding equations. The results of the tests are diagrams of the dynamics of these quantities and 95% confidence intervals for them. If the recursive estimates of the residuals go beyond the critical limits, then this indicates the instability of the model parameters. The results are presented in Figure 5.

As can be seen from Figure 5, both models are stable.

The heteroscedasticity of the residues is verified by the White test and the results are presented in the Tables 5 and 6. For the model (3), the value $nR^2 = Obs * R - squared$, where n = 26, R^2 is the coefficient of determination for the auxiliary

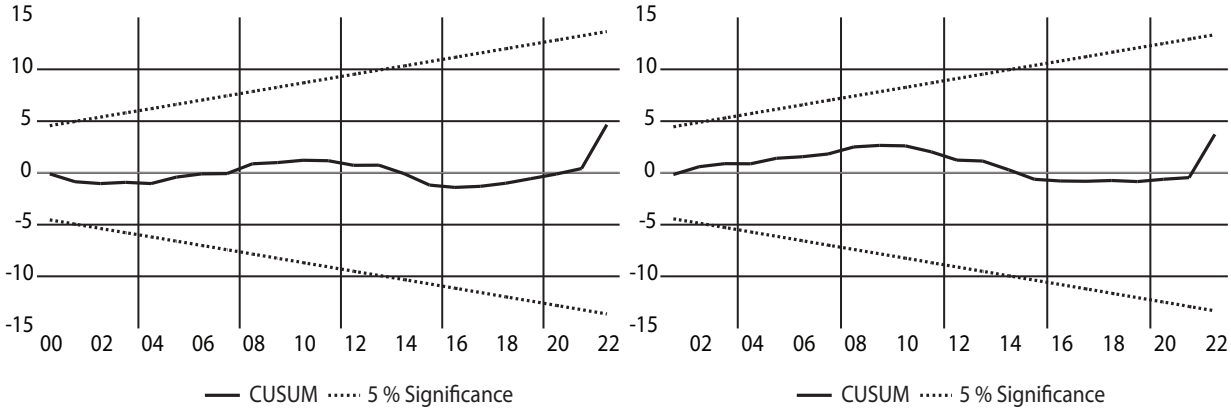

Fig. 5. The CUSUM stability test

Source: developed by the author

regression of the squares of the residuals for all regressors, their squares, pairwise products and constant, is equal to 20.20801. The estimate is $\chi^2_{0.0167}(9) = 20,20302109$. Since $nR^2 > \chi^2_{0.0167}$, the hypothesis of homoskedasticity is rejected and heteroscedasticity is present. The results are shown in the Table 5.

The value $nR^2 = Obs * R - squared$ for the model (4) equals 22.69591. And this value is bigger than the value of $\chi^2_{0.0455}(13) = 22,69387459$. Since $nR^2 > \chi^2_{0.0455}$, the hypothesis of homoskedasticity is also rejected and heteroscedasticity is present. The results are presented in the Table 6.

For exports from Ukraine to Azerbaijan, a similar model with statistically significant parameters was built, but the included variables were non-stationary, which would not allow for a cointegration analysis, since one of the conditions for cointegration is the stationarity of time series of the same order. Therefore, this model was not included in the research work.

The stationarity of the time series was checked using the extended Dickey-Fuller test. The results are presented in the Table 7.

The results showed that the time series LN(EXPAZ_UKR) is nonstationary at the initial level and is stationary of the first order at all significance levels for a specification with intercept, and is stationary at the 5% and 10% significance levels for a specification with trend and intercept.

The LN(GDP_UKR) series is also nonstationary at the initial level, being stationary of the first order at the 5% and 10% significance levels for the specification with intercept and at the 10% significance levels for the specification with trend and intercept.

