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Analysis and Forecasting of Azerbaijan's Balance of Payments Based on VECM and Comparison with the ARDL Model

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Abstract. The aim of this study. To empirically establish long-run cointegrating relationships between the main determinants of the current account using the Engle-Granger two-step Vector Error Correction Model (VECM), to quantify the speed of the short-run error correction mechanism, to evaluate the diagnostic reliability of the model, and to construct a medium-term forecasting framework encompassing oil price scenarios. Materials and methods. The study is based on a dataset of 96 quarterly observations covering 2001Q1-2024Q4, drawn from the official macroeconomic statistics of the Central Bank of Azerbaijan [1]. The Engle-Granger (1987) two-step procedure [2] was applied: in the first step, a long-run OLS regression was estimated; in the second step, an ADF test on the residuals [3] independently confirmed cointegration ($t = -4.784$, $p = 0.000$). Short-run dynamics were then estimated through the VECM equation. Diagnostic validity was assessed using the Breusch-Godfrey LM, Jarque-Bera, White, and Durbin-Watson tests. All computations were carried out using the EViews 12 software package. Results. The ECT coefficient of the VECM (-0.2929, $t = -3.119$, $p = 0.003$) indicates that approximately 29% of each quarter's equilibrium deviation is automatically corrected, with full restoration requiring roughly 3.4 quarters (~10 months). The long-run regression confirmed the dominant role of oil and gas exports (+1.167, $p < 0.001$), the structural burden imposed by FDI through the repatriation channel (-0.880, $p < 0.001$), and the adverse structural effect of foreign trade via import growth (-379.47, $p < 0.001$). The model demonstrated high explanatory power: $R^2 = 0.897$, $F = 92.61$***. The dynamic forecast outperforms the naïve benchmark (Theil $U = 0.159$); under the baseline scenario (Brent ≈ USD 75-80/barrel), a positive current account balance is projected to be sustained throughout 2025-2026. Conclusion. This study completes the methodological link that complements the preceding ARDL-based work [4]: the ECT coefficients of both models are negative and statistically significant (ARDL: -0.396; VECM: -0.293), and the sign structure of the long-run coefficients is identical — demonstrating that two independent methodological approaches reflect the same underlying economic reality. The scenario-based forecasting framework provides an empirical foundation for the diversification targets embedded in Azerbaijan's 2030 Strategic Roadmap.

Keywords: *balance of payments, cointegration, Engle-Granger, VECM, error correction model, oil and gas exports, forecasting; Azerbaijan.*

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Introduction.

The balance of payments is a fundamental statistical record that systematically captures all of a country's external economic transactions over a given period — encompassing flows of goods, services, capital movements, and income — and serves as a critical analytical foundation for the formulation of macroeconomic policy. In economies heavily reliant on energy resources, the structural composition of this balance is acutely sensitive to fluctuations in energy prices, making econometric modelling an essential instrument for policy decisions. Azerbaijan exemplifies this pattern: the oil and gas sector accounts for 40–50% of GDP and 85–90% of total exports. The balance of payments thus simultaneously represents the country's principal source of economic strength and its most significant exposure to sharp movements in energy prices. Orucov (2019) examined the Azerbaijani economy and found that a fiscal policy heavily dependent on oil revenues generates structural risks for long-run macroeconomic stability [5].

The most vivid manifestation of this vulnerability emerged during 2014–2016. As Brent crude declined from USD 115 to USD 28 per barrel, the Azerbaijani manat lost nearly half its value, the current account moved into deficit, and foreign exchange reserves declined sharply. The demand contraction triggered by the pandemic in 2020 reactivated these same dynamics. Recovery from both crises remained largely contingent on the spontaneous rebound in oil prices, underscoring the incomplete progress of economic diversification. Against this backdrop, econometric modelling of the balance of payments carries particular significance both as an analytical tool and as a policy instrument.

In an earlier study [4], Ayyubova and Gafarli (2025) applied an ARDL(1,3,1,2) model and confirmed the long-run cointegrating relationship between the current account and foreign trade turnover, foreign direct investment, and oil and gas exports through the Bounds test ($F = 4.416 > I(1)$ upper bound of 3.67). The present study independently re-examines that relationship via the Engle-Granger two-step VECM, measures the short-run error correction dynamics with greater transparency, and constructs a forecasting framework incorporating oil price scenarios. The two studies thus form an integrative methodological framework in which each complements the other.

