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Analysis of Cointegration Relationships Between Azerbaijan's Balance of Payments and World Oil Prices

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ABSTRACT

In a number of countries, an important economic problem is the imbalance of foreign economic relations, which manifests itself, in particular, in the positive and negative balances of the current account of the balance of payments. The **purpose** of the study is to investigate the impact of rising oil prices on Azerbaijan's balance of payments using a vector error correction model (*VECM*). In the paper, the analysis correctly applied econometric methods, the necessary statistical procedures to determine the order of integration of non-stationary time series of Azerbaijan's current account balance and the prices of Brent crude oil and West Texas Intermediate, covering the period from 1995 to 2024, to identify and evaluation of the model parameters to check the adequacy and validity of the forecast values both in the short term and in a long term. When constructing survey graphs and implementing econometric test procedures, the Eviews and Excel application packages were used. As a result of this study, a *VECM* was formulated, which makes it possible to carry out an economic and statistical analysis of the functioning of the current account of the balance of payments and world oil prices. The constructed models make it possible to measure both deviations from the equilibrium state and the rate of equilibrium recovery. It is **concluded** that the long-term equilibrium relationship between the variables can be considered stable, as stability is restored in short periods after disturbances from shock reactions to changes in world oil prices. The constructed models make it possible to measure both deviations from the equilibrium state and the rate of equilibrium restoration.

Keywords: payment balance; oil prices; stationarity; Dickey–Fuller test; cointegration; error correction model; responses of impulse functions

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INTRODUCTION

Statistical study of the development of the modern Azerbaijani economy for analysis and forecasting is only possible with an accurate description of its interaction with the outside world. The reasons for this are integration into world market relations, strong dependence on foreign trade, and the movement of investments in "two" directions between countries. In close dependence on foreign trade relations, the processes of raw material exports and consumer and investment imports are highlighted.

One of the tasks of Azerbaijan's macroeconomic policy, as well as in many countries with a market economy, is to ensure a positive balance of payments and foreign economic trade. The importance of solving the above problem is also related to the role of Azerbaijan in the world economy in the form of energy trade.

Processes in the global economy are complex processes. The decisions of the leading central banks, the growth of supplies in the world energy market, the economic slowdown in some developing countries, and other global factors can lead to a sharp decline in oil and gas prices in the world market. And this leads to cheaper national currencies. The exchange rate of national currencies and the state of the balance of payments are closely interconnected. Since the result of the balance of payments, a deficit is a change in the national currency's exchange rate. And the exchange rate of the national currency is one factor that significantly affects the state of the country's balance of payments. A long-term deficit in the balance of payments or a fall in the value of the national currency leads to other economic problems, such as covering the foreign exchange deficit by using official reserves, reducing their volumes, etc.

REVIEW OF LITERATURE

Many scientific articles have been written about these issues, taking into account regional differences in the process of national economic transformation and analyzing integration processes between individual countries and groups of countries in the post-Soviet space. The works frequently employ complex economic and statistical analysis methods to identify patterns of development of foreign economic cooperation and the direction of improvement of economic integration processes. In works [1–5], using the methods of complex economic and statistical analysis, regularities in the development of foreign economic cooperation, directions for improving economic integration processes are revealed. In studies of the dynamics, crises of the balance of payments, models of a small open economy are often used. Small open economy models are often used in studies of the dynamics of the balance of payments crises. Article [3] considers Azerbaijan's trade and investment relations for 2000–2014 in the context of problems of regional integration. A comprehensive analysis of foreign non-economic ties has shown that Azerbaijan seeks to pursue a multi-vector and balanced foreign policy, taking into account the interests of the leading regional players (the EU, Turkey, and Russia) but avoiding direct participation in integration. Considering the model of limited growth in the balance of payments in [6] the authors, assuming an insignificant effect of changes in the real exchange rate, in this paper predict that the long-term growth of a country's GDP can be approximated by the ratio of real export growth to the income elasticity of demand for imports. The formation of the model is studied, taking into account capital flows, interest payments on public debt, and terms of trade, and various tests are carried out for the model. The paper [7] deals with the problems of the balance of payments associated with rising oil prices. Necessary adjustments need to be made to the current account or trade balance subcomponents that take into account the country's high energy bills caused by persistently rising crude oil prices to prevent persistent oil price shocks from having a permanent impact on the current account deficit. The authors in the study look at empirical data collected in Turkey and show that, in the long run, a steady increase in net exports of products and services supports the current account balance. The studies performed were statistically significant for more than 24 periods. In the study [8], three structural equations are estimated as long-term equilibrium relations using Johansen's cointegration analysis for Brazil, Korea, Mexico and Turkey for 1980–2016. Hypotheses about the homogeneity of the real exchange rate and world income are also tested using adjustment factor tests. The Thurlwall Act was in favor of Brazil and Korea. In [9], an equilibrium business cycle model has been examined in which the probability of devaluation is an endogenous variable dependent on foreign exchange reserves. In [10], the authors conclude that the addition of controls for other important macroeconomic variables, which have risen significantly in recent decades, has little effect on the results regarding unemployment and inflation. Greater reliance on international trade increases inequality in some specifications. In works [11, 12], systems of cointegrated equations are studied. The simulation results show that the growth of government consumption does not change the real exchange rate and depreciates [13, 14], the nominal rate. Here, dependencies between cross-sectional units (countries) and cointegration between growth and trade openness were tested. The results reject the hypothesis of a general, unidirectional and homogeneous relationship between trade openness and economic development in Latin American countries.

