REPUBLIC OF AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ECONOMETRIC ANALYSIS OF TRADE AND ECONOMIC RELATIONS BETWEEN THE REPUBLIC OF AZERBAIJAN AND UKRAINE

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GENERAL CHARACTERISTIC OF THE WORK

The relevance and degree of development of the topic. In conditions of economic instability with complex political and socio-economic events and a full-scale war between Ukraine and Russia, the subject of the presented dissertation is one of the main topical issues of the study of trade and economic processes of foreign economic activity of Azerbaijan with Ukraine. A particularly salient issue in appraising the prospects of expanding mutually beneficial spheres in the trade and economic, fuel and energy, and logistics domains is to undertake a comprehensive econometric analysis of the interaction of aggregate foreign trade indicators of two strategic partners with complex dynamics. For effective state regulation of mutual trade between these countries, it is essential to conduct statistical, econometric, analytical and dynamic analysis of the complex interaction of the relevant indicators. In the context of the Russian-Ukrainian war, global crises and disrupted logistics, it is of particular importance to determine the conditions for long-term balanced dynamics of azerbaijani-ukrainian export-import operations. In such circumstances, it is of particular scientific interest to study the possibilities of adapting GUAM's development to the challenges of modernity. Conducting a deep econometric analysis of trade flows between these countries using modified gravity model approaches to determine the relationship between the relevant macroeconomic indicators in the current situation, as well as constructing cross-country regression models of economic growth in Ukraine and the Republic of Azerbaijan and ensuring the integration of the two countries against the backdrop of the strong influence of the financial and socio-economic crisis and war for a comparative analysis of the main indicators of inclusive growth of the two countries is relevant.

The gravity model of foreign trade is the principal tool for the assessment of trade flows. The Dutch scientist, Nobel Prize laureate in economics Jan Tinbergen developed a gravity model of the dependence of the volume of trade flow between countries on the size of their economies and the distance between them. Since then, plenty of works have appeared on the application of this model. Scientists in

the post-Soviet region have primarily employed the model's analogy in the context of the EAEU. In particular, the integration processes in the Common Economic Space (Russia, Belarus and Kazakhstan), in the EAEU, between individual and groups of post-Soviet countries were studied by Andronova, I.V.[1], Pylin, A.G.[2], Orudzhev, E.G., Huseynova, S.M.[3] taking into account their regional peculiarities in the course of economic transformation. In the research conducted by Frolov, S.M., Savytska, O.I.[4] the causal relationships between the components of foreign trade turnover in the region and the indicators that characterise the economic situation of the region, the country, and the world were investigated. Kovtun, T.D., Matviienko, A.P.[5] conducted a study on the contemporary trends in international trade in goods and the particularities of Ukraine's foreign trade. The reorientation in the geographical structure of exports from the CIS countries towards the EU countries was analysed and Ukraine's foreign trade relations with Azerbaijan and Georgia were not considered. In the work by Degtev, A.S., Margoev, A.R., Tokarev, A.A.[6] the economic relations of Georgia with Russia, Turkey, Iran and Kazakhstan were analysed using indicators of trade turnover, foreign

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[1] Андронова, И.В. Эволюция интеграционных процессов на постсоветском пространстве. // – Москва: Вестник РУДН, серия Экономика, – 2012. №5, – с. 72-81.

[2] Пылин, А.Г. Внешнеэкономические связи Азербайджана в контексте региональной интеграции // – Москва: Проблемы постсоветского пространства, – 2015. №1, – с. 58-76.

[3] Оруджев, Э. Г., Гусейнова, С.С. Коинтеграционный анализ взаимовлияния ВВП Азербайджана, России, Беларуси и Казахстана // – Санкт-Петербург: Известия Санкт-Петербургского государственного экономического университета, – 2020. № 4(124), – с. 31-41.

[4] Фролов, С.М., Савицька, О.І. Дослідження причинно-наслідкових зв'язків складових зовнішньоторговельного обороту й економічних показників регіону, країни та світу // – Харків: Проблеми економіки, – 2016. №1, – с. 282-288.

[5] Ковтун, Т.Д., Матвієнко, А.П. Актуальні тренди міжнародної торгівлі товарами та особливості зовнішньої торгівлі України // – Харків: Бізнес Інформ, – 2019. №9, – с. 28-35.

[6] Дёгтев, А.С., Маргоев, А.Р., Токарев, А.А. Экономика Грузии в пространстве противоречий региональных держав // – Москва: Вестник МГИМО-Университета, – 2016. №2(47), – с. 219-233.

direct investment, cross-border movement of finance, tourism and transport development. The subject of the interconnection of trade and economic relations of Georgia with Azerbaijan and Ukraine was not addressed. In the research conducted by Khaustova, V.Y., Reshetnyak, O.I., Pronoza, P.V.[7] it was determined that the economic consequences of contemporary military conflicts, in conjunction with other macroeconomic factors, exert a quantitative and qualitative influence on alterations in GDP per capita. In the work of Bulakh, T. M., Ivashchenko, O.A., Motuzka, O.M.[8] the primary risks and threats that hinder the expansion of trade between the two countries are identified. The authors were inclined to believe that the Azerbaijani side is unlikely to prioritise the supply of hydrocarbons, and there is a risk of unilateral violation by Baku regarding the implementation of the free trade zone. The expressed opinion of the authors of this article regarding risk is inappropriate in the realities, a response to which was adequately provided by the author in [4]. Aslanova, E.A., Namazova, E.[9] and Akhmedov, N.G.[10] have produced works which consider the issues of trade and economic cooperation between Azerbaijan and Ukraine, but without conducting an empirical analysis of the relevant indicators. In the study by Belashchenko, D.A., Shodzhonov, I.F.[11] the focus is directed towards the cooperation of Azerbaijan and Ukraine within the framework of international organisations and programmes (GUAM, 'Eastern Partnership'), with a concomitant analysis of

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[7] Хаустова, В.Є., Решетняк, О.І., Проноза, П.В. Сучасні війни та воєнні конфлікти: сутність, класифікація, особливості та вплив на економіку // – Харків: Бізнес Інформ, – 2022. №11, – с. 6-21.