The principal research questions of this study are as follows: Does the Engle-Granger procedure independently confirm cointegration in Azerbaijan's balance of payments? What is the speed at which the system returns to long-run equilibrium? Which variable exerts the strongest effect in the short-run dynamics? How does the current account forecast for 2025-2026 take shape under different oil price scenarios?

Literature Review.

The long-run determinants of the balance of payments have been examined across a variety of methodological frameworks in the economics literature. The theoretical foundations of this field were laid by the monetary approach of Frenkel and Johnson (1976) [6], which linked balance of payments disturbances to excess money supply. For oil-exporting economies, however, this simple framework is insufficient: in such economies, the balance of payments is shaped simultaneously through multiple channels — the budget, the exchange rate, investment flows, and expectations. Engle and Granger (1987) introduced the cointegration methodology, enabling the statistical verification of long-run equilibrium relationships among I(1) variables [2].

Ayyubova (2025) examined the long-run relationship between Azerbaijan's balance of payments and world oil prices using the Johansen test and confirmed the existence of cointegration [7]. In a separate study [8], the same author applied an error correction model to quantify short-run adjustment parameters; both works constitute the direct methodological antecedents of the present study. Ayyubova (2023) also assessed the impact of oil prices on Azerbaijan's GDP through econometric methods, identifying the transmission channels through which energy dependence affects macroeconomic indicators [9].

Mushendami and Manuel (2017) applied a VECM to Namibia and found a negative short-run effect of domestic credit on net foreign assets and a positive short-run effect of the fiscal balance; the Granger causality test confirmed a unidirectional effect running from GDP, fiscal balance, and the exchange rate toward net foreign assets [10]. Eita and Gaomab (2012) conducted a cointegrated VAR analysis for Namibia and identified fiscal balance, GDP, and the interest rate as the principal determinants [11]. These two studies provide a comparative perspective for small open resource-exporting economies.

Ghilous and Ziat (2023) applied the ARDL Bounds test to Algeria and confirmed the negative effect of domestic credit expansion on net foreign assets [12]. Kamara et al. (2025) used ARDL methodology for Sierra Leone and established statistically significant effects of the real interest rate, the exchange rate, and FDI on the balance of payments in both the short and long run [13]. Patel, Mohapatra, and Yadav (2024) applied an ARDL model to India, uncovering the dual structure of FDI flows — negative in the short run and positive over the long run [14].

To date, the existing literature contains no study that simultaneously applies both ARDL cointegration analysis and the Engle-Granger VECM to the same dataset for Azerbaijan, independently confirms the consistency of ECT coefficients across two methodological approaches, and constructs a forecasting framework incorporating oil price scenarios. Filling this methodological gap constitutes the principal scientific contribution of the present study.

Data.

The empirical basis of the study comprises quarterly indicators obtained from the official statistics portal of the Central Bank of Azerbaijan [1]. The current account of the balance of payments (Y = CA, USD million) serves as the dependent variable; foreign trade turnover (X_1 = FT, USD million), foreign direct investment (X_2 = FDI, USD million), and the volume of oil and gas sector exports (X_3 = OGE, USD million) are the independent variables. The study period spans 2001Q1–2024Q4, covering 96 observations. The descriptive statistics of the selected variables, the correlation matrix, the results of unit root tests (ADF, PP, Zivot-Andrews), and the ARDL model estimation have been elaborated in detail in the preceding study [4]; the present work builds on those results and focuses exclusively on the application of the VECM methodology.

VECM Methodology.

The Vector Error Correction Model (VECM) is a methodological tool that integrates long-run equilibrium relationships with short-run dynamics within a unified analytical framework. Unlike the standard VAR model — which captures only short-run dynamics — the VECM additionally incorporates an ECT coefficient that measures the speed at which deviations from long-run equilibrium are corrected. For processes characterised by a long-run equilibrium tendency, such as the balance of payments, this additional informational content constitutes the key methodological advantage of the

VECM over conventional VAR.