EMPIRICAL TESTS AND RESULTS

Dynamic descriptions of the considered time series of the current account of Azerbaijan's balance of payments and world oil prices are shown in *Fig. 1.*

The average annual oil prices shown in *Fig. 1* are inflation-adjusted using a standard consumer price index. It should be noted that the combined chart includes a histogram describing the dynamics of the current account of Azerbaijan's balance of payments and polygons characterizing the growth or decline in prices for Brent and West Texas Intermediate oil in 1995–2024. This type of graph creates conditions for comparative analysis and visibility of patterns in time series.

The analysis of the cointegration of time series should begin with studying the order of integration of the series under study according to the Dickey-Fuller

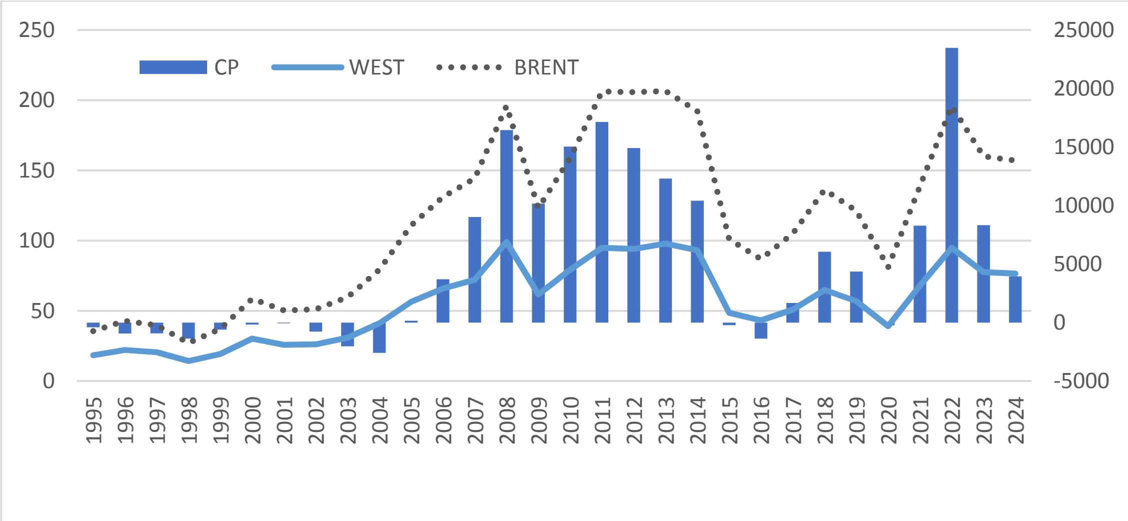

Fig. 1. **Time Series Dynamics of Azerbaijan's Current Account Balance of Payments, Brent and West Texas Intermediate Oil Prices in 1995–2024 (Million US Dollars)**