[8] Bulakh, T. M., Ivashchenko, O.A., Motuzka, O.M. Ukraine's Foreign Trade Relations with the Republic of Azerbaijan: State, Risks, Strategic and Innovative Areas of Strengthening // – Kyiv: Statistics of Ukraine, – 2022, 96(1), – p. 40-46.

[9] Асланова, Е.А., Намазова, Э. Экономическое сотрудничество между Азербайджаном и Украиной // – Warsaw: Science Review, – 2018, 8(3), – p. 6-8.

[10] Ахмедов, Н.Г. Направления развития торгово-экономических связей Азербайджана и Украины // – Київ: Європейські перспективи, – 2013. № 13, –с. 180-186.

[11] Белащенко, Д.А., Шоджонов, И.Ф. Украинско-азербайджанские отношения: основные сферы сотрудничества, проблемы и перспективы развития // – Белгород: Via in tempore. История. Политология., – 2020. №47(1), – с. 202-210.

regional crisis processes that exert a direct influence on the formation of the foreign policy of these countries. It is important to note the work of Tskhomelidze, E.[12], which examines the impact of the deep and comprehensive Free Trade Area on the integration of Georgia, Moldova and Ukraine into the European Union. However, the Republic of Azerbaijan as a member of GUAM is not touched upon. Empirical calculations for the construction of interrelationships of macroeconomic indicators for the former post-Soviet countries have been carried out in a small number of studies, and the issues of corrective mechanisms of impact have not been addressed.

The extant literature reviews noted and directly related to the topic of this thesis further confirm the relevance of the dissertation topic.

The object and subject of the research. The object of the study is trade and economic relations of the Republic of Azerbaijan and Ukraine. The subject of the study is the econometric analysis of trade and economic relations of the Republic of Azerbaijan and Ukraine both in the framework of bilateral relations and in the context of the GUAM regional programme.

The aim and objectives of the research. The study's objective is to construct an econometric model to estimate the factors influencing the level of trade relations between the two countries; determination of cointegration relations and joint movements of the corresponding dynamic series of economic indicators; building dynamic long-run equilibrium models for dynamic analysis of effective state regulation of foreign trade and economic activities both directly between the two countries and within GUAM; conducting a comparative cross-country analysis of the major components of inclusive growth of the two countries to build models of long-term joint equilibrium movement, as well as identifying imbalances and adjusting the degree of proximity of inclusive indicators. The purpose of the work has determined the setting and solving of the following tasks:

[12] Tskhomelidze, E. Effectiveness of the deep and comprehensive Free Trade Area: A structural gravity model approach // Journal of Eastern European and Central Asian Research (JEECAR), – 2022, 9(6), – p. 965-977.

-conducting econometric modelling of the impact of nominal GDP of these countries on trade turnover between them;

- the implementation of econometric analysis of cointegration processes between Azerbaijan, Ukraine and Georgia through nominal indicators of Azerbaijan's GDP and trade turnover of this country with the other two;

-realization of econometric analysis of long-term interrelation of per capita GDP indicators by PPP between Ukraine and Azerbaijan;

- cointegration analysis and error correction model construction of trade flows between Azerbaijan and Ukraine and their economies in per capita terms;

-cointegration analysis of export-import operations between the Republic of Azerbaijan and Ukraine in nominal value;

-cointegration analysis of changes in GDP growth of Azerbaijan Republic and Ukraine

-economic and econometric analysis between these countries trade flows and GDP per capita, economic openness and economically active population.

Research methods. The following primary methodologies were employed in the research process: methods of multivariate correlation and regression analysis[13]; econometric methodology of gravity modelling[14]; econometric cointegration methodology Engle-Granger[15], Johansen[16] interrelationships between non-stationary time series.

The main points to be defended are:

- the econometric analysis and VECM model results were performed for nominal indicators of trade turnover between Azerbaijan and Ukraine and GDP of these countries;

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[13] Вербик, М. Путеводитель по современной эконометрике. Перевод с английского В.А.Банников / М.Вербик. – John Wiley & Sons Inc., – 2008. – 616 p.

[14] Tinbergen, J. Shaping the World Economy: Suggestions for an International Economic Policy. – New-York: The Twentieth Century Fund, – 1962. – 330 p.

[15] Engle, R., Granger, C. Cointegration and Error Correction: Representation, Estimation and Testing // Econometrica, – 1987, 55, – p. 251-276.

[16] Johansen, S. Statistical Analysis of Cointegrating Vectors // Journal of Economic Dynamics and Control, – 1988, 12, – p. 231-254.

- the results of a cointegration analysis of Azerbaijan's GDP and trade turnover of this country with Ukraine and Georgia in the context of balancing trade between the three countries;

- The results of the cointegration analysis and the constructed ECM models of cross-country regression of per capita economic growth of Ukraine and the Republic of Azerbaijan for the equilibrium of joint movement of GDP at PPP of both countries and the conditions of imbalance reduction;

- built ECM-model encompassing trend-factor cointegration relationship between trade turnover between Ukraine and Azerbaijan and the GDP of these countries in per capita aspect;

- developed VECM model in the form of two vectors of cointegration between volumes of Azerbaijan's exports to Ukraine and GDP per capita of Ukraine, economically active population of Azerbaijan and openness of Ukraine's economy on Azerbaijan with unstable joint movements of these indicators and elimination of instability by corrective mechanisms;

- constructed statistically significant error correction equations for differential values of exports and imports of Azerbaijan and Ukraine and estimates of deviations from the equilibrium trajectory;

- obtained an ARDL cointegration relationship between the indicators of GDP growth rates of Azerbaijan and Ukraine with trend component and the conditions of adequacy of error correction models.

