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The Interactions of Trade Openness and Foreign Reserves in Algeria - An Econometric Study During the Period 1990-2023

Belkhir Fatima [1], Soumia Loghrab [2]
[1] Faculty of Economic, Commercial and Management Sciences, Department of Commercial Sciences, University of Ghardaia, Algeria.
Email: belkhir.fatima@univ-ghardaia.edu.dz
[1] Regional Tourism Laboratory and Institutions
[2]Faculty of Economic, Commercial and Management Sciences, Department of Commercial Sciences, University of Ghardaia, Algeria.
Email : loghrab.soumia@univ-ghardaia.edu.dz

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Abstract:

Reserves over the period 1990–2023. Using both analytical and quantitative approaches, the research analyzes the evolution of key variables and employs the Autoregressive Distributed Lag (ARDL) model to explore the dynamic relationships among them.

The findings reveal a statistically significant positive effect at the 5% level—both in the short and long run—between trade liberalization, oil prices, and foreign exchange reserves. Furthermore, the negative and significant error correction coefficient (–0.19) confirms the presence of a stable adjustment process toward long-term equilibrium.

The study concludes that Algeria's economy remains highly exposed to external shocks due to its heavy dependence on hydrocarbon exports. These results highlight the urgent need for comprehensive economic policies that promote export diversification and strengthen the contribution of non-oil sectors to foreign trade, thereby ensuring the long-term sustainability of foreign exchange reserves.

Keywords: Trade openness, foreign reserves, exports, imports, gross domestic product

I - Introduction

From its independence in 1962 until the late 1980s, the Algerian economy experienced an economic path based on the socialist model, which gave the state a central role in managing the economy and directing resources, through the dominance of the public sector, price setting, and control of foreign trade. However, this model began to face severe structural challenges, Especially after the collapse of oil prices in 1986, which revealed the fragility of the national economic structure and its excessive dependence on hydrocarbon revenues, this crisis led to a sharp decline in oil revenues, which negatively impacted the state's general budget, balance of payments, and foreign exchange reserves. It also contributed to the exacerbation of external debt and the increase in inflation and unemployment rates, In addition to the gradual disintegration of productive sectors, under these circumstances, Algeria had no choice but to engage in a comprehensive economic reform program, in cooperation with the International Monetary Fund, the most prominent features of which were the transition from a planned economy to a market economy.

One of the most important pillars of this transformation is trade openness, which has been a fundamental pillar for stimulating economic growth, attracting foreign investment, and achieving

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integration into the global economy. This approach has allowed for the easing of restrictions on foreign trade, the liberalization of prices, and the encouragement of exports, especially outside the hydrocarbon sector, One of the most important pillars of this transformation is trade openness, which has been a fundamental pillar for stimulating economic growth, attracting foreign investment, and achieving integration into the global economy. This approach has allowed for the easing of restrictions on foreign trade, the liberalization of prices, and the encouragement of exports, especially outside the hydrocarbon sector.

While trade openness provides opportunities to boost exports, if they are not diversified and remain dependent on oil revenues, it may lead to the erosion of foreign exchange reserves as a result of imports rising compared to exports, especially during periods of declining oil prices in global markets, hence, the importance of understanding the relationship between trade openness and foreign exchange reserves, given an economic reality plagued by a weak production structure and a fragile non-hydrocarbon export base.

I-1 The problem:

Research into such a problem is of great importance, given the vital role that foreign exchange reserves play in maintaining the country's economic and financial stability, and determining its ability to withstand external shocks, Analyzing this relationship would also contribute to evaluating the effectiveness of the trade policies being pursued and proposing alternatives that achieve a balance between economic openness and maintaining monetary stability. From this context, the following problem can be raised:

How did trade openness affect Algeria's foreign exchange reserves during the period 1990-2023?

-I 2. Study hypotheses:

- There is a joint integration relationship between the trade openness index and foreign exchange reserves in Algeria, during the period 1990-2023, at a significance level ($a \leq 0.05$).
- There is a statistically significant impact of the trade openness index on foreign exchange reserves in Algeria, during the period 1990-2023, at a significance level ($a \leq 0.05$).
- Algeria is relying on a set of policies to limit the decline in its foreign exchange reserves, including reducing imports.