Source: Prepared by the author in the Excel program. Macroeconomic statistics URL: https://www.cbar.az/ (accessed on 16.01.2025). Central Bank of Azerbaijan. URL: https://www.cbar.az/page-41/macroeconomic-indicators (accessed on 16.01.2025). Average annual Brent crude oil price from 1976 to 2024. Empowering people with data https://www.statista.com/statistics/262860/uk-brent-crude-oil-price-changes-since-1976/ (accessed on 16.01.2025). Crude Oil Prices — 70 Year Historical Chart. Macrotrends is the premier research platform for long-term investors. URL: https://www.macrotrends.net/1369/crude-oil-price-history-chart (accessed on 16.01.2025).

criterion, that is, with the definition of stationarity or vice versa. Unfortunately, often the statistics of a linear relationship between non-stationary variables lead to the misconception that the relationship between the dependent and independent variables is not random, but strong. In particular, any two nominal economic variables are likely to be correlated with each other, even if neither has a causal effect on the other. To substantiate the above and demonstrate possible false dependencies, we first performed a regression analysis.

Analyzing the works [15–19] carried out in this area and this direction, based on a comparative analysis of the considered studies, the results of descriptive statistics in *Table 1* and the combined graph in *Fig. 1* in this study, which include the dynamics of the development of time series of the current account of the balance of payments of Azerbaijan, prices for Brent and West oil and characterizing the primary growth trend of these variables, it can be assumed that the functional relationship between the considered time series under consideration can be described by a linear model of multiple regression. Let us designate the current account of the balance of payments as the dependent variable (y), and the prices for Brent and West oil as independent variables (x_1, x_2):

$$y_t = a_0 + a_1 x_{1t} + a_2 x_{2t} + \varepsilon_t, \quad (1)$$

where ε_t is the random component of the multiple regression model, which includes all unaccounted-for factors that affect the dependent variable. a_0 the free term of the model, a_1 and a_2 the regression coefficients that explain and estimate the influence of independent variables x_1 and x_2 on the dependent variable y.

The method of least squares was applied. The studied time series covers the periods from 1995 to 2024. The initial data in the development of the model were taken from official sources.

Based on the results obtained, the multiple regression model can be represented in the following formal form:

$$y_t = \underset{(0.334582)}{53.427 x_1} + \underset{(0.918517)}{166.283.x_2} - \underset{(-4.509531)}{7339.198}. \quad (2)$$

According to the results of regression analysis with the above parameters, the number of observations was

Table 1

Descriptive Statistics of Variables y, x_1, x_2

Descriptive Statistics	CP(y)	brent(x_1)	west(x_2)
Mean	5129.350	58.50900	56.18400
Median	2696.300	57.94500	56.71500
Maximum	23478.10	111.6300	99.06000
Minimum	–2589.000	12.80000	14.39000
Std. Dev.	7104.365	31.39784	27.69499
Skewness	0.870958	0.189600	0.083397
Kurtosis	2.709828	1.830549	1.708003
Jarque-Bera	3.898091	1.889258	2.121345
Probability	0.142410	0.388824	0.346223
Sum	153880.5	1755.270	1685.520
Sum Sq. Dev.	1.46E + 09	28588.91	22243.36
Observations	30	30	30

Source: Prepared by the author in the EViews program.

30; $R^2 = 0.77$; *F-stat.* = 47.7; probability = 0.00; *DW* = 0.93. The coefficient of determination indicates that the independent variables included in the model explain the dependent variable by 77%. Despite the fact that *Criterion F* received a fairly reliable estimate with high probability, the *F* and *t* criteria usual limiting Gaussian distribution or χ^2 [20]. With degrees-of-freedom $k1 = m + 1 = 3$, $k2 = n - m - 1 = 27$, where m is the number of independent factors in the model, tabular value for the criterion $F_{tab.} = 2.3$. Since the condition $F_{calc.} > F_{tab.}$ is satisfied, this allows us to speak about the significance of the coefficient of determination. The t-test for brent oil is 0.33 (*prob.* = 0.7405) and for west oil is 0.91 (*prob.* = 0.3665). This indicates the low significance of independent factors. The result obtained by the *DW* criterion cannot be considered satisfactory, which is likely a symptom of spurious regression that occurs with non-integrated, non-stationary time series. The critical limits of the *DW* criterion at $n = 30$ and $k = 2$ are $D_L = 1.070$ and $D_U = 1.339$. Observed value $D_{obs.} = 0.93$. Since $D_{obs.} < D_L$ and D_U then, we can conclude that there is a positive autocorrelation of the residuals of the model.