The scientific novelty of the research:

- as a result of correctly constructed VECM-model for qualitative economic analysis of balanced foreign trade relations between Ukraine and Azerbaijan econometrically justified recommendations have been developed, which allow to conduct dynamic analysis of effective state regulation of export-import operations between these countries;

- VECM model for indicators of cointegration of Azerbaijan's GDP and trade turnover of this country with Ukraine and Georgia in GUAM membership in conditions of Ukrainian-Russian and Georgian-Russian military-political and economic crisis has been constructed, which allows to measure deviations from equilibrium, as well as divergence of the corrective system from the equilibrium

trajectory;

-the conditions of long-term equilibrium of the joint movement of GDP by PPP of Ukraine and Azerbaijan were determined, taking into account structural breaks in both variables, the speed of imbalance liquidation for negative adjustment coefficients, as well as the positive adjustment coefficient, at which the joint movement converges from the equilibrium trajectory;

- the model of vector error correction was constructed taking into account impulse response functions and variance decomposition for economic indicators of export volume from Azerbaijan to Ukraine, GDP per capita of Ukraine and openness of Ukraine's economy on Azerbaijan, as well as the economically active population of Azerbaijan, with structural factor shifts and two statistically significant cointegration relations with trend component, the first of which has the correct sign of the adjustment coefficient, and the second - the wrong sign, which preserve cointegration in the long run with weakly unstable equilibrium joint movements;

- cointegration relationship between export and import volume indicators between Azerbaijan and Ukraine with structural spikes in 2009 and 2012 with correctable and uncorrectable imbalances was obtained;

- an ARDL model with distributed lag and linear trend of long-term equilibrium movement of GDP growth rates of Azerbaijan and Ukraine was built.

Theoretical and practical significance of the research. The theoretical significance of the research results lies in the development of econometric tools for the assessment of mutual trade between countries, taking into account the economies of these countries and regional peculiarities, as well as crisis conditions. The practical significance of the research findings lies in the possibility of utilising the methods and tools proposed in the dissertation to determine the strategy of stabilising export-import relations and directions of economic cooperation.

Approbation and application. The primary results of the dissertation have been published in the author's papers [1-9]. The ideas and results of the research were reported and discussed at the scientific

seminar of the department of 'Mathematical Economics' of Baku State University, at international scientific-practical conferences:1st International Scientific and Practical Conference "Modern Knowledge: Research and Discoveries"[3], «The sustainable development of economy and administration: problems and perspectives III international scientific and practical conference» (Baku,2023) [6], «Tendencii ekonomicheskogo razvitiya v XXI veke» (Minsk, 2024) [7], and at the conference of young researchers «Gənc tədqiqatçıların VII Respublika elmi konfrans» (Baku,2024) [8]. The methods and results of the dissertation are applicable to the development of public policy in assessing the real state of trade relations in the present period and obtaining adequate forecasts of the development of bilateral economic cooperation between the countries in the future, as well as multilateral trade and economic relations in the regional context.

Name of the organisation where the dissertation was carried out. The dissertation was performed at the Department of Mathematical Economics at Baku State University.

The total volume of the dissertation with the indication of the volume of structural sections of the dissertation separately. The dissertation consists of an introduction, 3 chapters including 9 paragraphs and 7 points, a conclusion, a list of used literature (88 titles) and appendices. The volume of appendices is 45 pages. The dissertation contains 4 graphs, 24 figures and 27 tables.

The volume of the work is 218 printed A4 pages, the volume of the introduction - 16473 characters, chapter I - 94701 characters, chapter II - 45784 characters, chapter III - 36585 characters, conclusion - 8373 characters. The total volume of the work (excluding figures, tables, graphs, list of references and appendices) is 201916 characters.

DISSERTATION SUMMARY

Paragraph 1.1. of Chapter I provides a dynamic analysis of the economies of the Republic of Azerbaijan and Ukraine and trade and economic co-operation between them. Trends in the development of

the economies and foreign trade of Azerbaijan and Ukraine, as well as trade and economic cooperation between them for the period 1992-2019 are described in the author's master's thesis[17].

Here, attention is focused on the above-mentioned relations in the period from 2020 to 2024. In this period, as a result of the 44-day Patriotic War (from 27 September to 8 November 2020) and the defeat of the Armenian occupation army, the primary task of the Republic of Azerbaijan was to restore and reintegrate the territories liberated from Armenian occupation into the economy of Azerbaijan.

The GDP of Azerbaijan for the period from 2020 to 2023 was 42693000,00; 54825411,71; 78807470,24; 72356176,59 thousand dollars[18] accordingly by year. Furthermore, Azerbaijan's GDP per capita during the aforementioned was 4229,91; 5408,04; 7770,60; 7155,10 USD respectively. Concurrently, Azerbaijan's GDP underwent a contraction in 2020, attributable to the impact of the pandemic. The country's revenues have also been adversely affected by reduced demand for oil and falling oil prices. Azerbaijan began to actively work to reduce its dependence on hydrocarbons and develop renewable energy sources. In addition, the country continued to develop trade and economic relations with various countries, including Turkey, Russia, China and the European Union. The role played by regional projects such as the Trans-Caspian International Transport Route (Middle Corridor) has been significant in the strengthening of these links.

GDP of Ukraine for the interval from 2020 to 2023 was respectively by years 156617722,34; 199765859,94; 161 989520,19; 178757021,81 thousand dollars[19]. The GDP per capita of Ukraine for the same period was 3751,73; 4827,84; 4576; 5181,4 USD.

Trade and economic relations between Azerbaijan and Ukraine in the period 2020-2023 were characterized by significant strengthening, despite the challenges posed by the global pandemic and geopolitical instability in the region The war in Ukraine in 2022

[17] Ализаде, А.Р. Коинтеграционный анализ торгово-экономических отношений между Азербайджанской Республикой и Украиной: / магистерская дис. / – Баку, 2021. – 69 с.

[18] https://data.worldbank.org/

[19] https://data.worldbank.org/

had an impact on trade and economic relations, creating logistical and financial challenges. Nevertheless, the countries were able to adapt to the new conditions. Simultaneously, the trade turnover between Azerbaijan and Ukraine for the specified period was as follows: 771451,3; 922483,5; 617704,1; 353774,6 thousand US dollars respectively. Azerbaijan continued to supply oil and oil products to Ukraine via Baku-Supsa and Baku-Tbilisi-Ceyhan pipelines. From the onset of the war to the present day, Azerbaijan has been providing humanitarian aid to the affected regions of Ukraine.