For the time series LN(EC_OPENNES_UKR), a first-order stationarity was found, that is, the series is nonstationary at the initial level, at all levels of significance both for a speci-

Table 5

White test for heteroscedasticity for the model (3)

F-statistic	5.619959	Prob. F(9,17)	0.0011
Obs*R-squared	20.20801	Prob. Chi-Square(9)	0.0167

Source: developed by the author

Table 6

White test for heteroscedasticity for the model (4)

F-statistic	5.273104	Prob. F(13,13)	0.0026
Obs*R-squared	22.69591	Prob. Chi-Square(13)	0.0455

Source: developed by the author

Table 7

Dickey-Fuller stationarity test

Time series	ADF-value	1% critical value	5% critical value	10% critical value	Prob.	Stationarity
LN(EXPAZ_UKR)	-1.88	-4.35	-3.59	-3.23	0.6341	NO
LN(GDP_UKR)	-1.44	-4.35	-3.59	-3.23	0.8209	NO
LN(EC_OPENNES_UKR)	-2.40	-4.35	-3.59	-3.23	0.3702	NO
LN(EC_POP_AZ)	-0.05	-4.35	-3.595	-3.23	0.9928	NO
ΔLN(EXPAZ_UKR)	-4.33	-4.37	-3.60	-3.23	0.0108	YES
ΔLN(GDP_UKR)	-3.453817	-4.37	-3.60	-3.23	0.0669	YES
ΔLN(EC_OPENNES_UKR)	-5.148006	-4.37	-3.60	-3.23	0.0018	YES
ΔLN(EC_POP_AZ)	-4.196877	-4.37	-3.60	-3.23	0.0147	YES

Source: developed by the author

fication with intercept and for a specification with trend and intercept.

The LN(EC_POP_AZ) series is nonstationary of zero order, and the first differences are stationary for the specification with trend and intercept at the 5% and 10% significance levels.

After determining stationarity, we can proceed to determine the presence of causal relationships between variables, which is carried out according to the Granger causality test. In the present research, these relationships were tested for the lags m = 1.2. The results are presented in the Table 8.

As can be seen from the Table 8, for the lag 1 there is a one-way relationship between the variables LN(GDP_UKR) and LN(EXPAZ_UKR), and for the pairs of variables LN(EC_POP_AZ) and LN(EXPAZ_UKR) there is a two-way causal relationship at a 10% significance level. Between the variables LN(GDP_UKR) and LN(EC_POP_AZ), one-way causal relationships were found for both the lag 1 and the lag 2 at a 10% significance level. Unidirectional relationships were also determined for the pair of variables LN(GDP_UKR) and LN(EC_OPENNES_UKR) for the lag m=1 and for the pair LN(EC_OPENNES_UKR) and LN(EC_POP_AZ) for the lag m=1 at the 5% significance level and for the lag m=2 at the 10% significance level.

The Johansen's cointegration test showed that all variables are cointegrated. The information criteria of Akaike and Schwartz showed that the lag of 2 turned out to be the best. Two cointegration relationships with a degree of integration of 1 and a rank of cointegration equal to 2 are obtained. The results of the carried out test are presented in the Table 9.

Following the procedures of the Eviews 12 program, the following error correction equations were found for the first- and second-order differences of logarithmic values of exports from Azerbaijan in Ukraine with GDP per capita of Ukraine, the openness of the economy of Ukraine and the economically active population of Azerbaijan:

Given that the cointegration rank is 2, constraints are imposed on each of the two cointegrating vectors, equating one of the components of the cointegrating vector to 0. According to economic analysis, there must be two long-term relationships between all variables, one of which links the variables

$$\begin{aligned} D(LN\_EXPORT\_AZ\_UKRAINE) = &-0.279206144855 * (LN\_EXPORT\_AZ\_UKRAINE(-1) - \\ &- 21.8117217516 * LN\_EC\_OPENNES\_UKR(-1) - 107.196069487 * LN\_EC\_POP\_AZ(-1) + 2.01474203421 * @TREND(96) + \\ &+ 837.446142066) + 2.97596511641 * (LN\_GDP\_PERCAPITA\_UKR(-1) - 1.81064569964 * LN\_EC\_OPENNES\_UKR(-1) - \\ &- 1.98826675288 * LN\_EC\_POP\_AZ(-1) + 0.0361623216543 * @TREND(96) + 6.68545754212) - \\ &- 0.300787480895 * D(LN\_EXPORT\_AZ\_UKRAINE(-1)) + 0.315044761265 * D(LN\_EXPORT\_AZ\_UKRAINE(-2)) - \\ &- 2.38394839739 * D(LN\_GDP\_PERCAPITA\_UKR(-1)) - 4.47148237438 * D(LN\_GDP\_PERCAPITA\_UKR(-2)) + \\ &+ 0.18345999567 * D(LN\_EC\_OPENNES\_UKR(-1)) - 0.823782961127 * D(LN\_EC\_OPENNES\_UKR(-2)) - \\ &- 47.2994893002 * D(LN\_EC\_POP\_AZ(-1)) - 70.434086321 * D(LN\_EC\_POP\_AZ(-2)) - 0.64189788465 + \\ &+ 0.181790803815 * @TREND(96) \end{aligned} \quad (5)$$