The Jarque-Bera test indicates the normal distribution of the levels of the series *y* the current account of the balance of payments, and x_1 is the price of Brent crude oil, x_2 is the price of West Texas Intermediate oil. As can be seen from the results of descriptive statistics in *Table 1*, $JB_{CP} = 3.898091$, with *prob.* = 0.142410 > 0.05, and $JB_{Brent} = 1.889258$, with *prob.* = 0.388824 > 0.05, $JB_{West} = 2.121345$, with *prob.* = 0.346223 > 0.05, which confirms the normality of the distribution for all variables.

Although most of the results are satisfactory and indicate a strong relationship, this cannot justify a cointegrating relationship. which is what we wanted to show.

To check the stationary of the times series *CP, brent, west* under consideration, an extended *Dickey-Fuller* test (*ADF*) should be carried out [21, 22]. The *ADF* test for the original series, for series with first and second differences with input parameters constant, maximum lag = 7, lag length = 0, gave the following results (*Table 2*).

The original rows show not the best results. This means that the original series *CP, brent, west* are non-stationary and, in particular, are *I*(1)-series. *t*-tests with breakpoints of 1%, 5%, and 10% give low scores with low probability. What cannot be said about series with the first and second difference — rather high *t*-tests, with high probabilities. The results showed that the first

Table 2

Results of the Dickey-Fuller Test

Variables	Critic. 1%	Critic. 5%	Critic. 10%	t-statistic	Probability
According to original rows					
CP	−3.679322	−2.967767	−2.622989	−2.316491	0.1738
brent	−3.679322	−2.967767	−2.622989	−1.788418	0.3785
west	−3.679322	−2.967767	−2.622989	−1.872646	0.3398
By rows with first differences					
CP	−3.699871	−2.976263	−2.627420	−5.027421	0.0004
brent	−3.689194	−2.971853	−2.625121	−4.969133	0.0004
west	−3.689194	−2.971853	−2.625121	−5.517640	0.0001
By rows with second differences					
CP	−3.711457	−2.981038	−2.629906	−7.219804	0.0000
brent	−3.711457	−2.981038	−2.629906	−6.996703	0.0000
west	−3.711457	−2.981038	−2.629906	−6.917630	0.0000

Source: Prepared by the author in the EViews program.

and second order difference operators are stationary series.

When modeling, the presence of homoscedasticity in the residuals is significant. This reduces the results' quality and, in general, the model's effectiveness. Since the variances are calculated with large deviations, the values of the *F* and *t* statistics become unreliable. To test the homoscedasticity of the residuals, the null hypothesis about their stability is tested $H_0:\sigma_1^2=\sigma_2^2=\ldots=\sigma_n^2$. An alternative hypothesis of heteroscedasticity of the residuals of the regression model $H_1:\sigma_1^2\neq\sigma_2^2\neq\ldots\neq\sigma_n^2$.

Using the Eviews package, a white test is carried out, and the observed value of the statistic and the p-value for it are calculated. The conclusion about the acceptance or refutation of the main hypothesis is made by comparing the p-value with the selected significance level of 0.05. The test results are as follows and are presented in *Table 3*.

At $n = 30$ $Obs{*}R^2$ — the coefficient of determination is 8.143251 and it is less than the value $\chi^2_{0,148}(5)=4.61$. The corresponding *p*-value exceeds the significance level of 0.05 (0.148 > 0.05), i.e. the null hypothesis that the random term is homoscedastic may not be rejected.

The *Granger* test was conducted to test the causal relationships between the factors. When implementing this test, lag values are used, the volume limit of which depends on the length of the time series since an increase in the lag values reduces the size of the series under study. The *Granger causality* test with annual years from 1995 to 2024 ($n = 30$) on the studied series gave some positive results, but they were not enough. Therefore, rows with quarterly data were used for the test implementation, which sufficiently increased the possibility of conducting the test. So, with quarterly data from 2000 to 2021 ($n = 88$) with lag values from 2 to 11, the following results are obtained, which confirm the presence of a two-way causal relationship. *Table 4* shows some of them.