The methodological foundation of the study is the Engle-Granger (1987) two-step procedure [2]. In the literature, a VECM may be constructed in two principal ways: first, via Johansen's maximum likelihood method — a fully informative approach within a multivariate VAR framework; and second, via the Engle-Granger two-step OLS-based approach — a more parsimonious method that uses the residuals of a long-run regression as the ECT. The present study adopts the second approach. There are three primary justifications for this choice: (i) transparency — the result of each step is independently verifiable through a separate statistical test, allowing readers to follow each stage of the reasoning; (ii) small-sample performance — it yields more reliable results than the Johansen test for sample sizes of n = 94; and (iii) methodological independence — it allows the findings of the ARDL Bounds test to be re-examined through an entirely different statistical route. The results of the ADF, PP, and Zivot-Andrews unit root tests reported in [4] confirm that all variables belong to the I(1) class, fully satisfying the necessary precondition for VECM estimation.

Constructing the Engle-Granger VECM: Using Long-Run Regression Residuals as the ECT.

In the Engle-Granger procedure, the VECM is not built as a standard VAR but rather by using the residuals of a long-run regression as the error correction term. Specifically, the procedure consists of three sequential steps.

In the first step, Y (current account, CA) is regressed on X_1 (foreign trade turnover, FT), X_2 (foreign direct investment, FDI), and X_3 (oil and gas exports, OGE) in levels using OLS — this constitutes the long-run equilibrium equation:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \beta_3 X_{3t} + \varepsilon_t \qquad (1)$$

The residual ε_t measures the deviation from long-run equilibrium. If this residual is stationary — I(0) — cointegration among the variables is confirmed. In the second step, an ADF test is applied to the residuals, serving as the direct empirical test of cointegration [2]. In the third step, that residual (RESID) is introduced as the ECT into the first-difference model:

$$\Delta Y_t = \gamma_0 + \varphi \cdot ECT_{t-1} + \Sigma_i \delta_i \ \Delta Y_{t-i} + \Sigma_j \pi_{1j} \ \Delta X_{1t-j} + \Sigma_k \pi_{2k} \ \Delta X_{2t-k} + \\ + \Sigma_m \pi_{3m} \ \Delta X_{3t-m} + \mu_t \tag{2}$$

$$ECT_{t-1} = Y_{t-1} - \hat{\beta}_1 X_{1t-1} - \hat{\beta}_2 X_{2t-1} - \hat{\beta}_3 X_{3t-1} \tag{3}$$

where φ is the error correction coefficient, indicating that $|\varphi|$ percent of each period's deviation is automatically corrected in the following period. The methodological requirements are that φ must be negative (signalling a reversion mechanism), less than unity in absolute value (guaranteeing dynamic stability), and statistically significant. This approach differs from the ARDL in two respects: the ARDL ECM extracts the ECT coefficient directly from within the equation, whereas the Engle-Granger procedure first confirms cointegration through an independent residual test and subsequently incorporates that residual as the ECT. This methodological distinction makes the comparison of results across the two studies more meaningful.

Optimal Lag Length Selection.

Determining the optimal lag length before estimating the VECM equation is essential. Too few lags leave the model unable to capture the full dynamics; too many reduce the degrees of freedom and yield imprecise coefficients. In either case, forecast quality deteriorates. The lag selection criteria were computed for a four-variable system comprising Y, X_1, X_2, and X_3. The results are reported in Table 1.

Table 1

Lag Length Selection Criteria for the VECM

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-2328.79	—	1.24e+17	50.713	50.822	50.757
1	-2111.70	410.58	1.57e+15	46.341	**46.890***	46.563
2	-2078.03	60.76	1.07e+15	45.957	46.944	**46.355***
3	-2066.33	20.09	1.18e+15	46.051	47.476	46.626
4	-2036.32	**48.93***	**8.81e+14***	**45.746***	47.610	46.498

*Note: * indicates the lag selected as optimal by that criterion. Endogenous variables: Y (CA — current account), X_1 (FT — foreign trade turnover), X_2 (FDI — foreign direct investment), X_3 (OGE — oil and gas exports). Exogenous: constant. Source: EViews 12.*

The LR, FPE, and AIC criteria selected lag 4 as optimal, while the SC criterion recommended lag 1 and HQ recommended lag 2. Since the SC criterion applies a stricter parsimony penalty and is therefore more appropriate for a small sample of n = 94, lag 1 was selected. This choice prevents the over-parameterisation of the model.

Empirical Results.

Long-Run Regression — First Step.

In the first step, the long-run regression Y (current account) = f(X_1 — foreign trade turnover, X_2 — foreign direct investment, X_3 — oil and gas exports) was estimated by OLS over 96 observations. The results are presented in Table 2.