Table 8

The Granger causality test

	m=1		m=2	
Null Hypothesis:	F-Stat.	Prob.	F-Stat.	Prob.
LN(GDP_UKR) does not Granger Cause LN(EXPAZ_UKR)	3.10844	**0.0912**	1.23716	0.3115
LN(EXPAZ_UKR) does not Granger Cause LN(GDP_UKR)	0.08642	0.7714	0.07977	0.9236
LN(EC_POP_AZ) does not Granger Cause LN(EXPAZ_UKR)	3.81834	**0.0630**	1.87419	0.1795
LN(EXPAZ_UKR) does not Granger Cause LN(EC_POP_AZ)	4.28741	**0.0498**	2.01403	0.1596
LN(EC_OPENNES_UKR) does not Granger Cause LN(EXPAZ_UKR)	0.00018	0.9895	0.01555	0.9846
LN(EXPAZ_UKR) does not Granger Cause LN(EC_OPENNES_UKR)	0.53988	0.4699	0.46591	0.6342
LN(EC_POP_AZ) does not Granger Cause LN(GDP_UKR)	0.15467	0.6977	1.58897	0.2288
LN(GDP_UKR) does not Granger Cause LN(EC_POP_AZ)	3.35844	**0.0798**	2.99473	**0.0728**
LN(EC_OPENNES_UKR) does not Granger Cause LN(GDP_UKR)	1.23350	0.2782	0.95815	0.4005
LN(GDP_UKR) does not Granger Cause LN(EC_OPENNES_UKR)	3.38685	**0.0787**	2.41982	0.1145
LN(EC_OPENNES_UKR) does not Granger Cause LN(EC_POP_AZ)	4.95452	**0.0361**	2.73691	**0.0890**
LN(EC_POP_AZ) does not Granger Cause LN(EC_OPENNES_UKR)	0.00186	0.9659	0.06549	0.9368

Source: developed by the author

$$D(LN\_GDP\_PERCAPITA\_UKR) = 0.0586422380022 * (LN\_EXPORT\_AZ\_UKRAINE(-1) + 21.8117217516 * LN\_EC\_OPENNES\_UKR(-1) - 107.196069487 * LN\_EC\_POP\_AZ(-1) + 2.01474203421 * @TREND(96) + 837.446142066) - 0.894656643502 * (LN\_GDP\_PERCAPITA\_UKR(-1) - 1.81064569964 * LN\_EC\_OPENNES\_UKR(-1) - 1.98826675288 * LN\_EC\_POP\_AZ(-1) + 0.0361623216543 * @TREND(9) + 6.668545754212) - 0.0206664141398 * D(LN\_EXPORT\_AZ\_UKRAINE(-1)) + 0.0405980846745 * D(LN\_EXPORT\_AZ\_UKRAINE(-2)) + 0.393944644993 * D(LN\_GDP\_PERCAPITA\_UKR(-1)) + 0,0497816394089 * D(LN\_GDP\_PERCAPITA\_UKR(-2)) - 0,279860201667 * D(LN\_EC\_OPENNES\_UKR(-1)) - 0.248307660559 * D(LN\_EC\_OPENNES\_UKR(-2)) - 6,92246549538 * D(LN\_EC\_POP\_AZ(-1)) - 0,616894055759 * D(LN\_EC\_POP\_AZ(-2)) + 0.051028152334 + 0.00546304388837 * TREND(96) \quad (6)$$