Engle-Granger and *Johansen's* test was conducted to identify cointegration relationships and determine cointegration relationships between time series. This test makes it possible to implement different trends and choose the direction with the best performance among them, fulfilling the cointegration test's necessary conditions [23]. According to the test results obtained, with possible data specifications (*Table 5*), where, according to the smallest values of the *Akaike* and *Schwartz* information criteria, the procedures

Table 3

White's Test Results

F-statistic	1.788354	probability F(5.24)	0.1534
Obs*R-squared	8.143251	probability Chi-Square (5)	0.1485

Source: Prepared by the author in the EViews program.

Table 4

Granger Test Results

Null hypothesis	F statistic	Probability	Laqs	Number of observations
Brent does not Granger Cause CP	2.75025	0.0342	4	84
West does not Granger Cause CP	2.84778	0.0296	4	84
Brent does not Granger Cause CP	2.69070	0.0130	8	80
West does not Granger Cause CP	2.80038	0.0102	8	80
Brent does not Granger Cause CP CP does not Granger Cause brent	2.44868 2.08150	0.0191 0.0454	9	79
Brent does not Granger Cause CP CP does not Granger Cause brent	2.24732 2.21965	0.0246 0.0265	11	77
West does not Granger Cause CP CP does not Granger Cause west	2.24375 2.03296	0.0249 0.0427	11	77

Source: Prepared by the author in the EViews program.

were carried out to provide us with information on the integration of the first order of the studied time series of the current account of the balance of payments of Azerbaijan, world prices for Brent and West oils, which allows us to perform the *Johansen* test for time series cointegration. *Table 5* analyzes five hypotheses in total. It is determined that the linear and quadratic trends indicate the presence of cointegration relationships between the studied time series *CP, Brent, West*. The lowest values of the *Akaike* and *Schwartz* criteria in *Table 5* for a deterministic linear trend with a constant and a direction are 34.29106* and 35.84984*, respectively, and for a deterministic quadratic trend with a continuous and a movement, 34.34249 and 36.08695. Cointegration tests with linear and quadratic (with regular and directional) types of trends indicate the presence of cointegration relationships. Rejecting the null hypothesis about the absence of co-integrating vectors, we accept the alternative hypothesis about the existence of one vector for both *Trace* and *Maximum Eigenvalue* tests for a linear trend since the calculated values exceed the critical ones. It cannot be said that there are two vectors for a linear trend because, in this case, the calculated values are less than the critical ones. And for this reason, the null hypothesis is accepted. When testing hypotheses, high probabilities (significance levels) that allow us to make decisions are considered (*Table 6*). For a quadratic trend in both *Trace* and *Maximum Eigenvalue* tests, we reject the null hypothesis and accept an alternative theory about the presence of two co-integrating vectors, taking into account the high probability and the fact that the calculated values exceed the critical ones (*Table 7*).

The above conclusions confirm the following results.

According to the Trace test: for a linear trend 52.28138 > 42.91525 with prob = 0.0045; 21.50599 < 25.87211 with prob. = 0.1590; for a quadratic trend 50.05335 > 35.01090 with prob. = 0.0007 and 20.68863 > 18.39771 with prob = 0.0235; 2.630865 < 3.841466 with prob. = 0.1048.

According to the Maximum Eigenvalue test: for a linear trend 30.77538 > 25.82321 with prob. = 0.0102; 18.05797 < 19.38704 with prob. = 0.0771; for a quadratic

Table 5

Results of the Engle-Granger and Johansen Test for Time Series Cointegration

Included observations: 27
Sample (adjusted): 1995–2024
Series: CP, brent, west
Lags interval: 1 to 2

Number of cointegrating ratios at the 0.05 level

Trend	There are no deterministic trends in the data	There are no deterministic trends in the data	Presence of a deterministic linear trend in the data	Presence of a deterministic linear trend in the data	Presence of a deterministic quadratic trend in the data
Test	No Intercept No trend	Intercept No trend	Intercept No trend	Intercept Trend	Intercept Trend
Trace	0	0	1	1	2
Max-Eig	0	0	0	1	2

Source: Prepared by the author in the EViews program.