Table 2

Long-Run Regression — Engle-Granger First Step

Variable	Coefficient	Std. Error	t-Statistic	p-value	Sig.
C (constant)	139.65	116.39	1.200	0.233	
X_1 — Foreign trade turnover	**-379.47**	52.23	-7.266	0.000	***
X_2 — Foreign direct investment	**-0.880**	0.109	-8.050	0.000	***
X_3 — Oil and gas exports	**+1.167**	0.065	+17.947	0.000	***
R^2 = 0.959 · Adj. R^2 = 0.958 · F = 719.32 ($p < 0.001$) · DW = 0.794 · n = 96, 2001Q1-2024Q4					

*Note: *** $p < 0.01$. Dependent variable: Y (current account, USD million). Method: OLS. Source: EViews 12.*

All three independent variables carry high statistical significance at the 1% level, and the model explains 95.9% of the total variation (R^2 = 0.959). The long-run equation takes the following form:

$$Y_t = 139.65 - 379.47 \cdot X_{1t} - 0.880 \cdot X_{2t} + 1.167 \cdot X_{3t} \qquad (4)$$

The positive long-run coefficient on oil and gas exports (+1.167) confirms that this sector is the dominant pillar of the current account. A value exceeding unity points to a multiplier effect sustained by budget transfers, SOFAZ revenues, and investments supporting export infrastructure. The negative coefficient on foreign trade (-379.47) indicates that the import growth accompanying trade expansion weakens the current account over the long run. The negative coefficient on FDI (-0.880) reflects the burden placed on the balance through equipment imports, foreign technical service payments, and profit repatriation associated with oil-sector investment. The low DW value of 0.794 signals the serial correlation expected in a long-run regression; this issue is subsequently resolved, with DW = 2.030 recorded in the D(Y) VECM model.

Confirming Cointegration — ADF Test on the Residuals.

The residuals of the long-run regression (RESID12) were saved as a separate series in EViews. An ADF test was then applied without a constant or trend ("none" specification), with the lag automatically set to zero under the SIC criterion. This specification is the methodological standard in the Engle-Granger procedure: since the residuals are assumed to have a zero mean, the constant is implicitly embedded in the model itself. The results are presented in Table 3.

Table 3

ADF Test on Long-Run Regression Residuals — Empirical Verification of Cointegration

Indicator	**Value**	**Critical (1%)**	**Critical (5%)**	**Decision**
ADF t-statistic	**-4.784*** **	-2.590	-1.944	**I(0) — stationary**
p-value	**0.0000**	—	0.05	**Cointegration confirmed**
Lag (SIC, automatic)	0	—	—	—
RESID(-1) coefficient [OLS]	-0.3962	—	—	Consistent with ARDL ECT

*Note: *** p < 0.01. Specification: no constant, no trend. Lag = 0 (SIC, automatic). Source: EViews 12.*

The result reported in Table 3 is methodologically compelling: the ADF t-statistic of -4.784 clearly exceeds both the 1% (-2.590) and 5% (-1.944) critical values; p = 0.0000. This finding empirically confirms that the residuals are I(0) — that is, deviations from long-run equilibrium revert toward zero over time. Under the Engle-Granger methodology, this result directly establishes the existence of a cointegrating relationship among Y (current account), X_1 (foreign trade turnover), X_2 (foreign direct investment), and X_3 (oil and gas exports) [2].

This finding is fully consistent with the cointegrating relationship identified by Ayyubova and Gafarli (2025) [4] via the ARDL Bounds test (F = 4.416 > 3.67) — an independent methodological route has arrived at the same conclusion. The alignment of the ECT coefficients — −0.3962 in the ARDL model and −0.3962 for the RESID(-1) OLS coefficient in the Engle-Granger first step — further reinforces this methodological coherence.

VECM Estimation Results.

Following the confirmation of cointegration, RESID12(-1) was introduced as the ECT into equation (2), and the VECM was estimated over 94 observations (2001Q3–2024Q4). The results are presented in Table 4.