-I 3. The importance of the study:

The importance of this study stems from the fact that it sheds light on one of the most important economic indicators, namely trade openness in Algeria, and the extent of its impact on foreign exchange reserves. This is achieved by understanding the relationship between trade openness and foreign exchange reserves and analyzing their development in Algeria, while relying on applied research that links two vital indicators in the Algerian economy.

-I 4..Study Methodology:

Based on the research problem and its objectives, we relied in this research on reviewing previous studies that addressed the research topic. We also relied on the analytical approach and the quantitative approach using the Autoregressive Distributed Lag Model to analyze the long- and short-term relationship between the study variables separately, providing a more detailed view of the research topic: The interactions of trade openness and foreign reserves in Algeria - an econometric study during the period 1990-2023. The statistical program (EVIEWS 13) was also used to ensure the accuracy and reliability of the results.

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-I 5. Previous studies:

There are several studies that have addressed topics similar to ours, the most important of which are:

A study by Walid Latrash and Zakaria Jaufry (2024): entitled: The Impact of Trade Openness on Foreign Exchange Reserves in Algeria during the Period (1990-2022) Using the ARDL Model, published in Remittances Review, Volume 9, Issue 2, This study aimed to analyze the short- and long-term dynamic relationship between trade openness and foreign exchange reserves in Algeria during the period 1990-2022, using the ARDL model. The study concluded that trade openness has a positive impact on foreign exchange reserves in Algeria in both the short and long term, In addition, the problem of autocorrelation of error sequences is absent with the homogeneity of random estimates over time.

Study by Boulashour, Sherifa. Qamri, Zeina (2021), entitled: The Impact of Trade Openness and Foreign Reserves on the Real Effective Exchange Rate as an Indicator of Economic Competitiveness: An Econometric Study of the Case of Algeria, published in the Journal of Economic Integration, Volume 9, Issue 4

This study aimed to investigate the competitiveness of the Algerian economy, by examining the impact of both foreign reserves and trade openness on the real effective exchange rate, during the period 1992-2019. The Stata software was used to analyze the data and estimate the regression model using the modified autoregressive least squares methodology. The standard results showed that there was no statistically significant effect of foreign reserves, while the effect of trade openness on the real effective exchange rate was negative, meaning that the greater the trade openness, the more it led to a deterioration in the value of the local currency. Given the continued dominance of oil exports in the export structure, despite the accumulation of significant foreign reserves thanks to the rise in oil prices,

and despite the trade openness achieved during the study period, this did not help improve the competitiveness of the Algerian economy.

Study by Ali Ismail Abdul Majeed, (2022) Doctoral thesis entitled: The impact of trade openness on some macroeconomic variables, Iraq, a case study for the period (2004-2020).

The study aimed to analyze the impact of trade openness on a number of economic variables in Iraq (GDP, unemployment, exchange rate, trade balance, international reserves, poverty) during the period 2004-2020, using the autoregressive distributed lag (ARDL) model, which explains the nature of the relationship in the short and long term, The study sought to answer questions related to the degree of openness of the Iraqi economy and the nature of its relationship with the aforementioned variables. The results showed that the degree of openness reached 66.5%, indicating a high level of integration with the global economy. There was a positive and significant effect of trade openness on GDP (with and without oil), unemployment, the trade balance, and international reserves. The parallel exchange rate had a negative and significant effect in the short term only, while its effect was insignificant in the long term.

Marcello Spanò's study (2012), entitled: The Impact of Openness on Foreign Reserves and Growth in Emerging Economies, published in the Economy Series, Issue No. 01.

This study aimed to highlight the impact of openness on foreign reserves and growth in emerging economies. The researcher indicated that the rise in reserves in emerging countries remains partially unexplained. It appears that emerging countries have reduced their exposure to short-term foreign capital flow risks over the past decade, while it increased its GDP growth with little growth in new capital assets and short-term external debt; it continued to increase its foreign reserves significantly. This work builds a model capable of explaining these typical facts as a result of the globalization process itself, and as numerical simulations demonstrate, the optimal solution depends critically on

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two structural criteria newly introduced into this model: the marginal cost of long-term financing and the competitiveness of the domestic industry.