Table 6

Trace Test Results (Lag Interval from 1 to 2, First Differences)

a) For a Linear Deterministic Trend

Hypothesis	Alternative hypothesis	Trace statistic	Crit.5%	Probability
H_0 : r = 0*	H_A : r > 0	52.28138	42.91525	0.0045
H_0 : r = 1	H_A : r > 1	21.50599	25.87211	0.1590
H_0 : r = 2	H_A : r > 2	3.448021	12.51798	0.8196

b) For a Quadratic Deterministic Trend

Hypothesis	Alternative hypothesis	Trace statistic	Crit. 5%	Probability
H_0 : r = 0*	H_A : r > 0	50.05335	35.01090	0.0007
H_0 : r = 1*	H_A : r > 1	20.68863	18.39771	0.0235
H_0 : r = 2	H_A : r > 2	2.630865	3.841466	0.1048

Source: Prepared by the author in the EViews program.

Note: * Rejecting the null hypothesis, accepting the alternative hypothesis at the 0.05 level.

trend 29.36472 > 24.25202 with prob. = 0.0097 and 18.05777 > 17.14769 with prob. = 0.0368; 2.630865 < 3.841466 with prob. = 0.1048.

Recent tests show that there are cointegrated relationships between the variables *CP, Brent, West*. This confirms the authenticity of the correlation and the long-term relationship between them. The generated vector error correction model expresses the long-term relationship of the time series in an equilibrium form. Also, *VECM* confirms the authenticity of close correlations between variables, which allows measuring the distance from the uniform state [23]. The results of the Granger feedback test allow for the construction of vector error correction models for all variables.

Table 7

Results of the Maximum Eigenvalue Test (Lag Interval from 1 to 2, First Differences)

a) For a Linear Deterministic Trend

Hypothesis	Alternative hypothesis	Maximum Eigenvalue statistic	Crit. 5%	Probability
H_0 : r = 0*	H_A : r > 0	30.77538	25.82321	0.0102
H_0 : r = 1	H_A : r > 1	18.05797	19.38704	0.0771
H_0 : r = 2	H_A : r > 2	3.448021	12.51798	0.8196

b) For a Quadratic Deterministic Trend

Hypothesis	Alternative hypothesis	Maximum Eigenvalue statistic	Crit. 5%	Probability
H_0 : r = 0*	H_A : r > 0	29.36472	24.25202	0.0097
H_0 : r = 1*	H_A : r > 1	18.05777	17.14769	0.0368
H_0 : r = 2	H_A : r > 2	2.630865	3.841466	0.1048

Source: Prepared by the author in the EViews program.

Note: * Rejecting the null hypothesis, accepting the alternative hypothesis at the 0.05 level.

The results of the procedures and tests carried out before the construction of vector error correction models are very encouraging and allow us to accept the studied time series *CP, Brent, West* as stationary. Having excluded insignificant variables from the initially obtained *VEC* models, we re-evaluated the models. The following error correction equations (3), (4), (5) for *CP*, *brent* and *west* for second-order differences are obtained. The exclusion of some variables from the primary models has made it possible to simplify them and improve the qualitative indicators in the *VECM*, such as t statistics and standard errors. Models (3), (4) and (5) are statistically correct, standard errors are indicated in parentheses.

$$\Delta(\Delta CP) = \underset{(0.0577)}{-0.499698}(\Delta CP(-1) + \underset{(86.2497)}{130.5023}\Delta BRENT(-1) - \underset{(89.7339)}{326.7058}\Delta WEST(-1) +$$

$$+10681.4) + \underset{(0.2492)}{0.722694}\Delta(\Delta CP(-1)) + \underset{(0.2503)}{0.303134}\Delta(\Delta CP(-2)) - \underset{(53.641)}{133.0822}\Delta(\Delta BRENT(-1))$$

$$-\underset{(0.5947)}{47.1678}\Delta(\Delta BRENT(-2)) \tag{3}$$

$$\Delta(\Delta BRENT) = \underset{(0.000658)}{-0.001242}(\Delta CP(-1) + \underset{(86.2497)}{130.5023}vBRENT(-1) - \underset{(89.7339)}{326.7058}\Delta WEST(-1) +$$

$$+10681.4) - \underset{(0.1247)}{0.2534}\Delta(\Delta BRENT(-1)) - \underset{(0.1269)}{0.35008}\Delta(\Delta BRENT(-2)) + \underset{(0.1887)}{0.3168}\Delta(\Delta WEST(-1)) \tag{4}$$

$$\Delta(\Delta WEST) = \underset{(0.0015)}{-0.000398}(\Delta CP(-1) + \underset{(86.2497)}{130.5023}\Delta BRENT(-1) - \underset{(89.7339)}{326.7058}\Delta WEST(-1) +$$

$$+10681.4) - \underset{(0.2944)}{0.059322}\Delta(\Delta BRENT(-1) - \underset{(0.4419)}{0.223856}\Delta(\Delta WEST(-1)) \tag{5}$$

