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Эмпирические доказательства эффекта j-кривой и условие Маршалла-Лернера на примере Азербайджана

Цель исследования. *Целью данного исследования является анализ применимости эффекта J-кривой и условие Маршалла–Лернера в экономике Азербайджана, а также оценка влияния изменений обменного курса на торговый баланс. Исследование направлено на выявление чувствительности экспорта и импорта к обесценению национальной валюты и определение того, способствует ли девальвация улучшению торгового баланса как в экономике в целом, так и в нефтяном секторе.*

Материалы и методы. *Исследование основано на годовых данных за период 1997–2024 гг. и квартальных данных по нефтяному сектору за 2005–2024 гг. В качестве официальных статистических источников использованы данные Государственного комитета статистики и Центрального банка Азербайджана. В работе применены количественные и эконометрические методы, включая множественный регрессионный анализ, тестирование стационарности с использованием теста Дики–Фуллера, векторное авторегрессионное моделирование, векторная модель коррекции ошибок, анализ коинтеграции, функции импульсного отклика и тестирование причинности. Оценка параметров проводилась методом наименьших квадратов. Данный методологический подход позволяет анализировать как краткосрочную динамику, так и долгосрочные равновесные взаимосвязи между макроэкономическими переменными.*

Результаты. *Эмпирические результаты показывают, что условие Маршалла–Лернера не выполняется для экономики Азербайджана в целом, поскольку сумма эластичностей спроса на экспорт и импорт остаётся ниже единицы. В результате девальвация национальной валюты не приводит к улучшению торгового баланса, и классический эффект J-кривой на агрегированном уровне не наблюдается. Однако в нефтяном секторе выявлена иная картина. Обнаружена устойчивая долгосрочная взаимосвязь между экспортом нефти, валовым внутренним продуктом нефтяного сектора, ценами на нефть и обменным курсом. Анализ подтверждает наличие коинтеграции и двусторонней причинно-следственной связи между этими переменными. В данном секторе условие Маршалла–Лернера выполняется, а эффект J-кривой частично проявляется во времени, что свидетельствует о положительном влиянии девальвации на улучшение торгового баланса в долгосрочной перспективе.*

Заключение. *Полученные результаты показывают, что эффективность девальвации в улучшении торгового баланса Азербайджана зависит от структуры экономики. В то время как ненефтяной сектор демонстрирует низкую чувствительность к изменениям обменного курса, нефтяной сектор играет доминирующую роль в процессах внешнеэкономической адаптации. В связи с этим ключевыми направлениями экономической политики являются диверсификация ненефтяного экспорта, увеличение производственного потенциала и снижение зависимости от импорта, что позволит повысить эффективность валютной политики и обеспечить долгосрочную экономическую устойчивость.*

Ключевые слова: *Азербайджан, эффект J-кривой, условие Маршалла-Лернера, обменный курс, торговый баланс, нефтяной сектор, экспорт, импорт, экономическая диверсификация.*

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Empirical Evidence of J-Curve Effect and Marshall Lerner Condition: Case of Azerbaijan

Purpose of researsh. *The purpose of this study is to analyze the applicability of the J-curve effect and the Marshall–Lerner condition in the economy of Azerbaijan and to evaluate the impact of exchange rate changes on the trade balance. The research focuses on identifying the responsiveness of exports and imports to currency depreciation and determining whether devaluation contributes to the improvement of the trade balance in both the overall economy and the oil sector.*

Materials and methods. *The study is based on annual data for the period 1997–2024 and quarterly data for the oil sector covering 2005 to 2024. Official statistical sources include the State Statistical Committee and the Central Bank of Azerbaijan. The research applies quantitative and econometric methods, including multiple regression analysis, stationarity testing using the Dickey–Fuller test, vector autoregressive modeling, vector error correction modeling, cointegration analysis, impulse response functions, and causality testing. The estimation of parameters is conducted using the least squares method. This methodological framework allows for the analysis of both short-term dynamics and long-term equilibrium relationships between macroeconomic variables.*

Results. *The empirical findings indicate that the Marshall–Lerner condition is not satisfied for the overall economy of Azerbaijan, as the sum of export and import demand elasticities remains below unity. As a result, currency depreciation does not improve the trade balance and the classical J-curve effect is not observed at the aggregate level. However, in the oil sector, the results reveal a different pattern. A stable long-term relationship exists between oil exports, oil gross domestic product, oil prices, and the exchange rate. The analysis confirms the presence of cointegration and bidirectional causality among these variables. In this sector, the Marshall–Lerner condition is satisfied and the J-curve effect is partially observed over time, indicating that exchange rate depreciation contributes to improving the trade balance in the long run.*

Conclusion. *The results demonstrate that the effectiveness of currency depreciation in improving the trade balance in Azerbaijan depends on the structure of the economy. While the non-oil sector shows weak responsiveness to exchange rate changes, the oil sector plays a dominant role in external adjustment processes. Therefore, strengthening non-oil export diversification, increasing production capacity, and reducing import dependence are essential for enhancing the overall effectiveness of exchange rate policy and ensuring long-term economic stability.*

Keywords: *Azerbaijan, J-curve effect, Marshall–Lerner condition, exchange rate, trade balance, oil sector, exports, imports, economic diversification.*

Introduction

Trade among countries historically has been influenced by various factors. Besides, the dynamics and structure of countries' exports and imports always received the attention of the relevant governments, which regularly try to achieve beneficial changes in indicators by stimulating development of national exports.

The Marshall-Lerner condition states that the sum of the price elasticities of demand for exports and imports must exceed one for currency devaluation to improve the trade balance in the long run. If this condition is satisfied, the trade balance in the long run will improve due to a depreciation in the exchange rate: exports will be cheaper and imports more expensive. With elasticities less than one, however, a devaluation may worsen the trade balance initially.

The J-Curve Hypothesis develops the Marshall-Lerner Condition by providing a more dynamic explanation of how exchange rate changes impact trade balances over time. Currency devaluation worsens the trade balance initially and then improves it, giving the curve a resemblance to the letter J, hence the phenomenon of the J-Curve [2]. In the short term, the trade balance (net exports) worsens because imports become expensive right after devaluation and exports don't rise immediately as contracts are fixed, and production levels cannot instantly increase. So, after this initial drop, exports start to increase as foreign buyers realize the products now have cheaper prices. Simultaneously, imports decrease because foreign products are more expensive for domestic consumers. Eventually as exports rise and imports fall, the net exports improve, moving upward on the graph which is seen as J-curve by mid-term period. The J-Curve explains this dynamic adjustment of trade balance (net exports) after a currency devaluation.

Krugman and Obstfeld (2008) describe the J-Curve phenomenon by arguing that following the devaluation of a currency, the values of exports and imports are still determined by past contracts based on the old exchange rate, which causes the cost of imports to rise in terms of domestic goods. Over time, as prices and trade quantities adjust to the new exchange rate, the trade balance would be improved and even exceed the pre-depreciation level in a long run [8].

J curve and the Marshall Lerner condition, which are key concepts in international trade and foreign exchange dynamics, tries to explain the effects of exchange rate changes on the trade balance, specifically when a country's currency is depreciated. Countries with less-diversified economy and regulated exchange rate, including Azerbaijan, could be drawn outlook about the general economy through the results of application of the J curve and the Marshall Lerner condition on exports. Therefore, the Marshall-Lerner coefficient will know what effects devaluation will have on exports and graphically determine what effects it will have through the J curve.