In 2020, Ukraine's total imports of goods totalled just $59.3 billion, while Azerbaijan's were only 0.6 per cent of that amount.

The index of economic freedom of Ukraine, as determined by the 2021 data, was 56.2. In contrast, the coefficient for Azerbaijan was 70.1, placing it in the category of countries with basic freedom of economy (group of 70-79 points). The respective scores for these countries in 2022 were 54.1 and 61.6. In 2023, this indicator exhibited a slight decrease for Azerbaijan, with a total of 61.4 points. The trends for the entire period 1995-2022 were plotted for Ukraine as a logarithmic function, and for Azerbaijan for the period 1995-2023 with a linear trend.

At present, the trade relations between Ukraine and Azerbaijan are being impacted by the geopolitical tensions and war between Russia and Ukraine, which is exerting a negative influence on the mutual flow of trade between the two countries.

In paragraph 1.2. by modifying the econometric methodology of gravity modelling VECM-models of the relationship between the foreign trade turnover of the Republic of Azerbaijan and Ukraine and the nominal GDP of these countries utilizing annual data from 1994 to 2023 were constructed. For this purpose, the initial step was to undertake key auxiliary steps of econometric modelling. Following this, a formal model of the impact of GDP on trade turnover between Azerbaijan and Ukraine was constructed by logarithmisation of the multiplicative-power relation, which does not satisfy the classical Gauss-Markov conditions for estimating the parameters of the model. The gravity model has been modified by the following alterations to its standard formulation: both GDPs are raised to a power with

unknown regression parameters, and the random component $\varepsilon_t, t = \overline{1,30}$, which includes the total influence of all weakly influencing factors unaccounted for in the model, i.e. the whole set of other factors is aggregated into one uncertain factor ε_t. In this case, the problem is reduced to establishing the function $TRADE\_TURNOVER_t = f(GDP\_UKR_t, GDP\_AZ_t, \varepsilon_t)$ and its parameters from the observed values of the variables and the unobserved variable ε_t. It is hypothesised that ε_t is subject to a lognormal distribution, characterised by zero mathematical expectation and finite variance, and is estimated on a par with the parameters of the main observable components. In this study, a comprehensive cointegration analysis of the specified time series was conducted utilising stationarity tests, the Granger causality test, and the Engle-Johansen cointegration test. A one novel, statistically significant new trend-cointegration decomposition is obtained, which determines the deviations of the joint movements of the studied logarithmic values of the indicators from the equilibrium trajectories:

$$\mathbf{Coint1_t} = \mathrm{LN\_TRADE\_TURNOVER_t} + 1.068880\mathrm{LN\_GDP\_AZ_t} - \\ -3.969953\mathrm{LN\_GDP\_UKR_t} + 0.044810\mathrm{TREND} + 41.43146 \quad (1)$$

Despite the significance of the coefficients (1), the coefficient of determination for the general VECM model is 0.16. On this basis, a VECM model with a lag of 3 is proposed

$$\mathrm{D(LN\_TRADE\_TURNOVER)} = -0.374887880602 * \\ * (\mathrm{LN\_TRADE\_TURNOVER}(-1) - 4.69281847364 * \\ * \mathrm{LN\_GDP\_AZ}(-1) + 8.21805751727 * \mathrm{LN\_GDP\_UKR}(-1) - \\ -0.0462260466112 * \mathrm{@TREND}(94) - 83.3849457892) + \\ +0.0414220748002 * \mathrm{D(LN\_TRADE\_TURNOVER}(-1)) + \\ +0.58271338107 * \mathrm{D(LN\_TRADE\_TURNOVER}(-2)) + \\ +0.214362166378 * \mathrm{D(LN\_TRADE\_TURNOVER}(-3)) - \\ -0.995053855374 * \mathrm{D(LN\_GDP\_AZ}(-1)) - 1.30240732261 * \\ * \mathrm{D(LN\_GDP\_AZ}(-2)) + 2.62129487402 * \mathrm{D(LN\_GDP\_AZ}(-3)) +$$

$$+2.44980750899 * \mathrm{D(LN\_GDP\_UKR(-1))} + 1.83205082663 * \\ * \mathrm{D(LN\_GDP\_UKR(-2))} + 0.403939440132 * \\ * \mathrm{D(LN\_GDP\_UKR(-3))} - 0.624479265976 + \\ +0.0164506881333 * \mathrm{@TREND(94)} \qquad (2)$$

with one cointegration vector, formed from the first-order difference levels of logarithmic values of the considered variables, are correct and adequate with the available statistical data. Then, the graphs of the obtained cointegration relations and residuals of non-equilibrium errors for LN_TRADE_TURNOVER have been analyzed. The values of inverse characteristic roots of the corresponding characteristic polynomial of the 12th degree and their location inside the unit circle in the complex plane with two unit roots were determined, which demonstrates the propensity of time series to second-order integration, indicating the low power of the used probabilistic tests for stationarity. The results obtained were compared with a model with a limited sample period of 1994-2018. In the context of the 1994-2018 period, for the second-order integrated indicators $\Delta^2 LN(\cdot)$ the corresponding cointegrating vector β (1; 1.021300; -0.51663; -0.0241085) with t-statistics elementwise equal to 1.96, 1.28, 7.955, and the correcting vector α (-0.790773; -0.081164; -0.030074; 4.510271) with corresponding t-statistics of -3.63, -1.06, -0.28, 3.83 for lag 2-2 with one cointegration vector for the first order difference level combinations determine the equilibrium trajectory of the joint motions. Here the symbol "·" denotes the corresponding variables. Analogous estimates are obtained for lag 3-3. The increase in the number of a small number of the sampling period resulted in the change of the order of integration of variables from two to one, and the rank of cointegration changed. These two significant moments are related to the behaviour of the examined variables in the unstable economic situation in Ukraine. It is imperative for the foreign trade authorities of both countries to undertake monitoring utilising the methodology of constructed gravity models and cointegration relations, error correction mechanisms based on the findings of each reporting year, and to take into account the irreversibility of the moving average process involved in the ECM model.