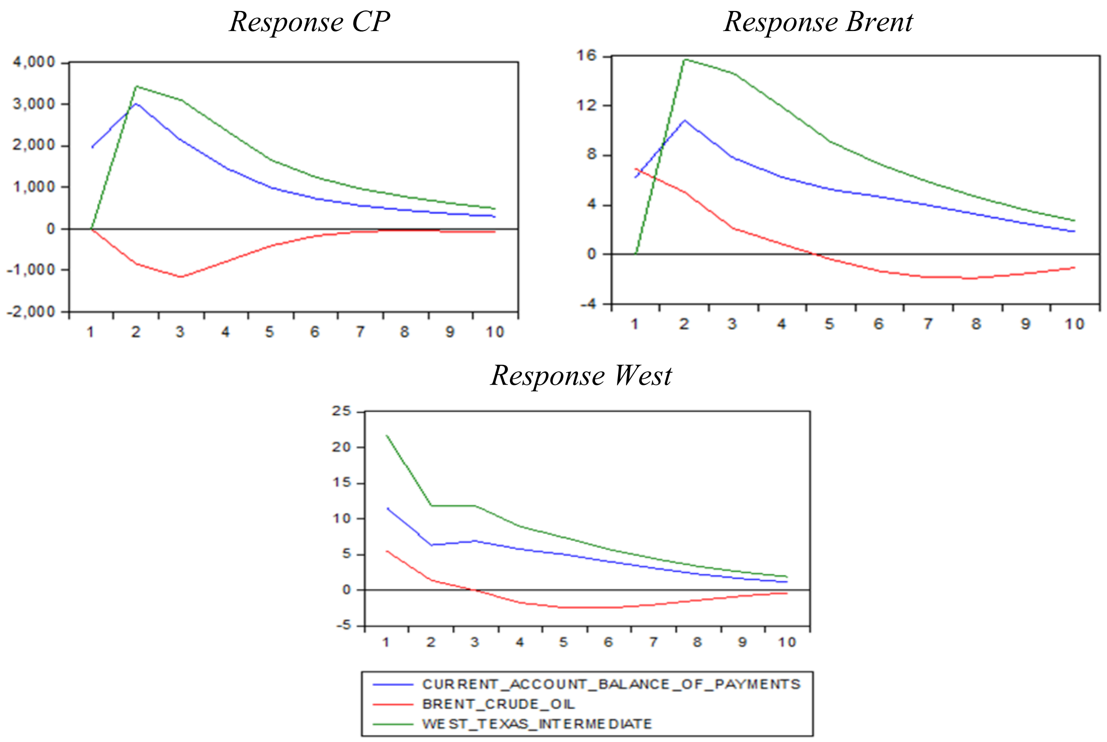

Fig. 2. **Responses of Impulse Functions**

Source: The graph was created by the author in the EViews software.

The obtained *VEC* models correct the short-term dynamics of endogenous variables depending on the deviation from the long-term dependence between *CP*, *Brent, and West*.

To obtain more comprehensive and detailed information, it is necessary to conduct and analyze the responses of impulse function responses and the composition of variances, which describe the response of a time series to some external shocks. The impulse response function makes it possible to trace the dynamics of the impact of surprises on the future value of variables.

The impulse response functions characterize the time of the return of the endogenous variable to the equilibrium trajectory under a single shock of the exogenous variable. The response responses of the impulse function characterize the median estimate with a 90% confidence interval of the endogenous variable to the standard deviation of the exogenous variable. As a result of the evaluation of the *VECM* model, we obtained the functions of impulse responses to structural shocks. So, plots of the reactions of the series under consideration are built on EViews 10 on 10-year time horizons. As can be seen from the graphs in *Fig. 2* the reactions of the impulse functions of variables to structural shocks cover the first 4–5 years of the 10-year period, with a further gradual transition to a stable period.