The research provides mathematical expressions for the application of the J curve in the export of Azerbaijan, as well as whether the Marshall-Lerner guarantee is allowed for the economy of Azerbaijan, creates a relationship between the J effect with this coefficient, the use of the J curve and the Marshall-Lerner contract in Azerbaijan, which have effects on the product.

Due to the weak export diversification of Azerbaijan's economy, exports are still dependent on oil prices. After the devaluation of 2015, what are the effects of the J curve and the Marshall-Lerner condition on exports, and if such a case happens again, to what extent will the Azerbaijani economy be resistant to it, i.e., are the possibilities of applying the J curve and the Marshall-Lerner condition currently being paid for the economy of Azerbaijan, this the results in this direction will be found in the research.

Literature Review

Recent studies on effects on the Balance of Trade through the J curve and the Marshall-Lerner condition reveal ambiguous findings especially for oil exporting and developing countries.

Rose (1990, 1991) and Ostry and Rose (1992) found that exchange rate devaluation does not have a real effect on the trade balance. In contrast, Marquez and McNeilli (1988) and Reinhart (1995) found that devaluation improves the trade balance [11,14,17,18,19].

Karaçor and Gerçeker (2012), analyzed the cause-and-effect relationship between the real exchange rate and foreign trade in Turkey and found existence of such relationship but only in the short-term period. Tokarick (2010) calculated the elasticities of demand and exports required for a high profit company. As a methodology, a standard general equilibrium model from international trade theory was used [7,22].

Aliyev, Gasimov and Adigozelov (2014) analyzed Azerbaijan's trade operations with 37 countries in the export sector and 29 countries in the import sector for the period 2001–2012. The results indicate that increased demand in export markets can significantly boost the country's exports. However, a noticeable appreciation of the manat (local currency), reflected in increases in the real bilateral and effective exchange rates, acts as a constraint on exports and has a limited restrictive effect on imports. For capital goods exports, growth is strongly positively influenced by both rising foreign demand and exchange rate appreciation. Import indicators, both in total and by product category, are elastic to domestic demand, meaning that increasing

domestic demand leads to higher imports. Jamilov (2011) investigated the general and non-oil trade balance between Azerbaijan and European countries and found that although the sharp real exchange rate has a negative effect on the trade balance in the short term, it has a positive effect on the trade balance due to the growth of exports in the long term [1,5].

Parray et al. (2023) examined BRICS countries (Brazil, Russia, India, China, and South Africa) in the period of 2000-2020 and found no evidence of the J-curve phenomenon. They tested both nominal and real effective exchange rates, where depreciation had insignificant effects on improving the trade balance, which contradicts the J-curve hypothesis. Study highlighted that currency appreciations are more impactful in worsening trade balances, whereas depreciations do not yield the expected improvement. This study suggests that to achieve a favorable trade balance countries should improve both the price and quality of their exports and strengthen domestic production capabilities to reduce reliance on foreign products. A partial J-Curve has been observed for Russia due to its exports on non-oil products (e.g., metals, agriculture) respond more effectively to currency devaluation. Since these countries have export-led structure with Russia more focused on oil products, diversifying export baskets could be critical for long-term trade balance stability and resilience against exchange rate fluctuations [16].

Miles (1979) examining 14 countries between 1956 and 1972, argued that devaluations didn't improve the trade balance due to several factors. He suggested that the Marshall-Lerner condition might not be satisfied, meaning trade volumes were inelastic to price changes caused by devaluation. Besides, structural and institutional rigidities, such as reliance on essential imports and limited export diversification, and cost-push inflation from higher imported material prices due to devaluation. The short-term J-curve effect, where trade balances worsen before improving, may also have skewed results. Finally, the use of aggregated annual data likely masked country-specific nuances and time-specific impacts, resulting in the conclusion that devaluations do not effectively enhance trade balances [12].

Kulkarni (1996) found that Egypt (1988-94 years) and Ghana (1993-89 years) exhibit the J-Curve effect, where the trade balance initially deteriorates following a currency devaluation before improving over time [9].

Global demand for oil tends to be relatively inelastic in the short term; consumers and industries cannot quickly reduce oil consumption despite price changes. Consequently, a devaluation that makes oil exports cheaper may not significantly boost export volumes immediately. immediate rise in import costs can worsen the trade balance shortly after devaluation. Many oil-exporting countries peg their currencies to the US dollar, the primary currency for oil transactions. Devaluing a currency pegged to the dollar can have complex effects, potentially impacting oil revenues and economic stability.

Mahmood et al (2017) examining the impact of exchange rates and oil prices for 1970-2015 years on Saudi oil exports found that world income positively influences Saudi oil exports, while the exchange rate's effect was insignificant in a linear analysis. They also found that appreciation of riyal worsened the trade balance but a devaluation improved trade balance in short run but not in long run. Their finding suggests maintaining fixed pegged exchange rate for longer time rather than devaluating [10].

Yousefi and Wirjanto (2003) examined the effects of changes in the exchange rate of the US dollar on the trade balances of Iran, Venezuela and Saudi Arabia as main oil-exporting countries. The study found that changes in the US dollar exchange rate affect their trade balances. The study also indicated that while these three countries raise the price of their primary export (crude oil) in response to a depreciation of the dollar, Saudi Arabia's long-run pricing strategy in securing a larger market share stands in contrast to that of the two other OPEC members. The sum of the estimated long-run price elasticities of demand for imports and exports is found to exceed unity for Iran and Venezuela, but less than unity for Saudi Arabia [24].

Due to inelastic nature of oil demand, the immediate increase in import costs, and the complexities of currency pegs contribute to this unique pattern. Therefore, in oil-exporting countries, the J-Curve effect may be less pronounced or follow a different trajectory compared to more diversified economies.

As known, crude oil is typically traded in US dollars in international markets and when a country devalues its currency, its export revenues in US dollars remain unchanged unless it increases export volumes, which is unlikely in the short run in oil export case. However, converting those US dollar revenues into local currency it takes pressure from local currency value. Besides, as many oil-exporting countries heavily rely on imports for consumer goods, machinery, and technology this will lead to rise in import bills, worsening the trade balance in the short term.

Studies have shown that Nigeria's trade balance does not exhibit a clear J-Curve after devaluation due to the dominance of crude oil exports and a high dependence on imports. Johnson and Onakoya (2018) investigated the J-curve effect from 1981 to 2016 in Nigeria and found no clear evidence of the J-curve phenomenon as they link such result with the country's heavy reliance on oil exports and the lack of export diversification. Bawa et al. (2018) employed the ARDL bounds testing approach to examine the J-Curve effect for 1994-2018 time period in Nigeria concluded that

J-curve phenomenon does not hold in Nigeria for that time period. Ogbonna and Ichoku (2022) analyzed the impact of oil prices and exchange rate fluctuations on Nigeria's trade balance. The study found evidence of the J-Curve effect in Nigeria's trade with the United Kingdom, where devaluation initially led to a deterioration of the trade balance, followed by improvement. However, this effect was not consistently observed in trade with other major partners, indicating that the J-Curve phenomenon in Nigeria may be partner-specific [3,6,13].

Özşahin (2017) examined Turkey's trade relations with 20 countries that account for 70% of its total imports and 60% of its total exports. The study found that, for 10 of these 20 countries, the bilateral real exchange rate had a statistically significant negative effect on the bilateral trade balance. This negative relationship indicates that between 1995 and 2015, a depreciation of the Turkish Lira against the currencies of its trade partners improved the trade balance with those countries, confirming the J-curve effect for these cases [15].