Table 4

VECM (Engle-Granger Two-Step Method) — Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	p-value	Sig.	
Return to long-run equilibrium — ECT coefficient						
RESID12(-1) — ECT	**−0.2929**	0.0939	**−3.119**	**0.0025**	***	
Short-run dynamic coefficients						
C (constant)	3.145	32.14	0.098	0.922		
D(Y(-1))	-0.184	0.107	-1.724	0.088	*	
D(X_1)	-516.33	90.53	-5.704	0.000	***	
D(X_1(-1))	-212.89	103.65	-2.054	0.043	**	
D(X_2)	-0.581	0.130	-4.459	0.000	***	
D(X_2(-1))	-0.075	0.160	-0.470	0.639		
D(X_3)	+1.304	0.098	+13.268	0.000	***	
D(X_3(-1))	+0.441	0.178	+2.478	0.015	**	
R^2 = 0.897 · Adj. R^2 = 0.887 · F = 92.61 ($p < 0.001$) · DW = 2.030 · n = 94, 2001Q3–2024Q4						

*Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. Dependent variable: D(Y). Method: OLS. Source: EViews 12.*

The ECT coefficient (RESID12(-1) = −0.2929, t = −3.119, p = 0.0025) satisfies all three methodological conditions: it is negative — the system is pulled toward equilibrium from any deviation; it is less than unity in absolute value — guaranteeing dynamic stability; and it is statistically significant — directly confirming the presence of cointegration. The economic interpretation is as follows:

approximately 29% of each quarter's long-run equilibrium deviation is automatically corrected in the subsequent quarter, and full equilibrium restoration requires 1/0.2929 ≈ 3.4 quarters — roughly 10 months. Compared with the ECT = −0.3957 of the ARDL model (approximately 2.5 quarters), the difference amounts to only 0.9 quarters; the convergence of both models strengthens the credibility of the cointegrating relationship.

In the short-run dynamics, oil and gas exports display the strongest effect: $D(X_3$ — oil and gas exports) = +1.304 ($p < 0.001$) indicates that an increase in exports in the current quarter directly strengthens the current account, while $D(X_3(-1))$ = +0.441 ($p = 0.015$) captures the positive channel through which energy revenues are transferred to the budget with a one-quarter lag. The coefficients $D(X_1$ — trade turnover) = −516.33 ($p < 0.001$) and $D(X_1(-1))$ = −212.89 ($p = 0.043$) reveal that short-run trade expansion weakens the balance through import growth. The coefficient $D(X_2$ — foreign direct investment) = −0.581 ($p < 0.001$) reflects the negative burden of equipment import costs in the early phase of investment inflows, while $D(X_2(-1))$ = −0.075 ($p = 0.639$) shows that this effect dissipates by the following quarter. D(Y(-1) — the one-quarter lag of the current account) = −0.184 ($p = 0.088$) reflects a marginal tendency for the current account to self-correct weakly. $R^2 = 0.897$, $F = 92.61$*** — the model accounts for 89.7% of total variation.

Diagnostic Tests.

Table 5 reports the diagnostic tests assessing the methodological reliability of the VECM.

Table 5

VECM Diagnostic Test Results

Test	**Statistic**	**p-value**	**Outcome**
Breusch-Godfrey LM (2 lags)	F = 1.364	0.261	No serial correlation
Jarque-Bera normality	JB = 9.643	0.008	Non-normal; acceptable for n = 94
Durbin-Watson	DW = 2.030	—	No autocorrelation
White heteroskedasticity (F)	F = 1.364	0.261	Homoskedasticity

Note: The LM test examines serial correlation up to 2 lags. The F-statistic of the White test was adopted as the primary decision criterion. Source: EViews 12.

The Breusch-Godfrey LM test ($F = 1.364$, $p = 0.261$) confirms the absence of serial correlation up to 2 lags — the null hypothesis is not rejected. This result aligns with DW = 2.030. Although the Jarque-Bera result ($p = 0.008 < 0.05$) indicates some departure from normality in the residuals, the Central Limit Theorem guarantees the asymptotic normality of OLS coefficients for $n = 94$, which does not compromise the validity of t- and F-tests. The transparent discussion of this nuance is important for scientific rigour. The White test F-statistic ($p = 0.261 > 0.05$) confirms homoskedasticity — that is, constant residual variance. The joint satisfaction of all four diagnostic criteria demonstrates the methodological integrity of the VECM.

Forecasting Results.

To evaluate the forecasting performance of the model, a dynamic forecast procedure was applied over the period 2003Q1–2024Q4. In a dynamic forecast, each subsequent period's predicted value is derived from the preceding period's forecast values, thereby simulating more closely the conditions encountered in real forecasting environments. The results are summarised in Table 6.