$$D(LN\_EC\_OPENNES\_UKR) = 0.0431130240072 * (LN\_EXPORT\_AZ\_UKRAINE(-1) + 21.8117217516 * LN\_EC\_OPENNES\_UKR(-1) - 107.196069487 * LN\_EC\_POP\_AZ(-1) + 2.01474203421 * @TREND(96) + 837.446142066) + 0.50115989908 * (LN\_GDP\_PERCAPITA\_UKR(-1) - 1.81064569964 * LN\_EC\_OPENNES\_UKR(-1) - 1.98826675288 * LN\_EC\_POP\_AZ(-1) + 0.0361623216543 * @TREND(9) + 6.668545754212) + 0.00515839173901 * D(LN\_EXPORT\_AZ\_UKRAINE(-1)) - 0.111079862424 * D(LN\_EXPORT\_AZ\_UKRAINE(-2)) + 0.317032051732 * D(LN\_GDP\_PERCAPITA\_UKR(-1)) + 0,298972264875 * D(LN\_GDP\_PERCAPITA\_UKR(-2)) + 0,904361994852 * D(LN\_EC\_OPENNES\_UKR(-1)) + 0.899820324377 * D(LN\_EC\_OPENNES\_UKR(-2)) + 15,6921999519 * D(LN\_POP\_AZ(-1)) + 15,7167765237 * D(LN\_POP\_AZ(-2)) + 0,17260717405 - 0.0376993899297 * TREND(96) \quad (7)$$

$$D(LN\_EC\_POP\_AZ) = -000822311235089 * (LN\_EXPORT\_AZ\_UKRAINE(-1) - 21.8117217516 * LN\_EC\_OPENNES\_UKR(-1) - 107.196069487 * LN\_EC\_POP\_AZ(-1) + 2.01474203421 * @TREND(96) + 837.446142066) - 0.0123386763104 * (LN\_GDP\_PERCAPITA\_UKR(-1) - 1.81064569964 * LN\_EC\_OPENNES\_UKR(-1) - 1.98826675288 * LN\_EC\_POP\_AZ(-1) + 0.0361623216543 * @TREND(9) + 6.668545754212) + 0.005139101627258 * D(LN\_EXPORT\_AZ\_UKRAINE(-1)) + 0.000240436502348 * D(LN\_EXPORT\_AZ\_UKRAINE(-2)) - 0.05391079582473 * D(LN\_GDP\_PERCAPITA\_UKR(-1)) - 0,1330825857013 * D(LN\_GDP\_PERCAPITA\_UKR(-2)) - 0,0374708672382 * D(LN\_EC\_OPENNES\_UKR(-1)) - 0.00921912928873 * D(LN\_EC\_OPENNES\_UKR(-2)) - 0,647394624289 * D(LN\_EC\_POP\_AZ(-1)) - 0,641110174452 * D(LN\_EC\_POP\_AZ(-2)) - 0.0122165620061 + 0.0028509779848 * @TREND(96) \quad (8)$$

Table 9

Johansen's cointegration test

Sample: 1996 2022					
Series: LN(EXPAZ_UKR)LN(GDP_UKR)LN(EC_OPENNES_UKR)LN(EC_POP_AZ)					
Lags interval: 1 to 2					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	1	1	1	2	2
Max-Eig	1	1	1	2	2
*Critical values based on MacKinnon-Haug-Michelis (1999)					
Information Criteria by Rank and Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Rank or	No Intercept	Intercept	Intercept	Intercept	Intercept
No. of CEs	No Trend	No Trend	No Trend	Trend	Trend
Log Likelihood by Rank (rows) and Model (columns)					
0	38.27812	38.27812	40.71596	40.71596	48.07055
1	53.17735	77.39271	79.58361	80.23715	85.84090
2	57.91949	84.16840	85.89913	99.95017	105.5455
3	61.22863	87.50467	88.07214	105.5668	107.6895
4	61.24805	89.35846	89.35846	107.7046	107.7046
Akaike Information Criteria by Rank (rows) and Model (columns)					
0	-0.523176	-0.523176	-0.392996	-0.392996	-0.672546
1	-1.098112	-3.032726	-2.965301	-2.936429	-3.153408
2	-0.826624	-2.847367	-2.824927	-3.829181	**-4.128790***
3	-0.435719	-2.375389	-2.339345	-3.547230	-3.640794
4	0.229329	-1.779872	-1.779872	-2.975386	-2.975386
Schwarz Criteria by Rank (rows) and Model (columns)					
0	1.047562	1.047562	1.374084	1.374084	1.290878
1	0.865311	-1.020217	-0.805535	-0.727578	-0.797300
2	1.529483	-0.393088	-0.272477	-1.178560	**-1.379998***
3	2.313073	0.520660	0.605789	-0.454838	-0.499317
4	3.370806	1.557947	1.557947	0.558776	0.558776