A study by Uzoma Chidoka Nnamaka, Odungweru Kingsley, Chukwuma - Ogbonna Joyce Adaku, (2021) titled: Foreign Trade and External Reserves in Nigeria, an article published in: International Journal of Developing and Emerging Economies,

This study examined the impact of foreign trade and external reserves in Nigeria empirically. The study aimed to examine the impact of oil imports, non-oil imports, oil exports, non-oil exports, and exchange rate on external reserves in Nigeria. Time series data from 1980 to 2019 were collected from the Statistical Bulletin of the Central Bank of Nigeria, The study used the techniques of unit root test (ADF), cointegration, and error correction model. The results of the estimated model showed that all-time series were stationary at the first degree. The model explained by the cointegration result showed a long-run equilibrium relationship between the variables. Similarly, the error correction result showed that the ECM coefficient had a negative sign and was statistically significant at the 5% level, Moreover, the error correction result revealed that both oil and non-oil exports had a positive impact on external reserves, although the impact of non-oil exports was small, while oil imports, non-oil imports and the exchange rate had a significant negative impact on external reserves in Nigeria, specifically, Oil exports, oil imports, non-oil imports and exchange rate were statistically significant at 5%, meaning they significantly influenced Nigeria's external reserves during the period covered by the study. In addition, Granger causality test revealed that oil exports had a unidirectional causal relationship with external reserves. While there was a two-way relationship between the exchange rate and external reserves, based on these findings, the study recommended, among other things, diversification of the national export base as a possible measure to improve Nigeria's external reserves. The study also suggests discouraging imports, especially for goods that can be produced locally; finally, the study recommends that the Central Bank of Nigeria, as the custodian of Nigeria's foreign exchange reserves, stabilize the value of the local currency, taking into account external shocks resulting from exchange rate fluctuations.

II. The reality of trade openness and foreign reserves in Algeria:

Since the beginning of the last decade of the twentieth century, Algeria has moved towards abandoning the socialist economic system and has adopted a new approach represented by adopting a trade liberalization policy. This policy is defined as “measures aimed at removing customs and non-customs restrictions that hinder trade exchange, where the level of trade openness is measured through a set of indicators, the most prominent of which are the following:

Commodity concentration index of national exports: The index measures the degree of concentration of a country's commodity exports. Its value ranges between 0 and 1, where a value of 1 means complete concentration of the country's exports, meaning that the country depends on a limited number of commodities in its exports. It is expressed using the "Hirschman" coefficient as follows:

$$Hi = \sqrt{\Sigma}=1(xifXf)2ni-\sqrt{1}n/1-\sqrt{1}n$$

- **Xij: Country j's exports of commodity i**
- **Xj: Country j's total exports**
- **N : Number of goods exported**

Geographical Concentration Index of Exports: This index measures the diversity of export destinations for the country in question. The higher this index indicates that the country focuses on a limited number of customers, which makes it bear any economic impacts that affect these countries. This must be done according to the following mathematical relationship:

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$$CGM = \sum_{i=1}^{i=n} 1\,(xit/xt)^2$$

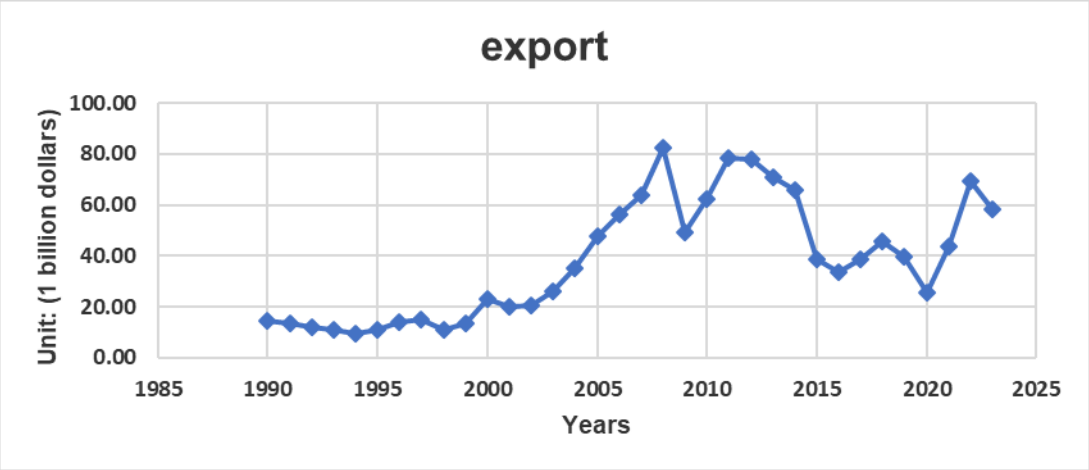
Trade openness index: This index is considered one of the most important indicators used to measure the degree of openness to the international economy, as it measures the extent of foreign trade's contribution to the formation of the gross domestic product. The rise in this index indicates the extent of the economy's deep dependence on foreign markets to sell its products and obtain its needs for goods and services. It can be calculated using the following mathematical relationship:

$$e = \frac{(X + M)i}{PIB}$$

Accordingly, in order to study the reality of trade openness in Algeria, it is necessary to analyze the components of this indicator by addressing each of exports, imports and the gross domestic product in Algeria.

II.1 Development of exports in Algeria during the period 1990-2023: The export index is one of the important indicators that express the competitiveness of a country. The rise in this index expresses the country's ability to produce and export and thus bring in hard currency, which, as we know, has positive effects on many other indicators such as the trade balance and the exchange rate, but Algeria As is known, it is a rentier state that relies very heavily on oil exports. In general, the following figure shows the developments in Algeria's total exports in the period from 1990-2023:

Figure No. (01) The development of exports in Algeria during the period 1990-2023



Source: Prepared by the researchers based on the publications of the Bank of Algeria.

According to statistics obtained from the Bank of Algeria's reports on the development of Algerian exports during the period from 1990 to 2023, we note that this indicator witnessed a decline and fluctuation during the 1990s, as the value of exports declined from $14.55 billion in 1990 to $9.59 billion in 1994. The reasons for this decline may be attributed to the economic and political challenges of that period, particularly the security crisis experienced by Algeria and the decline in global oil prices. However, by the end of 1999, the economy gradually improved, reaching $13.69 billion due to the beginning of a recovery in global oil prices. The period (2000-2008) also witnessed a significant jump in exports, from $23.05 billion in 2000 to $82.34 billion in 2008. This strong growth is due to the significant rise in oil prices, which reached record levels during this period, in addition to the relative political stability in Algeria after years of crisis. Exports declined to $48.98 billion in 2009, then rose again to $78.57 billion in 2011, benefiting from stable oil prices, Algeria began to face new challenges in 2014 as oil prices began to fall, with exports falling to $65.99 billion.

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While the period (2015-2020) was marked by a sharp decline in the value of exports, falling from $38.49 billion in 2015 to $25.61 billion in 2020, due to the decline in oil prices and the effects of the COVID-19 pandemic, this decline was a direct result of the decline in global demand for oil and the disruption of supply chains.

Exports began to recover as global prices rose again during the period (2021-2023), reaching $69.52 billion in 2022, before declining slightly to $58.49 billion in 2023. This improvement partly reflects the Algerian government's efforts to diversify the economy, along with a recovery in global energy demand.

II.2 Development of imports in Algeria during the period 1990-2023:

We previously mentioned that the trade openness index relied upon in this study is the total exports and imports of the gross domestic product, and this index has also undergone many changes, as shown in the following table:

Table No. (02) The development of the openness index in Algeria during the period 1990-2023

Unit: (%)

Year	1990	1991	1992	1993	1994	1995	1996	1997
Indicator	0.48	0.53	0.49	0.45	0.49	0.55	0.54	0.52
Year	1998	1999	2000	2001	2002	2003	2004	2005
Indicator	0.45	0.51	0.63	0.55	0.57	0.58	0.61	0.67
Year	2004	2005	2006	2007	2008	2009	2010	2011
Indicator	0.61	0.67	0.66	0.68	0.71	0.64	0.63	0.62
Year	2012	2013	2014	2015	2016	2017	2018	2019
Indicator	0.61	0.59	0.57	0.53	0.50	0.50	0.52	0.47
Year	2020	2021	2022	2023				
Indicator	0.40	0.47	0.51	0.44				

Source: Prepared by the researchers based on World Bank data.