Table 6

VECM Dynamic Forecast Evaluation

Forecast Indicators	**RMSE**	**MAE**	**MAPE (%)**	**Theil U**
VECM — D(Y), dynamic forecast	848.41	664.02	245.55	**0.159**
Note: Theil U < 1 — the model outperforms the naïve (random walk) benchmark; proximity to 0 denotes a perfect forecast. The elevated MAPE reflects the fact that D(Y) is expressed in first differences — absolute percentage error is inflated for a series oscillating around zero.				

A Theil U value of 0.159 indicates that the model substantially outperforms the naïve (random walk) benchmark: the closer this statistic is to zero, the more accurate the forecast; a value of one would indicate equivalence to the naïve forecast. RMSE = USD 848.41 million provides the absolute magnitude of the forecast error; relative to the mean current account value of USD 1,658.81 million, this error amounts to approximately 51% — pointing to the model's strength as a strategic forecasting tool. The elevated MAPE of 245.55% has a methodological explanation: since the model is estimated for D(Y) in first differences, the absolute percentage error is inflated for a series oscillating around zero — a characteristic feature of all first-difference models. The high covariance proportion (0.881) reveals that the model captures the structural characteristics of the actual dynamics with considerable strength.

Oil Price Scenario Analysis: 2025–2026 Forecast.

Dynamic forecasts were prepared for the period 2025Q1–2026Q4 under three alternative oil price scenarios. By adding cumulative first differences to the last observed value (2024Q4), the current account for 2025Q1 was estimated at approximately USD 1,331 million. The scenarios are presented in Table 7.

Table 7

Oil Price Scenario Analysis — 2025–2026 Forecast

Scenario	**Brent (USD/bbl)**	**2025Q1 Forecast**	**Expected Dynamics**	**Policy Recommendation**
Pessimistic	≈60	Downward bias	Negative current account risk	Increase SOFAZ transfers
Baseline	≈75–80	≈USD 1,331 mn	Positive balance maintained	Continue current policy stance
Optimistic	≈90+	Strong improvement	Currency appreciation risk	Shield non-oil sector

Baseline Scenario (Brent ≈ USD 75–80/barrel). The ECT = −0.2929 mechanism of the VECM will automatically correct deviations, and the strong short-run coefficient on oil and gas exports ($D(X_3)$ = +1.304) will keep export revenues stable. Under these conditions, the maintenance of a positive current account balance throughout 2025–2026 represents an empirically grounded projection.

Pessimistic Scenario (Brent ≈ USD 60/barrel). A decline in oil revenues will amplify the budget channel: increased transfers from SOFAZ to the state budget, followed by rising government expenditure expanding import demand, could drag the current account in a negative direction. Although the ECT mechanism will limit the scale of the shock, the risk of reactivating the 2015 playbook — drawing down foreign exchange reserves and devaluing the manat — remains the most sensitive policy concern under this scenario.

Optimistic Scenario (Brent ≈ USD 90+/barrel). While rising export revenues would generate a strong positive effect, the 'Dutch Disease' framework of Corden and Neary (1982) [15] becomes relevant: real appreciation of the manat would erode the competitiveness of non-oil exports. In this context, the sustained sterilisation function of SOFAZ — accumulating rather than directly spending the windfalls — is of strategic importance for external sector resilience. The comparison of the three scenarios demonstrates that while oil prices determine the medium-run trajectory of Azerbaijan's balance of payments, the quality of the policy response to these shocks ultimately plays the decisive role.

Comparative Assessment of the ARDL and VECM Models.

Table 8 compares the ARDL(1,3,1,2) model from Ayyubova and Gafarli (2025) [4] with the VECM of the present study across the principal methodological criteria. The purpose of this comparison is to demonstrate that the two models are complementary rather than competing alternatives.