An analysis of the impulse response function with a median estimate with a 90% confidence interval of the endogenous variable to a positive shock of one standard deviation of the exogenous variable has been carried out. The response of LN_TRADE_TURNOVER to a pulse of the variable LN_TRADE_TURNOVER in the previous period first decreases slightly in the second period, then rises rapidly until period 4, after which there is a sharp decline until period 7 and a gradual stabilisation thereafter. The response of LN_TRADE_TURNOVER to a pulse of the variable LN_GDP_AZ in the previous period is top-down until period 3, with a sharp rise until period 4, after which the response gradually declines until period 9 and stabilises after that. The effect of the LN_GDP_UKR pulse on LN_TRADE_TURNOVER is characterised by significant instability, with a marked decrease in period 4 and a sharp incline in period 7, followed by a subsequent decline. It is only in the 8th period when the stability of the response is observed. In the following stage of the research, the econometric method of decomposition of forecast error variance was employed in order to examine the estimation of the contribution of exogenous variables to the change in the endogenous variable over the next decade. In the annual ΔLN_TRADE_TURNOVER forecast, the largest errors are observed in the ΔLN_TRADE_TURNOVER, ΔLN_GDP_AZ, and ΔLN_GDP_UKR shocks, respectively, at the two-year horizon, three-year horizon, and ten-year horizon, with errors of 97.6%, 3.02%, and 20%, correspondingly. The following diagnostic tests were also performed: tests of residual serial correlation of Lagrange multipliers (Residual Serial Correlation LM Tests), heteroscedasticity test (Residual Heteroskedasticity Tests), as well as a normality test (Residual Normality Tests). The Residual Serial Correlation of Lagrange Multipliers test (Residual Serial Correlation LM Test) indicates the absence of serial correlation, as evidenced by a p-value of 0.4914 exceeding the significance level of 0.05. Residual Heteroskedasticity Tests demonstrated that there is no heterogeneous problem, as the probability of 0.2093 exceeds the value of 0.05. The Residual Normality tests demonstrated that the value of skewness approximates 2, with a value of 1.907594 being obtained, while the

value of kurtosis approximates 1, with a value of 1.168928 being determined. Moreover, the empirical distribution of the residuals is close to normal, as indicated by the Jarque-Bera criterion taking a value of 3.076522 with a probability of 0.7992.

Paragraph 1.3. studies the peculiarities of trade and economic relations between Azerbaijan, Georgia and Ukraine. A graphical analysis of the logarithmized nominal trade turnover of Azerbaijan with Georgia has been conducted, and a trend of dynamics with linear and quadratic functions of approximation has been constructed, along with corresponding high values of coefficients of determination. The descriptive statistics of the respective indicators were analysed, after which the possibilities of cointegration for both options were investigated. The option with a quadratic trend was deemed to be the preferable one. The ECM model incorporating a trend-factor component has been constructed to demonstrate the dependence of Azerbaijan's GDP on trade turnover with Ukraine and Georgia in GUAM format for the period 1994-2023 with statistically significant cointegration relation and with a normalised cointegrating vector $\beta\,(1;\ -0{,}312133;\ -1{,}171486)$ and a matrix vector of error correction equal to $\alpha\,(-0{,}294864;\ 0{,}68341;\ 0{,}381561)'$ with significant elements. The first element demonstrates a slow movement of the ΔLN_GDP_AZ indicator towards equilibrium after shocks of exogenous variables at previous time moments, the term for complete elimination of the deviation from equilibrium is provided after a period of approximately 3.5 years. Furthermore, an analysis of the factors of trade turnover of Azerbaijan with Ukraine, as well as Georgia, reveals that the distance of deviations from the equilibrium trajectory is respectively equal to 0.683410 and 0.381561. This indicates that these indicators are not returning to the equilibrium position of the system, as these coefficients are positive. The LM-test, normality test and the test of constancy of variance showed that there is no serial correlation in the residuals (test probability 0.1187, which exceeds the 0.05 level), amd that the distribution is close to normal (Jarque-Bera statistic 2, 378748 with a probability of p=0.8818) with a minor right-sided skewness (0.332191) and an excess of 2.046557 (the allowed value within 3±1), as well as the absence of heteroscedasticity (test

probability 0.3018). A comparative analysis of the obtained results with the results of the constructed regression model for the same factors based on data for 1994-2018 has been carried out. The results obtained can be used to develop specific measures in the dynamic analysis of effective state regulation of export-import operations between the three countries and balancing of Azerbaijan's mutual trade with Ukraine and Georgia. Georgia should intensify its foreign trade policy aimed at altering the structure in favor of net exports of foreign trade turnover with the other two countries.

In paragraph 1.4. a VECM-model of the mutual influence of export-import operations between Ukraine and Azerbaijan is constructed based on nominal data for the period 1994-2023 with cointegration vector β (1; -0,9117801) and adjustment vector α (-0,978475; -0,254749)' with statistically significant coefficients without taking into account structural changes. The first component of the vector α illustrates that, subsequent to deviation from the equilibrium trajectory of movement, the series LN_EXPORT_UKR will return to equilibrium within a period of one year. The second component demonstrates that the return to equilibrium of the series LN_IMPORT_UKR is ensured within a period of four years. A superior VECM model has been formulated to take into account the structural shifts in 2009 and 2012 for the variables LN_IMPORT_UKR and LN_EXPORT_UKR respectively with a significant vector β (1; -0,202896) and α (-1,387879; -0,059907)' with a substantial first component that exhibits a small scaling

$$\begin{aligned} \mathrm{D(EXPORT\_UKR)} = & -1.38787880343 * (\mathrm{EXPORT\_UKR}(-1) - \\ & -0.202895570596 * \mathrm{IMPORT\_UKR}(-1)) + 0.353196184 * \\ & * \mathrm{D(EXPORT\_UKR}(-1)) + 0.0258454601911 * \\ & * \mathrm{D(IMPORT\_UKR}(-1)) + 653524.070433 * \mathrm{DUMMY2009} - \\ & -402778.906026 * \mathrm{DUMMY2012} \end{aligned} \quad (3)$$

$$\begin{aligned} \mathrm{D(IMPORT\_UKR)} = & -0.0599066090379 * (\mathrm{EXPORT\_UKR}(-1) - \\ & -0.202895570596 * \mathrm{IMPORT\_UKR}(-1)) - 0.0116577673864 * \\ & * \mathrm{D(EXPORT\_UKR}(-1)) + 0.146412213619 * \end{aligned}$$

$$* \mathrm{D(IMPORT\_UKR}(-1)) + 45801.4232036 * \mathrm{DUMMY2009} - \\ -60151.2447117 * \mathrm{DUMMY2012} \quad (4)$$