Through the previous countries, we note that the trade openness index also witnessed a decline in the period extending from 1990 to 1999, not exceeding 55%. This is due to the closure of the Algerian economy, despite its adoption of a liberalization policy. However, the deteriorating conditions in that period and the decline in oil prices prevented this from being achieved; the period that followed had the same effects from 2000 to 2008, with an increase in the index due to the rise

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in oil prices, the increase in exports, and the opening of more space for imports. As for the period after 2015, openness declined due to the decline in oil prices and consequently the decline in both exports and imports, which also increased with the rise in oil prices. However, this increase did not last long due to the repercussions of the Corona pandemic, It is expected to rise again due to several factors, most notably the improvement in oil prices, in addition to internal reforms, most notably the 2022 Investment Law and the signing of the African Free Trade Agreement.

II. 5. Foreign reserves in Algeria:

II. 1.5 Theoretical literature on foreign reserves: According to the International Monetary Fund, foreign reserves: They are the assets easily available to monetary authorities, and at the same time they have the ability to control them in order to directly finance payments imbalances and indirectly regulate the amounts of these imbalances through intervention in the exchange markets to influence the currency exchange rate markets or for other purposes. For reference, foreign reserves consist of both monetary gold reserves, Foreign currencies, special drawing rights, and these reserves are of great importance to any economy, the most important of which are the following points:

- Establishing a buffer to protect the local economy from unexpected negative imbalances.
- Financing remittances and returns for foreign investors with projects in the country that generate revenue for the local market.
- Intervening in foreign exchange markets to support exchange rate policy, whether to achieve an independent exchange rate or to maintain the currency's value.
- Foreign reserves represent the first line of defense for the value of a currency, ensuring the stability of its exchange rate and financing expected imbalances in the current account.

II. 2.5. The reality and development of foreign reserves in Algeria:

Since the Algerian economy is an economy that depends almost entirely on hydrocarbons, various economic indicators are affected by hydrocarbon prices. Therefore, foreign reserves in Algeria had almost the same changes during the study period as the previous indicators, as shown in the following table:

Table No. (03) The development of foreign exchange reserves (minus gold) at current prices in Algeria for the period (1990-2023)

Year	1990	1991	1992	1993	1994	1995	1996	1997
Value	0.72	1.49	1.46	1.47	2.67	2.01	4.24	8.05
Year	1998	1999	2000	2001	2002	2003	2004	2005
Value	6.85	4.53	12.02	18.08	23.24	33.13	43.25	56.30
Year	2006	2007	2008	2009	2010	2011	2012	2013
Value	77.91	110.3	143.2	149.0	162.6	182.8	191.3	194.7
Year	2014	2015	2016	2017	2018	2019	2020	2021
Value	179.6	144.6	114.3	97.61	80.23	63.30	48.88	46.05
Year	2022	2023						
Value	61.74	69.71						

Source: Prepared by the researchers based on World Bank data

From the previous table, we note that the foreign exchange reserve had the same changes as for the rest of the other indicators. In the last decade of the last century, the foreign reserve witnessed a decline due to the deterioration of the situation on all levels. Then, starting from the beginning of the current century, the reserve began to rise due to the stability of the situation and the rise in oil

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prices, It was once again affected by two crises: the first was the drop in oil prices in 2015, and the second was the Corona pandemic. It then rose again due to the rise in fuel prices, as well as the increase in exports outside the fuel sector, which exceeded $6.6 billion in 2022.

III. Study model assessment:

Most modern studies rely on the use of statistical tools to measure the relationship between variables in order to arrive at accurate results that enable their users to know the direction of the phenomenon being studied in the short or long term. They also enable the researcher to measure the variables with each other in order to make sound decisions, Accordingly, in this context, the Autoregressive Lag Method will be adopted, which is considered more appropriate for measuring the impact of trade openness on foreign reserves in Algeria during the period 1990-2023.

III.1 Study data sources, sample, and variables:

III.1.1. Study data sources:

Our study data were obtained from the Bank of Algeria database.

III. 2.1 Study sample:

The study sample is the country of the two researchers: Algeria.