Source: developed by the author

LN(EXPAZ_UKR), LN(EC_OPENNES_UKR), LN(EC_POP_AZ), TREND and does not include the variable LN(GDP_UKR), and the other links the variables LN(GDP_UKR), LN(EC_OPENNES_UKR), LN(EC_POP_AZ), TREND and does not include the variable LN(EXPAZ_UKR). In this case, in the first long-term relationship, the explanatory variable is LN(EXPAZ_UKR), and in the second, the variable LN(GDP_UKR), where the first vector on the first component and the second vector on the second component are normalized [13; 14].

This corresponds to two long-term ratios with statistically significant coefficients:

$$(ECM1)_t = LN(EXPORT\_AZ\_UKRAINE)_t - 21.81172\, LN(EC\_OPEN\_UKR)_t - 107.1961\, LN(EC\_POP\_AZ)_t - 2.014742\, TREND_t + 837.4461. \quad (9)$$

$$(ECM2)_t = LN(GDP\_PERCAPITA\_UKR)_t - 2.8810646\, LN(EC\_OPEN\_UKR)_t - 1.988267\, LN(EC\_POP\_AZ)_t + 0.036162\, TREND_t + 6.685458. \quad (10)$$

According to these ratios, the first two of the estimated ECMs (5)-(8) can be rewritten as follows:

$$\Delta LN(EXPORT\_AZ\_UKRAINE)_t = \\ = -0.279206\,(ECM1)_{t-1} + 2.975965\,(ECM2)_{t-1} + e_{1t}. \quad (11)$$

$$\Delta LN(GDP\_PERCAPITA\_UKR)_t = \\ = 0.058642\,(ECM1)_{t-1} - 0.894657\,(ECM2)_{t-1} + e_{2t}. \quad (12)$$

where the corresponding combinations of the estimated short-term dynamics are denoted as e_{1t}, e_{2t}. Most of the coefficients of these combinations with the first and second differences in the lag values of the variables are statistically insignificant.

In representations (11)-(12), except for the adjustment factor of 2.975965 (t-statistic is 0.90743), all other adjustment factors are statistically significant.

The existing implementation of the Johansen's procedure does not allow imposing restrictions on the coefficients of short-term dynamics, so the possibility of using models (5)-(8) for their analysis is limited. In this regard, these models can only be used for the purpose of analyzing long-term dependence.

The Figure 6 shows graphs of cointegration relationships $Coint1_t = (ECM1)_t$, $Coint2_t = (ECM2)_t$ of the VECM models (5)-(8).

The Table 10 shows the Residual serial correlation LM tests, which did not reveal any problems because the p-value of 0.1977 is bigger than 0.05. The residual heteroskedasticity test did not reveal a heterogeneous problem (0.3445 is bigger than the value of 0.05). The residual normality test showed that the asymmetry value is close to 2 (1.582443) and the kurtosis value is slightly bigger than 2 (2.275669), and the empirical distribution of the residuals is close to normal, since the Jarque-Bera criterion takes the value of 3.858112 with a probability of 0.8697.

For more convincing informativeness of the study, it is necessary to analyze the response of impulse functions using one important tool, which Eviews 12 provides to assess the resistance of the obtained models to shocks (in our case, they mean one-time sharp jumps in exports itself and which affects one standard deviation). These functions represent a median estimate with a 90% confidence interval of the endogenous variable on the positive shock of one standard deviation of the exogenous variable, showing the time to return to the equilibrium trajectory. Here, the duration of the test is limited to 10