Sukar (1998) examined the short-term and long-term relationships between the real effective exchange rate and exports in the US economy. He found cointegration relationships between the variables with statistically significant results, showing that export elasticity with respect to foreign demand is positive, while it is negative with respect to the real effective exchange rate. However, the relationship between the real effective exchange rate and export levels is not statistically significant in the short term. Wu (2020), in a study on US–China trade, found that although there was no short-term J-curve effect, a devaluation of the Chinese yuan had a long-term positive impact on the trade balance with the United States. At the same time, the effect of US GDP on the trade balance with China was stronger than that of China's GDP. Based on these findings, the author recommends maintaining stable China–US relations and exchange rate stability to ensure a favorable long-term trade balance and economic growth [21,23].

Methodology

This study utilizes quarterly data from January 2005 to September 2024 to estimate the internal demand elasticity of imported goods and the external demand elasticity of exports in the Republic of Azerbaijan, while assessing the Marshall-Lerner condition and illustrating the J-curve effect on exports.

Although the J-curve hypothesis provides a dynamic description of how the trade balance responds to exchange rate depreciation, identifying its pattern alone is insufficient for rigorous empirical validation. A multiple regression model is necessary to quantify the magnitude and statistical significance of exchange rate effects while controlling for other macroeconomic determinants. Moreover, the Marshall–Lerner condition requires the estimation of export and import demand elasticities, which can only be obtained through econometric modeling. By applying a multiple regression framework, the analysis moves beyond descriptive observation and enables formal hypothesis testing, elasticity measurement, and distinction between short-run and long-run dynamics, thereby providing a more robust basis for policy conclusions.

A multivariate linear regression model was initially estimated to explore the relationships among the variables, and its statistical significance was evaluated through standard tests. Stationarity of the time series was assessed using the Augmented Dickey-Fuller (ADF) test. To analyze dynamic interactions and the effects of shocks, a Vector Autoregressive (VAR) model was estimated, with impulse response functions and variance decomposition employed to interpret the propagation of shocks over time. Upon confirming stationarity at the same order and determining the optimal lag length, cointegration analysis was conducted to identify long-run equilibrium relationships among the variables. Following contemporary econometric practice, a Vector Error Correction Model (VECM) was applied to capture both short-term dynamics and long-term relationships for cointegrated series, while Granger causality tests were used to determine directional causality among stationary variables. Notably, differencing of stationary series in a VECM eliminates long-run information; therefore, cointegration testing was performed prior to differencing to preserve long-term dynamics.

This methodological framework enables a robust assessment of both short-run adjustments and long-term equilibrium relationships in Azerbaijan's import and export demand, providing rigorous insights for policy and economic analysis.

Empirical Results and Discussion of the Findings

The main purpose of Multiple regression analyses is consist of relationship of economic indicators and examine its effect. The study used 27 annual years data which was obtained from the State Customs Committee and the Central Bank of Azerbaijan [20]. Instrumental analyses of research were used by Eviews 12 software program. The general formulation of the export function is shown as below:

$$\ln Export_t = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln EXchangerate_t + {}^{\varepsilon}t \quad (1)$$

Where, $\ln Export_t$ is export of Azerbaijan republic, $\ln GDP_t$ is Gross Domestic Product of Azerbaijan Republic, $\ln EXchangerate_t$ is exchange rate dollar to manat, t is time index, β_i's coefficients to be estimated and ${}^{\varepsilon}t$ is error term.

And

$$\ln Import_t = \beta_0 + \beta_1 \ln GDP_t + \beta_2 \ln Exchangerate_t + {}^{\varepsilon}t \quad (2)$$

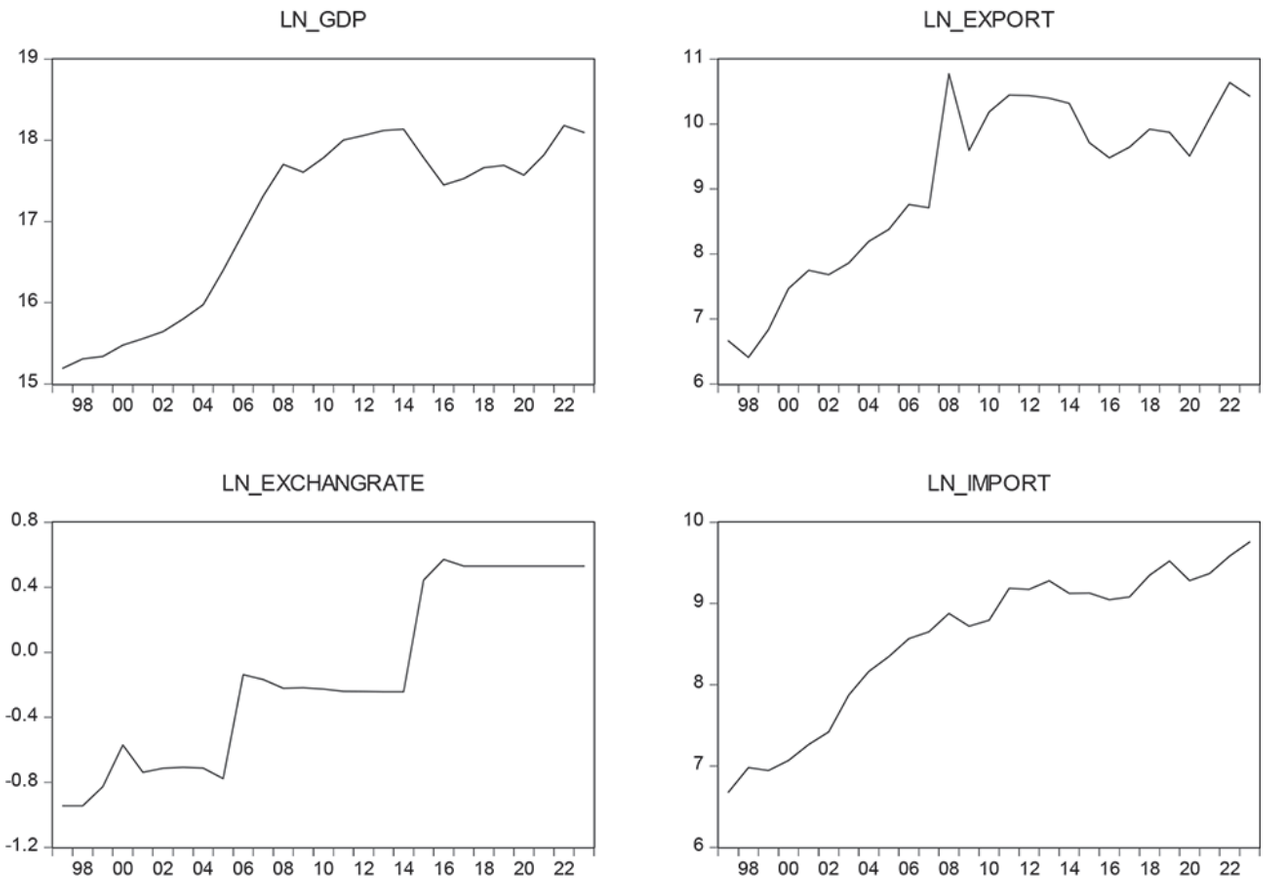

Рис. 1. Описания динамических данных
Fig. 1. Dynamic data descriptions

Where, $\ln Import_t$ is import of Azerbaijan republic, $\ln GDP_t$ is Gross Domestic Product of Azerbaijan republic, $\ln EXchangerate_t$ is exchange rate dollar to manat,t is time index, β_i's coefficients to be estimated and ^{c}t is error term. The research uses annual data from 1997 to 2023. Dynamic descriptions of the given data from [3] are shown in Figure 1.