Table 8

VAR Residual Sequential LM Correlation Tests

Laqs	LM Statistics	Probability
1	7.727057	0.5619
2	4.621512	0.8660
3	10.12649	0.3403

Source: Prepared by the author in the EViews program.

When analyzing *Fig. 2*, one can see the responses over time from the shock experienced and conclude the answer of the endogenous variable to the surprise in each of the exogenous variables over ten years. And the fact that the response of variables to the standard deviation is sometimes different.

Also, the residuals of these models should be analyzed to check the adequacy of the constructed vector error correction models. It will be appropriate to

Table 9

VAR Residual Normality Tests

Component	Jarque-Bera	Degree of freedom	Probability
1	1.460602	2	0.4818
2	0.476875	2	0.7879
3	0.513977	2	0.7734
Joint	2.451453	6	0.8739

Source: Prepared by the author in the EViews program.

check *VAR Residual Serial Correlation LM* Tests — about the mutual independence of residuals, *VAR Residual Normality* Tests — about the normal distribution of residuals, and *VAR Residual Heteroskedasticity* Tests — about the constancy of dispersions of residuals. Let's consider the results of the above tests successively. The number of included observations for the three tests is 24. Lags 1, 2, 3 are applied.

Table 8 shows the results of the *LM* test of the residual serial correlation VAR. The null hypothesis is as follows: no serial correlation with lag delay.

Probabilities are used to make a decision. When testing in all cases, the p-value is more significant than 5%. Therefore, the null hypothesis is accepted, and there is no serial correlation with a delay of lags 1, 2 and 3.

As can be seen from the results (*Table 9*) the asymmetry in the distribution of residuals is close to zero, minimal, which means insignificant. The kurtosis does not pass the value 3. That is, there is no peaked distribution. For both characteristics, the distribution can be considered normal. According to the *Jarque-Bera test*, the distribution is also normal in all cases. $JB_1 = 1.460602$, with $prob. = 0.4818 > 0.05$, $JB_2 = 0.476875$, with $prob. = 0.7879 > 0.05$ and $JB_3 = 0.513977$, with $prob. = 0.7734 > 0.05$, which confirms the normal distribution of all variables. The hypothesis about the normal distribution of the model's residuals is accepted.

When testing heteroscedasticity in the residuals, the probability of the absence of heteroscedasticity is 11%, therefore, the null hypothesis is accepted, and there is no heteroscedasticity in the residuals. The variance can be considered constant in the residuals, and the mathematical expectation is equal to zero. The results were obtained to ensure the fulfillment of the Gauss-Markov conditions for the residuals of the model, thereby substantiating the adequacy of the constructed vector error correction models (3), (4), (5).

CONCLUSIONS

Based on the results of this work, the following conclusions can be drawn:

- The models (3), (4) and (5) obtained in the course of the study can be considered statistically significant. This justifies the positive results of a large number of tests and graphical analysis, both at the beginning of the study based on second-order differences from the original data and when checking the adequacy after the formulation of vector error correction models.
- The constructed model is quite adequate, demonstrates stationarity for time series for both endogenous and exogenous variables, and can be helpful for predictive values of the current account of the balance of payments both in the short term and in a long time.
- The constructed vector model of error correction makes it possible to quantify the characteristics of the studied indicators and the links between them in the short and long term to evaluate the prospective dynamics of the arrows.
- The long-term equilibrium relationship between variables can be considered stable since stability is restored after a violation in short-term periods from shock reactions. The constructed models make it possible to measure both deviations from the equilibrium state and the rate of equilibrium restoration.
- These models make it possible to measure deviations from equilibrium and the rate of its recovery. The obtained *VEC* models correct the

short-term dynamics of endogenous variables depending on the deviation from the long-term dependence between *CP*, *Brent, and West*. Reactions of the impulse functions of variables to structural shocks cover the first 4–5 years of the 10-year period, with a further gradual transition to a stable period. This mechanism provides long-term dependence. The results obtained can be helpful for identifying actual trends in Azerbaijan's balance of payments on the current account and determining its interdependencies with other macroeconomic variables, for developing recommendations, and for forming directions for future development of the balance of payments.

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