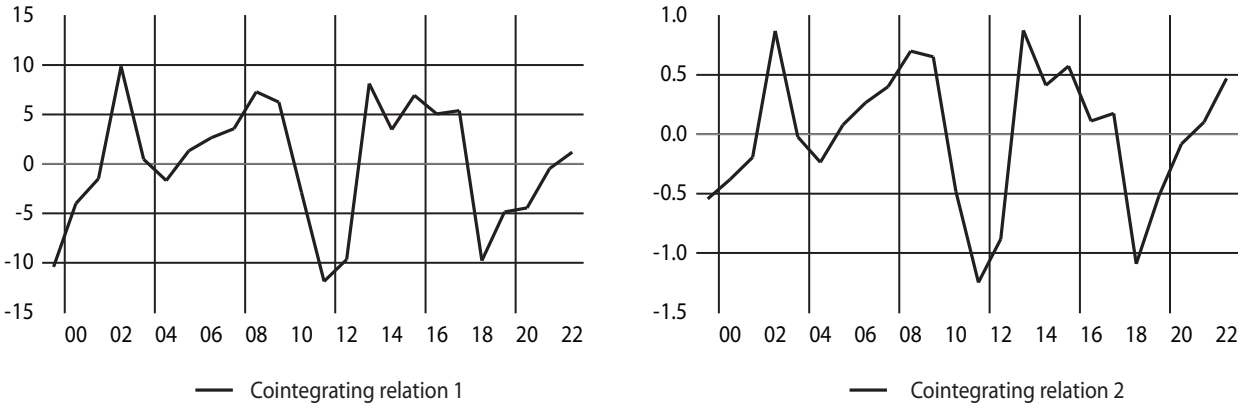

Fig. 6. The cointegration relations hips $Coint1_t$, $Coint2_t$

*Source: d*eveloped by the author

Table 10

Diagnostic tests

Statistics	Estimated value	Probability
Residual Serial Correlation LM Tests	20.52004	0.1977
Residual Heteroskedasticity Tests	227.8233	0.3445
Residual Normality Tests	3.858112	0.8697
Skewness	1.582443	0.8119
Kurtosis	2.275669	0.6852

Source: developed by the author

years. The results of testing on 10-year time horizons are described in the Figure 7. Here, in the time period t = 0, all variables are equal to 0, afterwards the variables in turn increase by one unit of their standard deviation for the entire period. The responses of variables to these shocks in periods t = 1.2,..., 10 were estimated. The values of the variables in these time periods represent the corresponding impulse response functions. The Figure 7 shows the corresponding dynamics for all factors.

The Table 11 shows the calculated values of impulse responses, where the standard error of the VECM model is 1.507727.

To study the influence of exogenous variables on the endogenous variable over the next 10 years, the econometric method of decomposition of variances of forecast errors was used, which determines the contribution of changes in this variable to its own variance of forecast errors and the variance of other variables. The results of the respective tests are shown in the Table 12.