The empirical part started with the creation of a multiple regression model. Multiple regression model coefficients estimated by the Least Squares Method and implemented in Eviews 12 software program.

$$\begin{gathered}\text{LNEXPORT} = 1.57737967997*\text{LN\_GDP} + \\ + 0.103920308411*\text{LN\_EXCHANGRATE} + \\ + 3.80052031358e\text{-}05*\text{LN\_RESIDUALS} - \\ - 18.0634238916 \end{gathered} \quad (3)$$

$$\begin{gathered}\text{LNIMPORT} = 1.05772883877*\text{LN\_GDP} + \\ + 0.0647259440072*\text{LN\_EXCHANGRATE} - \\ - 6.03395498029e\text{-}06*\text{LN\_RESIDUALS} - \\ - 9.6473406933 \end{gathered} \quad (4)$$

The Marshall-Lerner condition is expressed as the sum of the internal demand elasticity of imported goods (e_x) and the external demand elasticity of exported goods (e_m) equal to or greater than 1. According to the Marshall Lerner condition, the following conditions must be met for devaluation to have a positive effect on the country's economy, mainly on exports:

$$ex + em \geq 1 \quad (5)$$

According to the model we evaluated, the condition $0.10+0.06 \geq 1$ is not satisfied, which means that devaluation reduces foreign exchange reserves and has a negative effect on the country's economy. Revenues from the increased volume of export goods due to the depreciation of export goods are less than the increase in the price of imported goods, which has a negative effect on the trade balance.

If the Marshall-Lerner condition is not satisfied, the J effect on exports has a weak effect, that is, when there is a devaluation, exports are expected to decrease first, and then to have a rapid increase.

When we look at the period of Azerbaijan's devaluation, it seems that there was a decrease in exports, but the growth was very small, and the full formation of the J curve did not take place. When the Marshall-Lerner ratio is less than 1, exports and balance of payments have strong effects on the J curve. This means that the increase in the price of domestic goods was more than the increase in the price of export goods.

According to the J-curve in Figure 2, between 2015 and 2016, trade should have gone negative, then increased to positive, but there was a certain

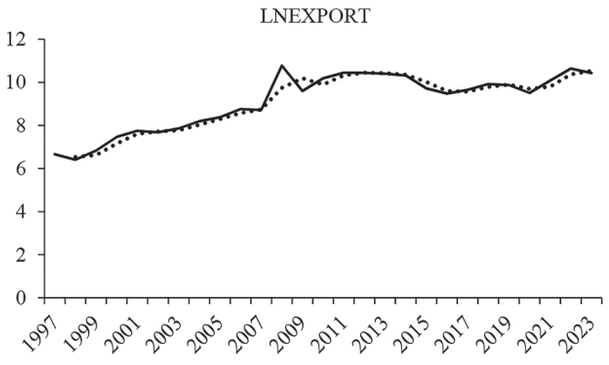

Рис. 2. J-кривая в экспорте Азербайджана

Fig. 2. J-curve path in Azerbaijan export

Источник: авторская работа на основе данных [3]
Source: Author's work based on data [3]

decrease in exports, it could not decrease to negative, and at the same time, the growth in 2016-2017 was very weak. Thus, it is concluded that the J effect is not visible in Azerbaijan's foreign trade.

Furthermore, the existence of the J-curve effect was examined, and an empirical study was conducted to identify it in macroeconomic statistics for Azerbaijan. Based on quarterly data for the period from January 2005 to September 2024. Multiple regression model was estimated to study export of oil sector responses to GDP of oil, currency devaluation and oil price in the short and long run relation. To test the hypothesis of the presence of a J-curve effect for the trade balance of Azerbaijan, we use econometric analysis and assessment of the short-term and long-term impact of changes in the macroeconomic indicators using an autoregressive distributed lag model. For certain analysis between the export of oil sector and GDP of oil sector , the exchange rate and oil price uses the following model:

$$Export\ of\ oil\ sector = \beta_0 + \beta_1 GDP\ of\ oil\ sector + \\ + \beta_2 Exschangerate + \beta_3 Oil\ price + {}^{\varepsilon}t \qquad (6)$$

Multiple regression model (6) coefficients estimated by the Least Squares Method and implemented in Eviews software program.

$$\text{EXPORT\_OF\_OIL sector} = \\ = 2.65813039779e\text{-}05\text{OIL\_GDP\_Q} - \\ - 0.00013\text{DOL\_MAN} + \\ + 0.0143971975155\text{OIL\_PRICE} + \\ + 6.371319\text{RESIDUAL} + 7.2150491285 \qquad (7)$$

(7) multiply regression model β_2 exchange rate coefficient is a negative value, it means that depreciation of the real exchange rate would lead to an improvement in the trade balance. Be that as it may, in the opinion J-curve hypothesis, real exchange rate depreciation primarily worsens the trade balance, since devaluation initially reduces the demand for that country's exports and increases its demand for imports. But over time, export and import volumes will adjust to price changes and the trade balance will improve. Hence, the real exchange rate (7) is negative. In particular, if the J-curve hypothesis is confirmed, β_2 will become positive in the short term and negative in the long-term relations.

For certain analysis between the import of oil sector and GDP of oil sector, the exchange rate and oil price uses the following model:

$$Import\ of\ oil\ sector = \beta_0 + \beta_1 GDP\ of\ oil\ sector + \\ + \beta_2 Exschangerate + \beta_3 Oil\ price + {}^{\varepsilon}t \qquad (8)$$

Multiple regression model (8) coefficients estimated by the Least Squares Method and implemented in Eviews software program.

$$\text{IMPORT\_OF\_OIL\_AND\_GAS} = \\ = 5.72243524276e\text{-}05\text{*OIL\_GDP\_Q} + \\ + 8.70796\text{DOL\_MAN} - \\ - 0.00820071182506\text{*OIL\_PRICE} - \\ - 4.22608934522e\text{-}05\text{*RESIDUAL} + \\ + 6.07091557063 \qquad (9)$$

According to the model we evaluated, the condition (5), $-0.00013 + 8.70796 \geq 1$ is satisfied, according to Marshall-Lerner condition, devaluation of the real exchange rate will lead to an improvement trade balance if the sum of the elasticities of demand for exports and imports is greater than one. It is important to note that in the short run the Marshall-Lerner condition does not fulfill, since the elasticity of demand is quite small. Differences between elasticities of demand for imports and exports in the short and long term explain the essence of the "J-effect", which is discussed below.

The J effect is explained as follows: Dynamical data Based on quarterly data for the period from January 2005 to September 2024 in in Azerbaijan, where accumulated over the last 10 years spending reserves were at a fairly fast pace for one year (2014). As holding fixed regime became expensive, Government had to devaluate its currency twice in 2015 overall 98% and adopted managed floating exchange rate regime. The initial weakening effect of currency increases domestic prices for imported goods, which in turn increases the cost of imports. However, the cost, and therefore the volume of exports increase considering the time lag required to adapt new prices and conclusion of contracts. Thus, with a constant volume of imports, their value increases, and the value of exports increases at a slower rate.

In other words, in the short term, the trade balance deteriorates. It should be noted that this effect involves a high level elasticity of export supply and low short-term elasticity of demand for import. Over time, rising import costs will reduce imports volumes, while the volume and value of exports will increase. Thus, when initially observed reduction in the trade balance in the long term there will be a recovery in the future.