III. 3.1 Study variables:

Table No. 04: Study variables

Code	Type	Definition of variable	Variable name
FR	Dependent variable	Represents the value of a country's foreign exchange reserves.	Foreign reserve
TO	Independent variable	It is measured by the ratio of foreign trade (exports + imports) to GDP.	Trade openness
Oilp	Control variable	Average price of oil in global markets (e.g. Brent crude in US dollars)	Oil prices

Source: Prepared by the researchers

III.2 Method and tools:

Through this study, we will try to limit the dependent variable represented by foreign reserves (FR), and the independent variable represented by trade openness (TO), and based on what the economic theory has provided, as well as based on previous studies that have dealt with and dealt with this topic, in addition to taking into account the nature and specificity of the Algerian economy, Therefore, our study was limited to the interactions of trade openness and foreign reserves in Algeria - an econometric study during the period 1990-2023, as the data for the study were obtained from the World Bank database for the period 1990-2023, The validity of the appropriate model for the dependent variables will be estimated and selected based on the nature of the study data and the hypotheses and factors it provides that enter into studying the phenomenon, relying on the Eviews13 program. The estimation process will be based on a linear model, and the model will be formulated through economic theory, prepared for the dependent variable that relates to the study problem.

III.3 Study Model:

We obtain the autoregressive distributed lag (ARDL) model and the following equation for the dependent variable foreign reserves (FR):

FR = f (TO) T=1990-2023

Therefore, the equation of the proposed model in its explicit form and in linear form is as follows:

$$\Delta FR_t = B_0 + \sum B_1 \Delta FR_{t-1} + \sum B_2 \Delta TO_{t-1} + \sum B_3 \Delta oilp_{t-1} + \alpha_1 \Delta FR \Delta + \Delta\alpha_2 TO_{t-1} + \Delta\alpha_3 oilp_{t-1} \varepsilon t$$

Whereas:

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- : Δ refers to first-order differences.
- Pq: represents the upper bound of the time lags for the dependent and independent variables in the model.
- B1, B2 represent the short-term relationship coefficients (error correction model).
- 2α:1 α represents the long-term relationship coefficients.
- Foreign reserves (FR), dependent variable
- Trade openness (TO), independent variable
- Oil prices (OILP), control variable

III 1.3 Testing the stationarity of time series:

The stationarity test of the time series depends on the presence or absence of a unit root. This means that the series is not stationary due to the presence of a false deviation, and thus it is a problem in standard analysis. Many tests are used to determine stationarity or stationarity, such as the AUGMENT DICKEY-FULLER test, the mechanism was tested for delay degree to study stability using Avios program.

Table 5: ADF test for the stability of the series under study: Trade openness (FR), foreign exchange reserves (TO), and oil prices (OILP).

ADF									
Variable	Level				First Deference				
	Characteristics	t-Statistic	Result of stillness	Critical values	Characteristics	t-Statistic	Result of stillness	Critical values	Degree of integration
(FR)	Trend and Intercep	-1.65 0.74	Not static	at level 5%	Trend and Intercep	-6.60 0.00	static	at level 1%	I(1)
	Intercept	-1.68 0.43	Not static	at level5%	Intercept	-6.07 0.00	static	at level 1%	
	None	-0.36 0.54	Not static	at level5%	None	-6.17 0.00	static	at level 1%	
(TO)	Trend and Intercep	-2.77 0.21	Not static	at level5%	Trend and Intercep	-4.88 0.00	static	at level 1%	I(1)
	Intercept	-2.27 0.18	Not static	at level5%	Intercept	-4.30 0.00	static	at level 1%	
	None	-1.21 0.19	Not static	at level5%	None	-4.70 0.00	static	at level 1%	
Oilp	*Trend and Intercep*	*-2.25 0.44*	Not static	*at level5%*	*Trend and Intercep*	*-5.16 0.00*	static	*at level 1%*	*I(1)*
	Intercept	*-1.47 0.53*	Not static	*at level5%*	*Intercept*	*-5.25 0.00*	static	*at level 1%*	
	None	*-0.25 0.58*	Not static	*at level5%*	*None*	*-5.25 0.00*	static	*at level 1%*	

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Source prepared by the researchers based on the outputs of the EVIEWS.13 program.