The introducing of dummy variables enabled the estimation of the coefficients at these variables, which proved to be statistically significant. This indicates the significance of the indicated structural changes in the time series. When returning to equilibrium or close to equilibrium after shocks in the previous year for the trajectory of Ukraine's exports, and for Ukraine's imports, a small negative value suggests that such a return will be very slow. For the resulting VECM models (3)-(4) with a cointegration vector β (1; -0,202896) of the cointegration relation containing neither a trend nor a constant and including two dummy variables allowing to take into account structural changes at time points in 2009 and 2012, it was found that the error correction mechanism works for both variables D(EXPORT_UKR) and D(IMPORT_UKR).

In paragraph 2.1.an econometric analysis is performed of the relationship between the indicators of per capita GDP per PPP between Azerbaijan and Ukraine and the graphical visualisation of these indicators with quadratic trends and high coefficients of determination is also presented. A modified quadratic-trend-factor formal model was constructed with a coefficient of determination of 0,96, but a low Durbin-Watson statistic (0,68). Therefore, cointegration analysis was conducted, and a VECM model

$$\mathrm{D(LN\_GDP\_UKR)} = -0.464595170524 * (\mathrm{LN\_GDP\_UKR}(-1) - \\ -0.441205405708 * \mathrm{LN\_GDP\_AZ}(-1) - 0.0125103538354 * \\ * @\mathrm{TREND}(90) - 4.76590513093) + 0.145703848322 * \\ * \mathrm{D(LN\_GDP\_UKR}(-1)) - 0.0883635610149 * \\ * \mathrm{D(LN\_GDP\_UKR}(-2)) - 0.356968819685 * \\ * \mathrm{D(LN\_GDP\_AZ}(-1)) + 0.150407424203 * \\ * \mathrm{D(LN\_GDP\_AZ}(-2)) - 0.175546230229 + \\ +0.0213242970159 * @\mathrm{TREND}(90) - 0.139613007631 * \\ * \mathrm{DUMMY2007} - 0.196412146176 * \mathrm{DUMMY2008} \quad (5)$$

$$\mathrm{D(LN\_GDP\_AZ)} = -0.137628966514 * (\mathrm{LN\_GDP\_UKR}(-1) -$$

$$-0.441205405708 * \text{LN\_GDP\_AZ}(-1) - 0.0125103538354 * * @\text{TREND}(90) - 4.76590513093) + 0.214782245962 * * \text{D}(\text{LN\_GDP\_UKR}(-1)) + 0.0272832248626 * * \text{D}(\text{LN\_GDP\_UKR}(-2)) + 0.284685798392 * * \text{D}(\text{LN\_GDP\_AZ}(-1)) + 0.0405206835644 * * \text{D}(\text{LN\_GDP\_AZ}(-2)) - 0.0429605502171 + +0.010181332598 * @\text{TREND}(90) - 0.150424923006 * * \text{DUMMY2007} - 0.0575370232921 * \text{DUMMY2008} \quad (6)$$

was constructed to analyze the relationship between the indicators of per capita GDP per PPP between Azerbaijan and Ukraine for the time period 1990-2023 incorporating dummy variables for structural shifts in the first differences in 2007 and 2008 for the factors LN_GDP_UKR and LN_GDP_AZ, respectively, and with the trend in the statistically significant cointegrating equation, where the coefficient of imbalance elimination is statistically significant and equal to -0.46, which shows ensuring convergence to the equilibrium trajectory after 2.2 years. The VECM models (5)-(6) have been constructed using the Engle-Granger approach, contain a VAR(2) for differences with a lag of two years, a constant term and a trend in the cointegration relation, as well as two dummy variables accounting for structural changes in the series in 2007 and 2008. Both dummy variables are statistically significant for equation (5), however, for equation (6), the variable dummy2007 is weakly significant and dummy2008 is insignificant. The efficacy of the error correction mechanism is found to be effective for equation (5) and only marginally effective for equation (6). At the same time, for a statistically significant cointegration equation with a trend and a constant ter

$$\text{Coint}_t = \text{LN\_GDP\_UKR}_t - 0{,}4412\text{LN\_GDP\_AZ}_t - -0{,}0125\text{TREND}_t - 4{,}7659 \quad (7)$$

the predicted values of the variables were evaluated by the following indicators: Root Mean Squared Error (RMSE), Mean Absolute Error

(MAE), Mean Absolute Percentage Error (MAPE) and Theil inequality coefficient. For LN_GDP_UKR, the corresponding indices are 0.076986, 0.064292, 0.714359, 0.004282, and for LN_GDP_AZ they are 0.167319, 0.142597, 1.595908, 0.009249. The average approximation error for LN_GDP_UKR is 6%, which does not exceed the acceptable level of 10%, and for LN_GDP_AZ is 14%, which is slightly higher than the acceptable level. The Theil coefficients for both variables are found to be close to 0 and possess low values of 0.004282 and 0.009249, respectively, thereby indicating the accuracy of the model. These criteria confirm the quality of forecasts.

In order to ensure the long-term equilibrium of the joint movement of GDP per capita PPP of both countries and to reduce the imbalance, it is necessary to increase the scale of diversified inter-country trade flows, investments that have an impact on GDP growth and welfare, it is important for the respective government services of these countries to conduct monitoring at the end of each reporting year to compare key transmission indicators with each other in order to adjust the degree of proximity of the factors under study.