Таблица 1 / Table 1

Описательная статистика
Descriptive statistics

	EXPORTOFOIL	OIL_GDP	DOL_MAN	OIL_PRICE	RESIDUAL
Mean	8.483466	7554.341	233.7602	76.41579	-2.161937
Median	8.511980	6776.200	1.559400	74.73941	-79.02070
Maximum	9.367041	18827.60	1.700000	122.2186	2356.580
Minimum	6.907755	870.6000	0.784400	33.37716	-1617.390
Std. Dev.	0.477434	3932.738	1013.156	23.46211	630.4038
Skewness	-0.673968	0.990853	4.099186	0.302798	0.491456
Kurtosis	3.365217	4.032826	17.80333	1.997784	5.341046
Jarque-Bera	6.419783	16.43821	942.5746	4.513480	21.22010
Probability	0.040361	0.000269	0.000000	0.104691	0.000025
Sum	670.1938	596792.9	18467.06	6036.847	-170.7930
Sum Sq. Dev.	17.77958	1.21E+09	80065868	42936.70	30997896
Observations	79	79	79	79	79

Таблица 2 / Table 2

Корреляционная матрица
Correlation matrix

	EXPORTOFOIL	OIL_GDP	DOL_MAN	OIL_PRICE
EXPORTOFOILSECTOR	1.000000	0.937426	-0.745095	0.791152
OIL_GDP	0.937426	1.000000	-0.715522	0.799218
DOL_MAN	-0.745095	-0.715522	1.000000	-0.710085
OIL_PRICE	0.791152	0.799218	-0.710085	1.000000

Even though the existence of the J-effect is economically and mathematically justified, there are some hypotheses that complement this effect. It is possible to consistently adapt import prices to changes in the exchange rate, which minimizes the initial negative effect of the J-curve . Thus, the existence of the J-curve depends on a number of assumptions: weak response volume of imports on changes in import prices in the short term, rapid change in import prices under the influence of exchange rate dynamics and time lag between changes in export volumes and exchange rates.

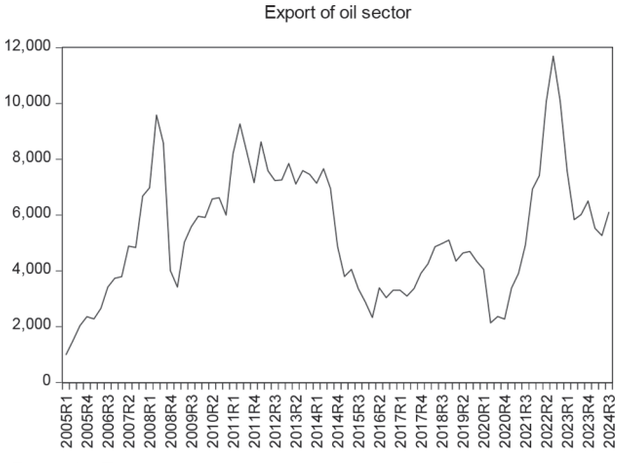

Рис. 3. Динамические данные на основе квартальных данных за период с января 2005 года по сентябрь 2024 года

Fig. 3. Dynamical data based on quarterly data for the period from January 2005 to September 2024

Thus, theories and a variety of empirical studies offer many a set of economic indicators that may become potential determinants factors for exchange rate dynamics. However, selection and testing of innovativeness such factors need to be carried out in each specific country in present time. The use of econometric methods in the study allows us to perform several tasks at once: provide descriptive statistics of the data used, make a macroeconomic forecast, quantify the dynamics of variables and analyze current policies in different sectors of the economy.

Descriptive statistics table 1 show us presenting statistical variables in an informative way.

It is essential that one report the most appropriate descriptive statistics using a systematic approach to reduce the likelihood of presenting misleading results. Since the results of statistical analysis are fundamental in influencing the future of economic indicators, the appropriate use of descriptive statistics allows regulation of economic indicators and providers to more effectively weigh the impact of economic environment.

Let us pay attention to the correlation coefficients between Export of oil sector and GDP of oil sector, exchange rate factors and oil price presented by the correlation matrix in Table 2.

A qualitative assessment of the closeness of the relationship between factors is revealed using the Cheddock scale. Based on this scale, if the value

of an element of this matrix is between 0.5 and 0.7, then the closeness of the relationship between the corresponding factors is considered noticeable, and if the value of the element is in the interval (0.7; 0.9), then the closeness of the relationship between the corresponding steam is accepted as high.

The regression model (7) determination coefficient has a higher value of 89%. To check the significance of the constructed model (7) , the observed and critical values of the Fisher criterion were calculated. These values are respectively at the 5% significance level and degrees of freedom. Since Fstatistic = 156,42 > F = 2,18 table and P-value less than 0.05, the model (7) are considered significant.

Autocorrelation is tested using the Durbin-Watson. According to the d-statistic results table for results 79, number of explanatory variables 3 and significance level 0.05 d_{low} = 1.42 and d_{up} = 1,57 which parse the segments [0,4] in five regions, $d_{observed}$ = 0.76 < d_{low} = 1.42 < d_{up} = 1,57 for regression model (7). The observed value falls into the positive autocorrelation using the Durbin-Watson criterion.

Stability diagnostic of parameters of multiply regression model (7) is defined by the CUSUM Square test. CUSUM test result is shown in Figure 4.

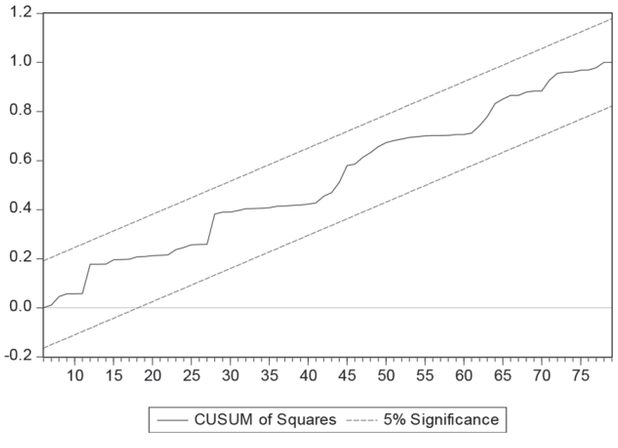

Figure 4. Result of CUSUM of Squares test

Рисунок 4. Результаты теста кумулятивной суммы квадратов

The main line of Figure 4 doesn't intersect with border line. It means that parameters of multiple regression model (7) are stable.

We were analyzed the heteroskedasticity of the errors of the regression model (7). Heteroskedascity, as it is known, is based on Gauss-Markov hypothesis and classical least squares. One of the main assumptions of the method is that the error term has a constant variance for all observations. The value of the $\chi^2_{0,35}(5) = 5.563807 < nR^2$ and corresponding P-value is greater than 0.05, the null hypothesis that the random term is homoscedastic is not rejected.

To reveal the cointegration relationship between time series first of all, it is necessary to examine at which level the series are stationary. If the series become stationary at the same level, then they can be included in the cointegration analysis. If one of the series does not become stationary at the same level as the others, that series is not included in the analysis. If the probability value of the series is not found significant at the determined level as a result of the unit root tests at the level, the series are re-analyzed by taking their differences (1st difference). Here, the series whose probability values are found significant are accepted as having a unit root and are included in the analysis. The stationarity of the time series was checked using the augmented Dickey-Fuller test. The test results showed that the original series and their first differences theme not stationary, but the second order difference operators are stationary. The test results are shown in Table 3.