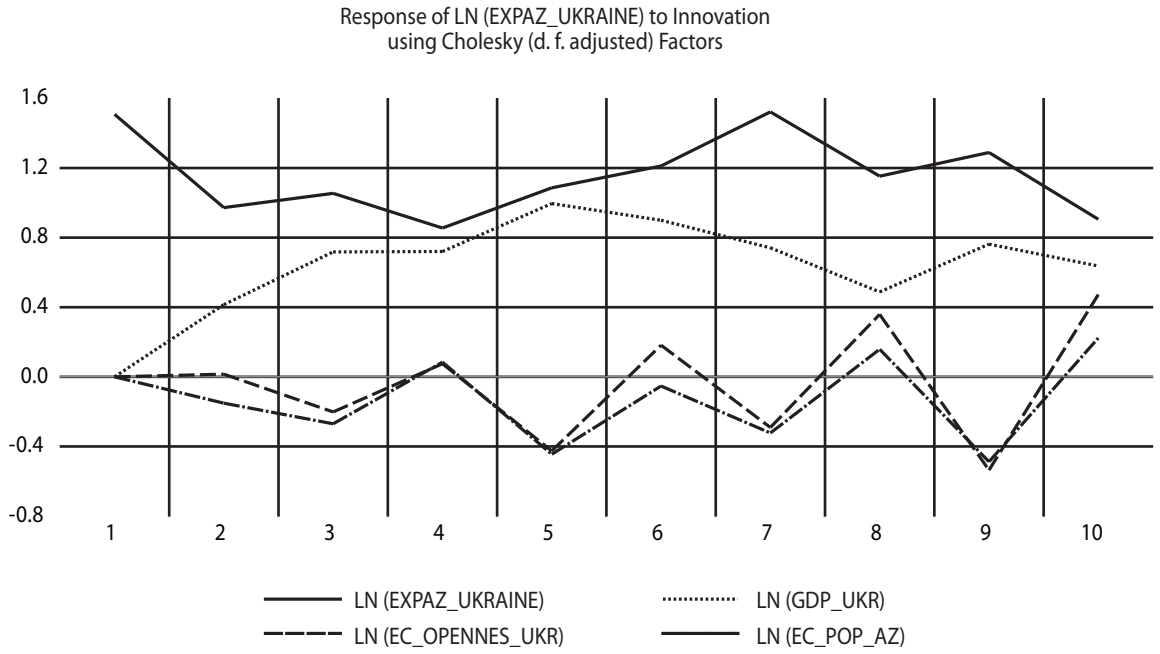

Fig. 7. Impulse response function

Source: developed by the author

Table 11

The calculated impulse responses

Response of LN(EXPAZ_UKR):				
Period	**LN(EXPAZ_UKR)**	**LN(GDP_UKR)**	**LN(EC_OPENNES_UKR)**	**LN(EC_POP_AZ)**
1	1.507727	0.000000	0.000000	0.000000
2	0.972395	0.415439	0.015180	-0.150896
3	1.054726	0.717486	-0.201390	-0.269572
4	0.854744	0.720159	0.075707	0.084842
5	1.085815	0.995575	-0.425206	-0.444312
6	1.211641	0.898886	0.181551	-0.052274
7	1.521685	0.740684	-0.291073	-0.321782
8	1.152233	0.488041	0.358470	0.158794
9	1.288410	0.762416	-0.535952	-0.488053
10	0.904799	0.636426	0.472348	0.223272

Source: developed by the author

The Table 12 shows that in the annual forecast ΔLN(EXPAZ_UKR), the largest errors are met by the shocks ΔLN(EXPAZ_UKR), ΔLN(GDP_UKR), ΔLN(EC_OPENNES_UKR), ΔLN(EC_POP_AZ), respectively, in the amount of 94% on the two-year horizon, 26.6% on the six-year horizon, 4.84% on the ten-year horizon, and 3.55% on the nine-year horizon. The visually described results can be seen in the Figure 8.

Conclusion. For the first-order differences of logarithmic values of exports from Azerbaijan in Ukraine, together with GDP per capita of Ukraine, the openness of the economy of Ukraine and the economically active population of Azerbaijan, a representation is obtained in the form of a sum of combinations of two cointegration equations with the expected signs of adjustment factors and the lag values of the 1st and 2nd orders of differences in logarithmic values of all variables.

The following two statistically significant cointegration relationships are obtained:

$$Coint1_t = \mathrm{LN}(\mathrm{EXPORT\_AZ\_UKRAINE})_t = \\ = -21.811721\ \mathrm{LN}\ (\mathrm{EC\_OPEN\_UKR})_t - \\ - 107.1961\ \mathrm{LN}\ (\mathrm{EC\_POP\_AZ})_t + 2.014742\ TREND_t + 837.4461. \quad (13)$$

$$Coint2_t = \mathrm{LN}(\mathrm{GDP\_PERCAPITA\_UKR})_t = \\ = -1.810646\ \mathrm{LN}\ (\mathrm{EC\_OPEN\_UKR})_t - \\ - 1.988267\ \mathrm{LN}\ (\mathrm{EC\_POP\_AZ})_t + 0.036162\ TREND_t + 6.685458. \quad (14)$$

Table 12

Decomposition of forecast error variances

Variance Decomposition of LN(EXP_AZ_UKRAINE):					
Period	**S.E.**	**LN(EXPAZ_UKR)**	**LN(GDP_UKR)**	**LN(EC_OPENNES_UKR)**	**LN(EC_POP_AZ)**
1	1.507727	100.0000	0.000000	0.000000	0.000000
2	1.847804	94.27160	5.054777	0.006749	0.666875
3	2.270428	84.02274	13.33456	0.791264	1.851436
4	2.533178	78.88166	18.79394	0.724951	1.599455
5	2.994222	69.61033	24.50736	2.535533	3.346771
6	3.358143	68.35867	26.64837	2.308039	2.684928
7	3.785437	69.95636	24.80041	2.407642	2.835586
8	4.006129	70.73343	23.62733	2.950356	2.688888
9	4.337717	69.15499	23.24242	4.043143	3.559441
10	4.506934	68.08986	23.52391	4.843640	3.542593