In paragraph 2.2, a cointegration analysis and construction of an error correction model of trade flows between Azerbaijan and Ukraine, and the economies of these countries in the per capita aspect, was carried out. The corresponding statistically significant cointegration relationship for the variable LN_TRADE_TURNOVER_AZ, representing trade turnover per capita of Azerbaijan, was obtained

$$\boldsymbol{Coint_t} = \mathrm{LN\_TRADE\_TURNOVER\_AZ_t} - \\ -3{,}433200\mathrm{LN\_GDP\_AZ_t} + 5{,}743750\mathrm{LN\_GDP\_UKR_t} - \\ -0{,}128548TREND_t - 18{,}49720 \qquad (8)$$

This relationship is defined as a long-run and equilibrium joint movement of factors. It is stationary in relation to trend i.e. the series $\boldsymbol{Coint_t} + 0{,}128548TREND_t + 18{,}49720$ is stationary. The trajectory of this series follows the trend line, being above and below this line, with sufficient frequency and change of positions above and below. In this case, the impact of preceding shocks is diminished over time. The coefficient of imbalance speed for trade turnover per capita of Azerbaijan is statistically significant equal to -0.49. It is

demonstrated that under shock effects of independent factors, a positive imbalance will ensure a fall, and a negative imbalance will ensure an increase in the trade turnover per capita of Azerbaijan. Liquidation and return to the equilibrium trajectory from the impact of shocks of the previous year is ensured in about two years. The imbalance adjustment coefficients for the remaining equations are statistically insignificant values. In this instance, the simultaneous joint deviation for the year is 0,49+0,07+0,09=0,65 or 65%.

The statistically significant linear-trend-factor cointegration relationship for trade turnover per capita in Ukraine is as follows

$$Coint_t = \text{LN\_TRADE\_TURNOVER\_UKR}_t - \\ -3{,}127293\text{LN\_GDP\_AZ}_t + 5{,}091795\text{LN\_GDP\_UKR}_t - \\ -0{,}133414TREND_t - 14{,}19084 \qquad (9)$$

This ratio is a long-run and joint factor movement. The adjustment coefficient for Ukraine's trade turnover per capita is statistically significant, with a value of -0.53, indicating a return to equilibrium after a period of almost two years. For D(LN_GDP_AZ), the adjustment coefficient is positive, the long-run equilibrium does not reflect the direction of causality, and if there is a shock in the previous year, the deviating trajectory does not recover in the following year. In general, the simultaneous joint deviation from equilibrium is 0,53+0,08+0,09=0,7 or 70%.

In paragraph 2.3, an ARDL model of the long-run equilibrium movement of changes in the GDP growth rates of the Republic of Azerbaijan and Ukraine for the period 1994-2023 was constructed, which is a long-run and equilibrium relationship with an adjustment coefficient for the variable GROWTH_GDP_AZ equal to -0.61 and shows a return to the equilibrium trajectory approximately 1.5 years after shocks to the independent variable.

In paragraph 3.1. of Chapter III, a statistical analysis of the dynamics of the openness of Ukraine’s economy on Azerbaijan and the economically active population of Azerbaijan was carried out using the Excel software package for analytical alignment of the considered series, the equations of trend development in time were

found in the form of a polynomial of the second order, allowing to establish the nature of the dynamics development, a formal model of Azerbaijani exports to Ukraine was constructed taking into account the considered factors and the possibilities of cointegration of the corresponding time series were proposed. In this case, the multiplicative-power relationship between the factors with the usual normal distribution of the random term is considered as the initial dependence. The reasons for the unsatisfiability of the classical least squares method approach have been established, which are as follows: heteroscedasticity in the residuals, falling into the uncertainty zone of the observed value of the Durbin-Watson statistic. In paragraph 3.2. a vector error correction model (VECM) of cointegration between export volumes from Azerbaijan to Ukraine, GDP per capita of Ukraine, openness of Ukraine's economy on Azerbaijan and economically active population of Azerbaijan is constructed with the correct application of a wide range of cointegration analysis approaches taking into account the two most favoured of all detected structural shifts (the relative small number of observations allows including only two dummy variables as exogenous variables in the VECM model) in the indicator of exports from Azerbaijan to Ukraine in 2011 and in the indicator of the openness of Ukraine's economy on Azerbaijan in 2017 with a trend component in a statistically significant cointegration relation with restrictions on adjustment elements, and with the adaptation coefficient for the variable of exports from Azerbaijan taking the value of -0,07, interpreted as a very slow movement to the equilibrium state when deviating from it in the previous period. An ECM model

$$\begin{aligned}\mathrm{D(LN\_EXPORT\_AZ)} = {} & -0.07487361719 * (14.5281231659 * \\ & * \mathrm{LN\_EXPORT\_AZ}(-1) + 2.68144879563 * \mathrm{LN\_GDP\_UKR}(-1) - \\ & -63.192718832 * \mathrm{LN\_OPEN\_EC\_UKR}(-1) - 185.511968221 * \\ & * \mathrm{LN\_EAP\_AZ}(-1) + 2.44277416729 * \mathrm{@TREND}(96) + \\ & +1274.00970292) + 0 * (-69.3303050931 * \\ & * \mathrm{LN\_EXPORT\_AZ}(-1) - 80.6409104878 * \mathrm{LN\_GDP\_UKR}(-1) + \\ & +351.57388922 * \mathrm{LN\_OPEN\_EC\_UKR}(-1) + 811.748901068 *\end{aligned}$$