The verification of causal relationships between factors for lagged values m = 1,2,3,4 was carried out by the Granger test. The Granger Causality test except for two directions confirmed the presence of a two-way cause-and-effect relationship, which indicates the existence of a third variable, which is the real cause of the change in the two variables under consideration. Only for lag m = 1 between ΔEXPORTOFOIL and ΔGDPOIL and for lag m = 3 between ΔGDPOIL and ΔPRICEOFOIL opposite cause-and-effect relationships are found, where Δ denotes the difference operator of the corresponding variable.

To fully inform the research, an analysis of the response of impulse functions is necessary. These functions represent the median estimate with a 90% confidence interval of the endogenous variable per positive shock of one standard deviation of the exogenous variable and indicate the time to return to the equilibrium path. Confidence intervals were obtained by bootstrapping with 100 replications, as described in [3]. Test results over 10-year time horizons are described in Figure 5.

Таблица 3 / Table 3

Result of Dickey-Fuller test

Результаты теста Дики-Фуллера

Time series	Statistical criteria	Critical value 1%	Critical value 5%	Critical value 10%	Prob.
First difference trend, intercept					
Export of oil sector	-7.213218	-4.081666	-3.469235	-3.161518	0.0000
Exchange rate	-7.723540	-4.416345	-3.622033	-3.248592	0.0000
GDP of oil sector	-7.698086	-4.081666	-3.469235	-3.161518	0.0000
Oil price	-6.755613	-4.083355	-3.470032	-3.161982	0.0000

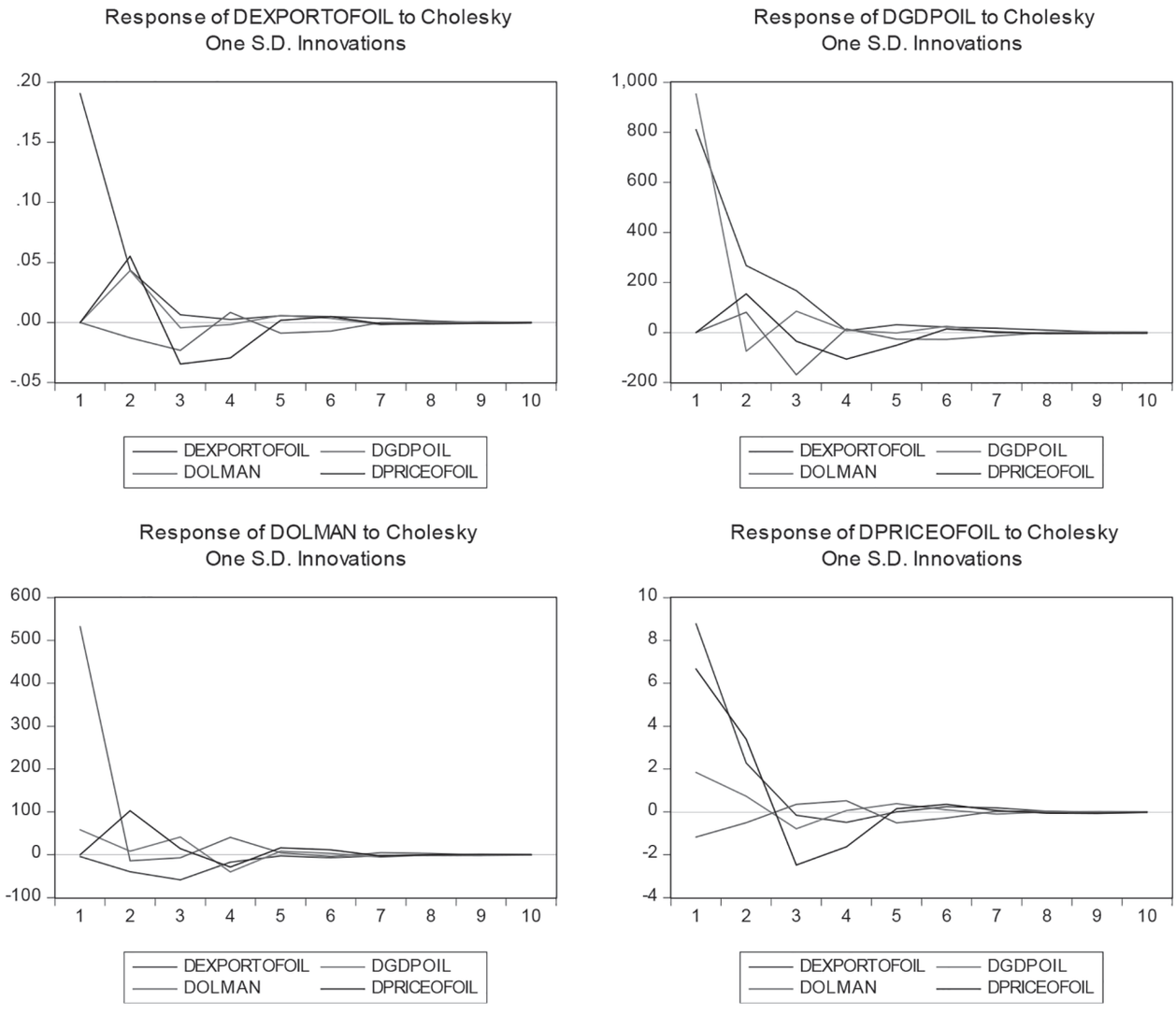

Рис. 5. Реакции функций импульсного отклика

Fig. 5. Responses of impulse response functions

The IRF results indicate a system dominated by strong self-responses and short-lived cross-variable effects. Oil exports drive oil GDP and prices in the short run, while domestic demand largely reacts only to its own shocks. Overall, the model suggests that short-term dynamics are primarily driven by immediate, transitory shocks rather than persistent interactions among the variables. The results suggest a short-term J-curve effect, where oil exports temporarily boost GDP and prices before returning to equilibrium.

The results of checking the corresponding tests are shown in Figure 6:

The variance decomposition analysis reveals that oil exports and prices are the dominant sources of variation within Azerbaijan's oil economy. Oil exports are largely self-determined, while oil GDP is mainly influenced by export and price shocks. Domestic oil demand demonstrates autonomous behavior, showing minimal response to external factors. In contrast, oil prices are significantly affected by both export performance and domestic demand, indicating strong market interdependence. These findings confirm that export fluctuations play a leading role in shaping the long-run and short-run dynamics of Azerbaijan's oil sector. The Eviews program also provides the normalized cointegrating coefficients of the cointegrating equations obtained within the scope of the Johansen Cointegration Test. Result of Trace test and Max Eigen test is shown Table 4 and Table 5.

The results of the Johansen cointegration tests presented in Tables 4 and 5 confirm the presence of long-run equilibrium relationships among the variables. According to the Trace test (Table 4), the null hypothesis of no cointegration is rejected up to the case of "at most 2" cointegrating equations, while it cannot be rejected at "at most 3." Similarly, the Max-Eigenvalue test (Table 5) yields consistent results, rejecting the null hypothesis up to "at most 2" cointegrating vectors but not beyond that level. Both tests, therefore, indicate the existence of three