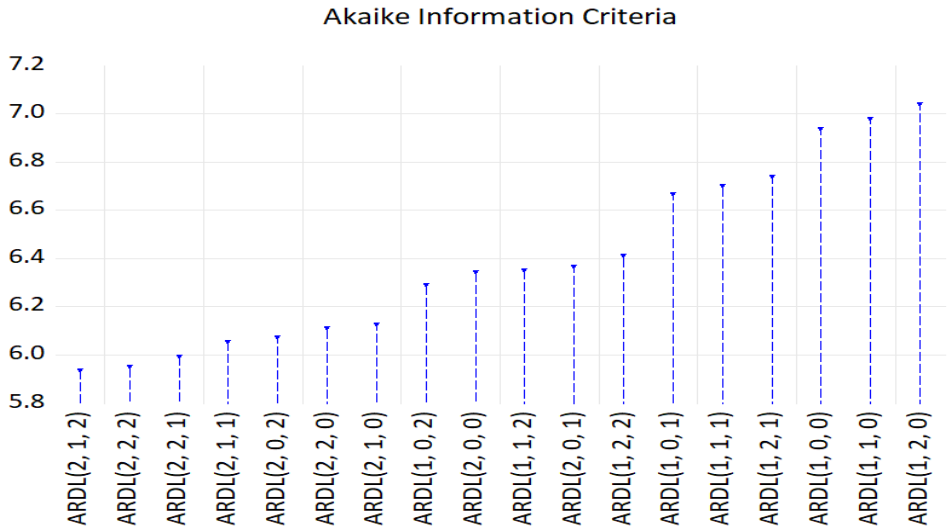
The results of the augmented Dickey-Fuller unit root test (Adf) for the study variables series confirm the presence of a unit root at the level, and thus the study variables are not stationary at the level. In contrast, after setting the first difference, all study variables series were stationary at the first difference, We can say that we reject the null hypothesis H0, which states that there is a unit root, and accept the alternative hypothesis, which states that there is no unit root, at the 0.05% and 0.1% levels.

Since the study variables are stationary at degree I(1), the ARDL autoregressive lag model will be applied to achieve the condition of stationarity of the time series at the level or the first difference.

- Testing optimal lag periods:

Based on the AIC test, the lag periods were determined. It was found that Model (2.1.2) is the optimal model, as shown in the following figure:

Figure No. (03): Results of the test of optimal slowdown periods



Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

III.2.3 Bounds test for cointegration using bounds test:

The table below shows the results of the joint integration test using the Bounds Test methodology. The results below indicate that the calculated value of the F-statistic, F=5.54, is greater than the critical values for the lower limit at most levels of significance, hence, we reject the null hypothesis, which states that there is no co-integration relationship between the variables. This indicates the existence of a long-term equilibrium relationship between the study variables, the dependent variable, foreign reserves (FR), and the independent variables, trade openness (TO), oil prices (oilp). In order to test the possibility of a long-term equilibrium relationship between the variables, a boundS test will be conducted, and the table below shows this:

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Table 06: Bounds test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	5.543304	10%	2.63	3.35
k	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
Actual Sample Size	32	Finite Sample: n=35		
		10%	2.845	3.623
		5%	3.478	4.335
		1%	4.948	6.028

Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

III.3.3 Estimating the parameters of the study model: The proposed model for the dependent variable, foreign reserves (FR). After determining the degree of certainty of the existence of a joint integration relationship between the variables, we estimated the following model:

Table 07: Estimation of the study model using the model: Model: (2.1.2)

Dependent Variable: FR
Method: ARDL
Date: 07/19/25 Time: 12:52
Sample (adjusted): 1992 2023
Included observations: 32 after adjustments
Maximum dependent lags: 2 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): OILP TO
Fixed regressors: C
Number of models evalulated: 18
Selected Model: ARDL(2, 1, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
FR(-1)	1.219726	0.147542	8.266992	0.0000
FR(-2)	-0.417358	0.108716	-3.838972	0.0008
OILP	0.472165	0.058281	8.101521	0.0000
OILP(-1)	-0.206849	0.089435	-2.312837	0.0296
TO	14.23976	22.29821	0.638605	0.5291
TO(-1)	27.63995	26.21421	1.054388	0.3022
TO(-2)	50.74422	23.21745	2.185607	0.0388
C	-50.71864	14.51839	-3.493407	0.0019

R-squared	0.996738	Mean dependent var	72.97281
Adjusted R-squared	0.995787	S.D. dependent var	65.15443
S.E. of regression	4.229170	Akaike info criterion	5.934207
Sum squared resid	429.2611	Schwarz criterion	6.300640
Log likelihood	-86.94730	Hannan-Quinn criter.	6.055669
F-statistic	1047.665	Durbin-Watson stat	2.255258
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection

Source: Prepared by the researchers based on the outputs of the Eveiws 13 program.