$$* \mathrm{LN\_EAP\_AZ}(-1) - 8.15384269121 * @\mathrm{TREND}(96) -$$
$$- 4942.20963621) + 0.0235950198023 *$$
$$* \mathrm{D}(\mathrm{LN\_EXPORT\_AZ}(-1)) - 0.0207132350039 *$$
$$* \mathrm{D}(\mathrm{LN\_EXPORT\_AZ}(-2)) - 0.689677953767 *$$
$$* \mathrm{D}(\mathrm{LN\_GDP\_UKR}(-1)) + 0.487494676739 *$$
$$* \mathrm{D}(\mathrm{LN\_GDP\_UKR}(-2)) - 3.3437616125 *$$
$$* \mathrm{D}(\mathrm{LN\_OPEN\_EC\_UKR}(-1)) - 2.03097749662 *$$
$$* \mathrm{D}(\mathrm{LN\_OPEN\_EC\_UKR}(-2)) - 28.214151996 *$$
$$* \mathrm{D}(\mathrm{LN\_EAP\_AZ}(-1)) - 22.9538063322 * \mathrm{D}(\mathrm{LN\_EAP\_AZ}(-2) -$$
$$-1.8107841238 + 0.308512113623 * @\mathrm{TREND}(96) -$$
$$-3.51322302867 * \mathrm{DUMMYEXP2011} - 1.535146806 *$$
$$* \mathrm{DUMMYOPEN2017} \qquad (10)$$

with a convenient structure of imposing restrictions on the correction factors is obtained, the model satisfies the approximation of the studied time series, consistent with the available observations.

CONCLUSIONS

1. By modifying the econometric methodology of gravitational modelling VECM-models of the interrelation between foreign trade turnover of the Republic of Azerbaijan and Ukraine and the nominal GDP of these countries utilising annual data of 1994-2023 were constructed, which enables to conduct dynamic analysis of effective state regulation of export-import operations between these countries. (the findings for the period 1994-2018 have been published in the author's paper [1], co-authored with E.G.Orudzhev, with the formulation of the problem being attributed to the latter and the solution being the exclusive domain of the applicant);
2. The author's VECM model for indicators of cointegration between the GDP of Azerbaijan and its trade turnover with Ukraine and Georgia in GUAM membership, based on annual data from 1994

to 2023, has been developed in the conditions of the military-political and economic crisis between Ukraine and Russia, and Georgia and Russia, which allows to measure deviations from equilibrium, as well as the divergence of the corrective system from the equilibrium trajectory (the results for the period 1994-2018 have been published in the author's papers [2,3]);

3. Conditions of long-term equilibrium of the joint movement of GDP by PPP of Ukraine and Azerbaijan according to annual data of 1990-2023, the speed of liquidation of imbalance for negative adjustment coefficients are determined, and the positive adaptation coefficient at which the joint motion deviates from the equilibrium trajectory (the results for the period 1990-2022 have been published in the author's paper [4]);
4. A cointegration analysis was conducted, and error correction models of trade flows between Azerbaijan and Ukraine, and the economies of these countries in terms of per capita, were constructed for the time period 1994-2023 (the results pertaining to the period 1994-2022 have been published in the author's academic papers [5,6]);
5. An ARDL model with distributed lag and linear trend for the long-term equilibrium movement of GDP growth rates of Azerbaijan and Ukraine was constructed utilising annual data from 1994 to 2023 (the results for the period 1994-2022 have been published in the author's paper [7]);
6. A cointegration relationship between export and import volume indicators between Azerbaijan and Ukraine on annual data from 1994 to 2023 with correctable and uncorrectable imbalances, was discovered (the results for the period 1994-2022 have been published in the author's paper [8]);
7. The model of vector error correction, incorporating considerations of impulse response functions and decomposition of forecast error variance, has been proposed for the analysis of economic indicators, including export volume from Azerbaijan to Ukraine, GDP per capita of Ukraine and openness of Ukraine’s economy on Azerbaijan, as well as the economically active population of Azerbaijan, with two statistically significant cointegration relations

with trend component have been identified: the first of which exhibits the correct sign of the adaptation coefficient, while the second displays an incorrect sign, thereby preserving cointegration in the long run with weakly unstable[9].

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1. Orudzhev, E., Alizade, A. Cointegration analysis of the impact of Azerbaijan and Ukraine GDPs on the trade turnover between these countries // Journal of International Studies, – 2021, 14(3), – p. 274-290.
2. Алізаде, А. Р. к. Про одну задачу коінтеграції торговельних зв'язків України, Азербайджану та Грузії // – Харків: Бізнес Інформ, – 2022. №7, – с. 49-60.
3. Alizade, A. Econometric analysis of trade relations between Azerbaijan, Ukraine and Georgia // Scientific Collection «InterConf+» with the Proceedings of the 1st International Scientific and Practical Conference «Modern Knowledge: Research and Discoveries». Vancouver, Canada, – 2023, – p. 16-34.
4. Алізаде, А. Р. к. Про спільні зміни ВВП за паритетом купівельної спроможності на душу населення України та Азербайджанської Республіки // – Харків: Проблеми економіки, – 2023. №3, – с. 5-14.
5. Ализаде, А. Коинтеграция показателей двусторонних торговых потоков между Азербайджаном и Украиной и экономик этих стран в подушевом аспекте // Journal Of Baku Engineering University: Economics And Administration, – 2023, 7(2), – p. 104-117.
6. Ализаде, А. Построение ECM-модели взаимосвязи торгового оборота Азербайджана с Украиной и ВВП этих стран в подушевом аспекте // The sustainable development of economy and administration: problems and perspectives III

international scientific and practical conference proceedings. Baku, Azerbaijan, – 2023, – p. 28-37.
7. Ализаде, А.Р. Коинтеграционный анализ изменений темпов роста ВВП Азербайджанской Республики и Украины // Тенденции экономического развития в XXI веке : материалы VI Междунар. науч.-практ. конф., посвящ. 25-летию экон. фак. БГУ, – Минск: – 28 – 29 февраля, – 2024, – с. 146-147.
8. Ализаде, А. Коинтеграция экспортно-импортных операций между Азербайджанской Республикой и Украиной // GƏNC TƏDQİQATÇILARIN VII RESPUBLİKA ELMİ KONFRANSININ MATERİALLARI, – Bakı: Azərbaycan Universiteti, – 15 mart, – 2024, – s. 133-135.
9. Alizade, A.R. Johansen's Cointegration Analysis of Some Factors of Economic Growth and Exports of Products from the Republic of Azerbaijan to Ukraine // – Kharkiv: The Problems of Economy, – 2024. №2, – p. 5-20.

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