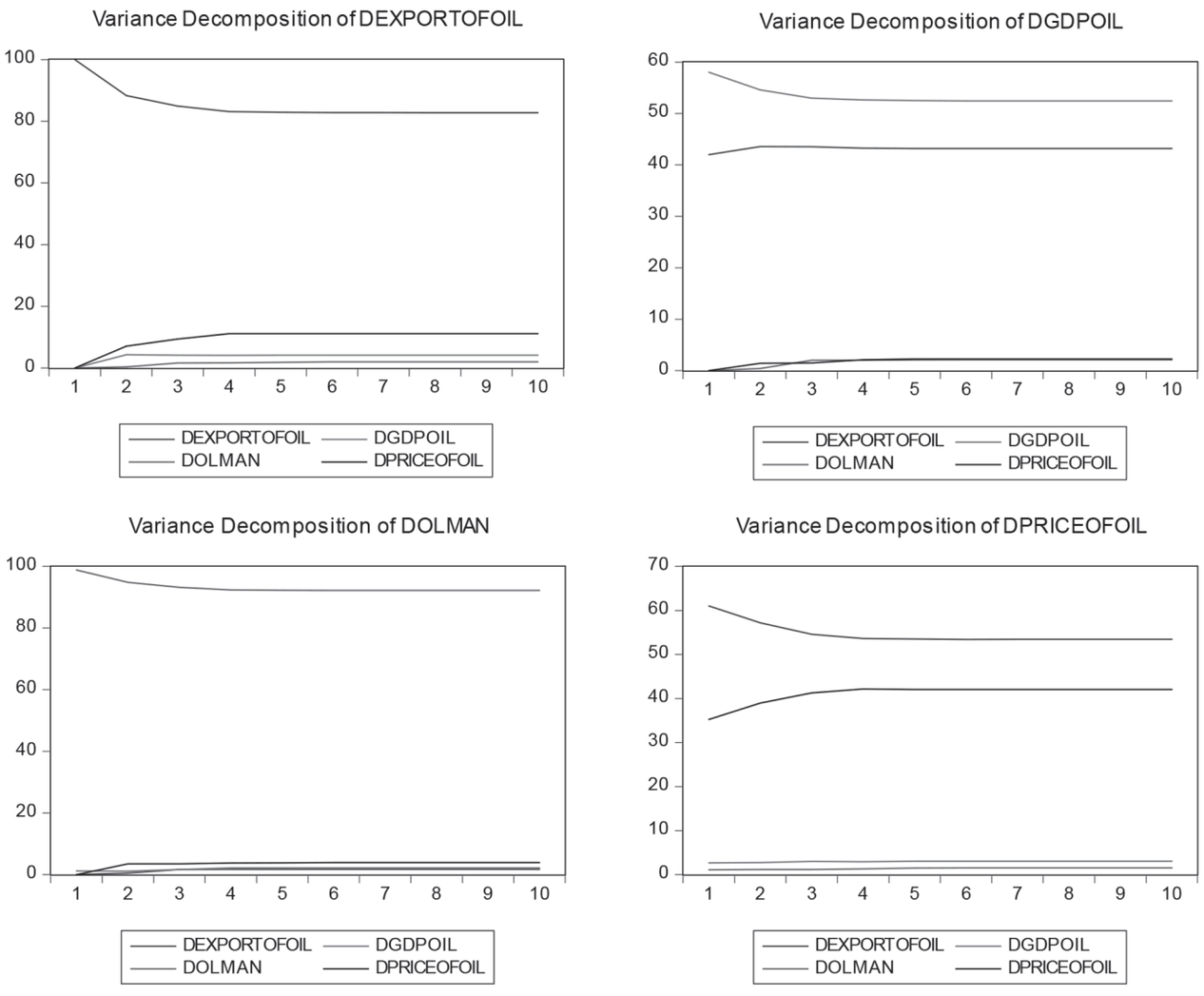

Рисунок 6. Дисперсия разложения
Figure 6. Variance of decomposition

Таблица 4 / Table 4

Result of Trace test
Результат теста трассировки

Hypothesis	Eigenvalue	Trace Statistic	Critical Value 0.1	Prob.
None *	0.665523	73.40656	39.75526	0.0046
At most 1	0.422853	29.31246	33.34234	0.0127
At most 2	0.279767	17.219978	20.66637	0.0221
At most 3	0.176737	13.678989	17.678979	0.0434

Таблица 5 / Table 5

Результат теста максимального собственного значения
Result for Max Eigen test

Hypothesis	Eigenvalue	Max Eigen Statistic	Critical Value 0.1	Prob.
None *	0.625875	73.73739	37.48696	0.0000
At most 1	0.322558	29.20740	30.83396	0.0172
At most 2	0.241497	20.73062	23.97534	0.0318
At most 3	0.157650	12.86702	16.55386	0.0437

cointegrating relationships among the examined variables at the 10% significance level.

This finding implies that the variables share a stable long-term relationship and tend to move together over time despite short-run fluctuations. Consequently, the presence of cointegration justifies the application of a Vector Error Correction Model (VECM) to capture both the short-term dynamics and the long-term equilibrium adjustments within the system.

The completed procedure of the Eviews 12 found the following error correction equation for first-order differences results of Azerbaijan's export of oil:

$$\begin{aligned}
&\text{D(DEXPORTOFOIL)} = \\
&- 1.18940881759*(\ \text{DEXPORTOFOIL(-1)} - \\
&-\ 8.00590333892e\text{-}05*\text{DGDPOIL(-1)} + \\
&+ 0.000146572679003*\text{DOLMAN(-1)} - \\
&- 0.00885372952442*\text{DPRICEOFOIL(-1)} + \\
&+ 0.0107752646733\ ) - \\
&- 0.0798792521181*\text{D(DEXPORTOFOIL(-1))} + \\
&+ 0.18380823088*\text{D(DEXPORTOFOIL(-2))} - \\
&- 7.07233198711e\text{-}05*\text{D(DGDPOIL(-1))} - \\
&- 2.75247522223e\text{-}05*\text{D(DGDPOIL(-2))} + \\
&+ 0.000151958865998*\text{D(DOLMAN(-1))} + \\
&+ 5.87657179623e\text{-}05*\text{D(DOLMAN(-2))} + \\
&+ 0.0029312184958*\text{D(DPRICEOFOIL(-1))} - \\
&- 0.00519617753817*\text{D(DPRICEOFOIL(-2))} + \\
&+ 0.000203928914505 \qquad (9)
\end{aligned}$$

The result of Granger test showed us between the stationary time series has inverse relationship. EViews 12 instrumental procedures obtain the error correction models for the remaining variables:

$$\begin{aligned}
&\text{D(DGDPOIL)} = \\
&= 1494.57646026*(\ \text{DEXPORTOFOIL(-1)} - \\
&- 8.00590333892e\text{-}05*\text{DGDPOIL(-1)} + \\
&+ 0.000146572679003*\text{DOLMAN(-1)} - \\
&- 0.00885372952442*\text{DPRICEOFOIL(-1)} + \\
&+ 0.0107752646733\ ) - \\
&- 460.028571364*\text{D(DEXPORTOFOIL(-1))} + \\
&+ 818.922928588*\text{D(DEXPORTOFOIL(-2))} - \\
&- 0.728231360208*\text{D(DGDPOIL(-1))} - \\
&- 0.286674765139*\text{D(DGDPOIL(-2))} + \\
&+ 0.0856779170305*\text{D(DOLMAN(-1))} - \\
&- 0.182489806949*\text{D(DOLMAN(-2))} + \\
&+ 35.2392139231*\text{D(DPRICEOFOIL(-1))} - \\
&- 3.79104605453*\text{D(DPRICEOFOIL(-2))} + \\
&+ 1.63023163376
\end{aligned}$$