Source: developed by the author

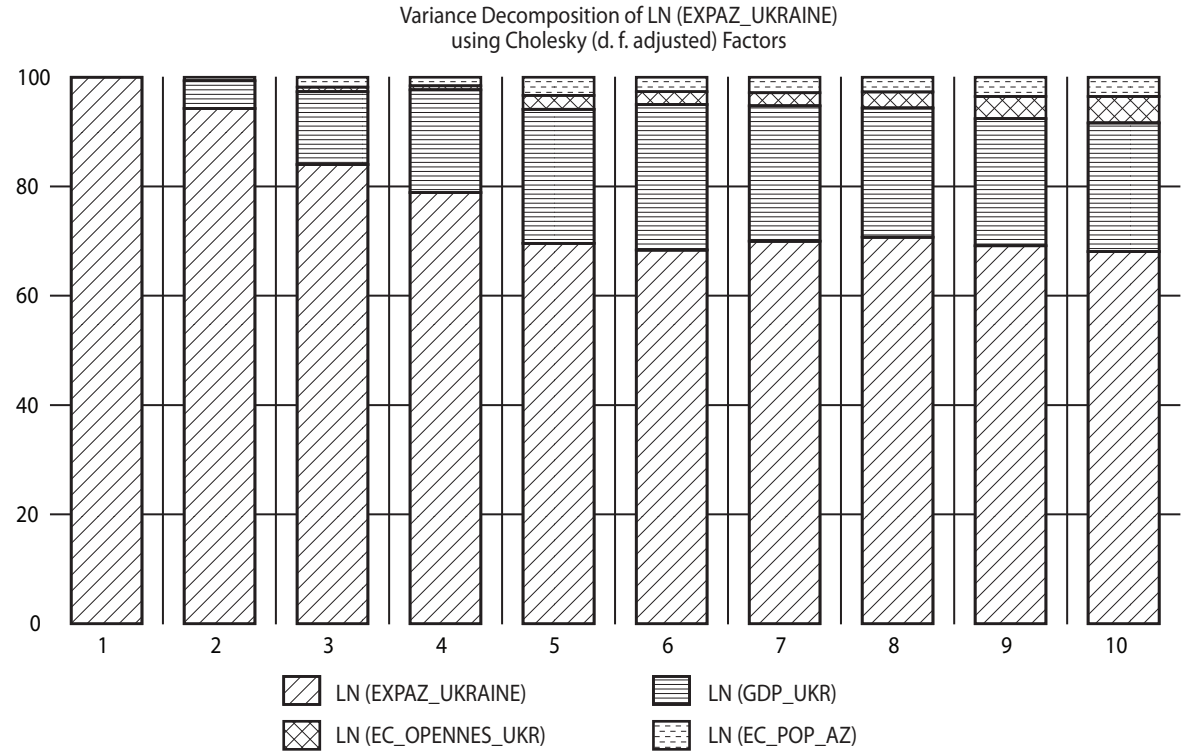

Fig. 8. Decomposition of variances

Source: developed by the author

This relationship represents the long-term and equilibrium joint movements of factors. The imbalance rate coefficients for (13) and (14) are statistically significant values, equal to -0.27 and -0.89, respectively.

Thus, in the absence of changes in other variables, the deviation of the model (13) from the long-term equilibrium for this factor is equal to a 27% increase per year. This means that it takes almost 4 years for the deviation from long-term dependence to return. And for (14) this period is just over a year. At any given time t there is some deviation of the system from the equilibrium position, characterized by the magnitudes $Coint1_t$ and $Coint2_t$. As can be seen from Figure 6, the series , $Coint1_t$, $Coint2_t$ can be considered almost stationary time series, having zero mathematical expectation, i. e. often crossing the zero level, that is, a given system of factors oscillates around the above equilibrium position.

The results of the impulse response functions, variance decomposition and the VECM (Vector Error Correction Model) indicate the fact that the economic indicators used in the analysis for the period from 1996 to 2022 maintain cointe-

gration in the long term with two cointegrating vectors $Coint1_t$, $Coint2_t$, the first of which in the decomposition of the difference LN (EXPAZ_UKR) has the correct sign of the adjustment coefficient, and the second of which the wrong sign with a negligible adjustment coefficient.

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