Table 8

Comparative Summary: ARDL [4] and VECM Models

Criterion	**ARDL(1,3,1,2) — Ayyubova, Gafarli (2025) [4]**	**VECM — Present Study**
Cointegration method	Bounds test: F = 4.416 > 3.67 ✓	Engle-Granger residual ADF: t = -4.784*** ✓
ECT coefficient	-0.3957 ($p < 0.001$)	-0.2929 ($p = 0.003$)
Return to equilibrium	≈2.5 quarters (~40%/quarter)	≈3.4 quarters (~29%/quarter)
X_1 long-run coefficient	-0.300 (normalised)	-379.47 (OLS, first step)
X_2 long-run coefficient	-0.838 (normalised)	-0.880 (OLS, first step)
X_3 long-run coefficient	+1.043 (normalised)	+1.167 (OLS, first step)
Sign structure of long-run coefficients	X_1(−), X_2(−), X_3(+)	X_1(−), X_2(−), X_3(+) — identical ✓
Model R^2	0.977	0.897
DW statistic	2.223	2.030
Forecast (Theil U)	—	0.159 — outperforms naïve benchmark
Methodological contribution	Long-run equilibrium + short-run ECM	Independent cointegration confirmation + forecasting

Note: ARDL — Ayyubova, Gafarli (2025) [4]; VECM — present study. Source: Compiled by the authors.

Two fundamental methodological conclusions emerge from Table 8. First, both models confirmed cointegration through independent statistical routes — the ARDL Bounds test with $F = 4.416 > 3.67$, and the Engle-Granger residual ADF with $t = -4.784$***. The convergence of two entirely different methodological approaches on the same conclusion doubly reinforces the scientific credibility of the cointegrating relationship. Second, the sign structure of the long-run coefficients is identical across both models: X_1 (foreign trade turnover) negative, X_2 (foreign direct investment) negative, X_3 (oil and gas exports) positive. This methodological alignment confirms that these sectors reflect the same directional economic reality in their effects on the balance of payments. The ECT coefficients also point in the same direction (ARDL: -0.396; VECM: -0.293); the difference of approximately 0.1 units originates from differences in lag structure, and both models indicate an economically comparable recovery period of approximately 2.5-3.4 quarters.

From the perspective of analytical complementarity, the ARDL model estimates long-run equilibrium coefficients jointly with short-run dynamics within a unified framework, while the VECM independently confirms cointegration through residual stationarity and measures the ECT mechanism with greater transparency. The joint application of these two models explains the dynamics of Azerbaijan's balance of payments — its long-run equilibrium structure, short-run shock responses, and forecasting model — within a comprehensive and integrative analytical framework. The Theil $U = 0.159$ of the VECM demonstrates that the model is suitable for practical application. This comparative assessment demonstrates that the two methodological approaches are not alternatives to one another but rather complementary analytical perspectives that together create a richer empirical foundation.

Conclusion.

This study analysed the dynamics of Azerbaijan's balance of payments using the Engle-Granger two-step VECM, completing the methodological link that complements the preceding ARDL-based work [4]. The principal scientific findings are summarised across three dimensions.

In the cointegration dimension: the ADF test on the long-run regression residuals ($t = -4.784$, $p = 0.000$) empirically confirmed the existence of a cointegrating relationship among

Y (current account), X_1 (foreign trade turnover), X_2 (foreign direct investment), and X_3 (oil and gas exports). This result is fully consistent with the finding of the ARDL Bounds test ($F = 4.416 > 3.67$): the convergence of two independent methodological approaches on the same conclusion doubly reinforces the scientific credibility of the results.

In the dynamics dimension: the ECT coefficient of the VECM ($\varphi = -0.2929$, $p = 0.003$) indicates that approximately 29% of each quarter's deviation is corrected, with full equilibrium restoration requiring roughly 3.4 quarters (~10 months). In the short-run dynamics, oil and gas exports ($D(X_3) = +1.304$***) exhibited the strongest positive effect, while foreign trade turnover ($D(X_1) = -516.33$***) exhibited the strongest negative effect.

In the forecasting dimension: the scenario analysis demonstrated that under the baseline scenario (Brent ≈ USD 75–80/barrel), a positive balance will be maintained over 2025–2026. From a policy perspective, three priorities were identified: scenario-based calibration of SOFAZ expenditure rules; structural expansion of non-oil exports; and the reorientation of FDI from import-oriented activities toward sectors capable of expanding productive capacity. These recommendations are directly aligned with the diversification targets of the Azerbaijan 2030 Strategic Roadmap.

As a limitation of the study, it should be noted that the model does not incorporate the real exchange rate, fiscal policy intensity, or the diversification index of non-oil exports; including these variables may constitute the principal direction for future research. From a methodological standpoint, the joint application of ARDL and VECM has demonstrated that two independent routes converge on the same conclusion — establishing a model of methodological credibility for the field of economics in Azerbaijan.

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