$$\begin{aligned}
&\text{D(DOLMAN)} = \\
&= -5446.64794339*(\text{DEXPORTOFOIL(-1)} - \\
&- 8.00590333892e\text{-}05*\text{DGDPOIL(-1)} + \\
&+ 0.000146572679003*\text{DOLMAN(-1)} - \\
&- 0.00885372952442*\text{DPRICEOFOIL(-1)} + \\
&+ 0.0107752646733\ ) + \\
&+ 3879.12839446*\text{D(DEXPORTOFOIL(-1))} + \\
&+ 2192.30588481*\text{D(DEXPORTOFOIL(-2))} - \\
&- 0.380025914498*\text{D(DGDPOIL(-1))} - \\
&- 0.169051549345*\text{D(DGDPOIL(-2))} - \\
&- 0.119964140714*\text{D(DOLMAN(-1))} - \\
&- 0.0461544085452*\text{D(DOLMAN(-2))} - \\
&- 25.3147784794*\text{D(DPRICEOFOIL(-1))} - \\
&- 21.412299543*\text{D(DPRICEOFOIL(-2))} + \\
&+ 27.7845497825 \qquad (10)
\end{aligned}$$

$$\begin{aligned}
&\text{D(DPRICEOFOIL)} = \\
&= 18.1253359743*(\ \text{DEXPORTOFOIL(-1)} - \\
&- 8.00590333892e\text{-}05*\text{DGDPOIL(-1)} + \\
&+ 0.000146572679003*\text{DOLMAN(-1)} - \\
&- 0.00885372952442*\text{DPRICEOFOIL(-1)} + \\
&+ 0.0107752646733\ ) - \\
&- 23.1884526819*\text{D(DEXPORTOFOIL(-1))} + \\
&+ 7.21965611485*\text{D(DEXPORTOFOIL(-2))} - \\
&- 8.66253803313e\text{-}05*\text{D(DGDPOIL(-1))} - \\
&- 8.86229677746e\text{-}06*\text{D(DGDPOIL(-2))} - \\
&- 0.00138976777778*\text{D(DOLMAN(-1))} - \\
&- 0.0017073767227*\text{D(DOLMAN(-2))} + \\
&+ 0.0830840636971*\text{D(DPRICEOFOIL(-1))} - \\
&- 0.464659435464*\text{D(DPRICEOFOIL(-2))} - \\
&- 0.10728956806
\end{aligned}$$

Interpretation and discussion

The results of the error correction models confirm a strong long-run equilibrium relationship among Azerbaijan's oil exports, oil GDP, domestic oil demand, and oil prices. The negative and significant adjustment coefficient in the oil export equation (−1.189) demonstrates that deviations from long-run equilibrium are rapidly corrected through changes in export volumes. This implies that oil exports serve as the key adjustment mechanism in the system. Conversely, oil GDP and domestic oil demand respond asymmetrically, indicating partial and delayed adjustment, while oil prices exhibit limited correction behavior due to external market influences. Overall, the findings highlight that fluctuations in oil exports are central to restoring macroeconomic balance in Azerbaijan's oil sector.

This study evaluates whether Azerbaijan satisfies the Marshall–Lerner condition and exhibits the J-curve effect following currency depreciation. Using annual macroeconomic data for 1997–2024 and quarterly oil-sector data for 2005Q1–2024Q3, the research applies multiple econometric techniques including OLS, ADF unit root tests, VAR, VECM, cointegration analysis, impulse responses, and Granger causality tests.

The findings reveal that the Marshall–Lerner condition does not hold for Azerbaijan when the full economy is analyzed. Export and import demand elasticities remain too low, causing depreciation to worsen the trade balance rather than improve it. This reflects the country's limited export diversification, dependence on imports, and slow short-run response of domestic production to exchange rate shifts. Consequently, the classical J-curve pattern is not observed in aggregate trade indicators for Azerbaijan.

In contrast, results for the oil sector demonstrate a strong long-run equilibrium relationship among oil exports, oil GDP, oil prices, and the exchange rate. The error-correction terms show rapid adjustment of oil exports to deviations from long-run equilibrium, supporting both the Marshall–Lerner condition and a long-run J-curve–type improvement. Bidirectional causality among the variables further confirms the oil sector's central role in restoring macroeconomic balance. These outcomes are consistent with theoretical expectations for oil-exporting economies, where export revenues are highly sensitive to external price movements and exchange rate adjustments.

Overall, the study concludes that devaluation can only improve Azerbaijan's trade balance within the oil sector, while the broader economy remains unresponsive. This highlights the urgent need to diversify exports, strengthen non-oil production, and enhance the elasticity of both exports and imports to exchange rate movements.

Conclusion and Policy Implications

This study examined the applicability of the Marshall–Lerner condition and the J-curve effect for Azerbaijan using annual data for 1997–2024 and then considering quarterly oil-sector indicators for 2005Q1–2024Q3. The empirical results show that, when using the full-economy annual dataset, neither the J-curve pattern nor the Marshall–Lerner condition holds for Azerbaijan. The estimated elasticities of export and import demand do not satisfy the requirement that their sum exceeds one, indicating that exchange-rate depreciation does not improve the country's trade balance in the short run. This finding reflects structural characteristics of the Azerbaijani economy, particularly low export diversification, strong dependence on oil revenues, and limited immediate responsiveness of domestic production to currency shocks.

However, when the analysis focuses specifically on the oil sector, the results differ. VAR, VECM, and cointegration tests indicate the presence of stable long-run relationships among oil exports, oil GDP, oil prices, and the exchange rate. The significant error-correction dynamics and bidirectional long-term causality reveal that the Marshall–Lerner condition is satisfied within the oil sector and that the J-curve effect partially emerges over time. This suggests that oil exports adjust strongly to exchange-rate movements, while other macroeconomic indicators—particularly import demand—adjust more slowly. The dominance of oil revenues in Azerbaijan's external accounts means that the oil sector effectively drives the country's long-run adjustment mechanism.

Overall, the mixed results underscore that the effectiveness of currency depreciation in improving Azerbaijan's trade balance depends heavily on sectoral structure. In the general economy, depreciation fails to stimulate exports sufficiently to offset higher import costs. In contrast, in the oil sector—where price responsiveness is higher and global demand is strong—exchange-rate changes do translate into improved export performance in the long run. These findings align with previous studies in oil-exporting economies and highlight the need for stronger non-oil export diversification, flexible production capacity, and policy strategies that reduce vulnerability to external shocks. Strengthening these areas would increase the likelihood that exchange-rate adjustments can have positive and predictable effects on Azerbaijan's trade balance in the future.

Based on the empirical findings, several policy conclusions emerge for Azerbaijan:

- **Strengthen Non-Oil Export Diversification**

Since the Marshall–Lerner condition fails for the overall economy, Azerbaijan must enhance the responsiveness of non-oil exports. Policies should include targeted subsidies and tax credits for non-oil export industries, export promotion programs, support for SMEs and industrial upgrading, and expansion of logistics infrastructure to reduce trade costs.

- **Improve Elasticity of Export Supply**

For depreciation to stimulate exports, domestic producers must be able to increase supply quickly. This requires greater investment in manufacturing and agriculture, improvements in productivity and technology adoption, reducing regulatory barriers to scaling production.

- **Reduce Import Dependence**

High imports with low elasticity weaken the J-curve effect. Policy options include import substitution for essential goods, local production of intermediate inputs, incentives for domestic manufacturing of consumer goods.

- **Strengthen Exchange Rate Management**

The managed floating regime adopted after 2015 requires careful monitoring of external shocks, coordination between monetary and fiscal policy, and transparent communication by the central bank to stabilize expectations.

- **Reinforce Oil Revenue Management**

Azerbaijan's oil sector satisfies the Marshall–Lerner condition, meaning exchange-rate depreciation effectively improves oil-sector exports. To maximize this benefit, sovereign wealth fund policies should prioritize stabilization, exchange-rate adjustments should consider oil market volatility, and fiscal buffers should be strengthened during high-price periods.

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