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From the table above:

The coefficient of determination R2 is estimated at 99.67%, which is acceptable and indicates that 99.67% of the changes in foreign reserves (FR) are caused by the independent variables (trade openness TO, oil prices (oilp)). The Fisher value is 1047.66 and is greater than the table value, which indicates that the model has statistical significance.

III.4.3 Model Quality Testing:

Based on the model (1.2.2), in estimating the short- and long-term effects, the quality of the performance of this model must be ensured by using a set of the following tests:

1. **Testing the problem of autocorrelation: (Breusch - Godfrrey Correlation lm test)**

This test indicates, through the data in the table, that the model is free from the problem of autocorrelation, since the value of prob chi-square reached 0.34, which is greater than the significance level of 0.05. Therefore, we accept the null hypothesis, which states that the residuals have no autocorrelation.

Table No. 08: Breusch-Godfrrey Correlation lm test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	1.107628	Prob. F(7,24)	0.3902
Obs*R-squared	7.813608	Prob. Chi-Square(7)	0.3493
Scaled explained SS	4.240951	Prob. Chi-Square(7)	0.7516

Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

2. **Test the problem of heteroscedasticity (HETREIOSKEDASTICITYTest ARCH)**

The results of this test showed that the value of Prob chi-square for this test reached 0.68, which is greater than 0.05. Therefore, the null hypothesis can be accepted, which indicates the homogeneity of the residuals and does not contain the problem of heterogeneity of variance.

Table No. 09: HETREIOSKEDASTICITY Test ARCH

Heteroskedasticity Test: ARCH

F-statistic	0.157824	Prob. F(1,29)	0.6941
Obs*R-squared	0.167795	Prob. Chi-Square(1)	0.6821

Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

3. **Histogram-normality Test**

From the results of this test, we note that the value of the Prob jarque - Bera is equal to: 0.50, which is greater than the significance level of 0.05, and thus the null hypothesis is not rejected, which indicates that the residuals are free from the problem of normal distribution, i.e. they are normally distributed.

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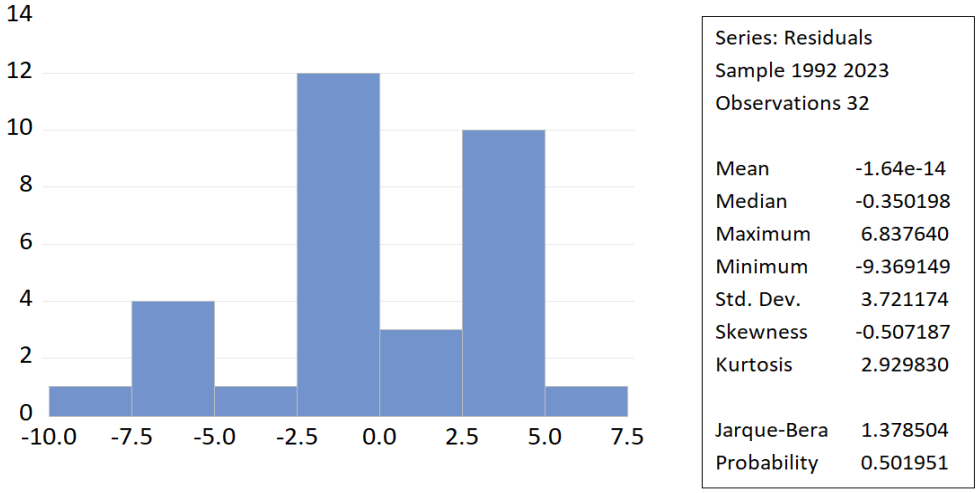
Table No. (10): Histogram-normality Test.

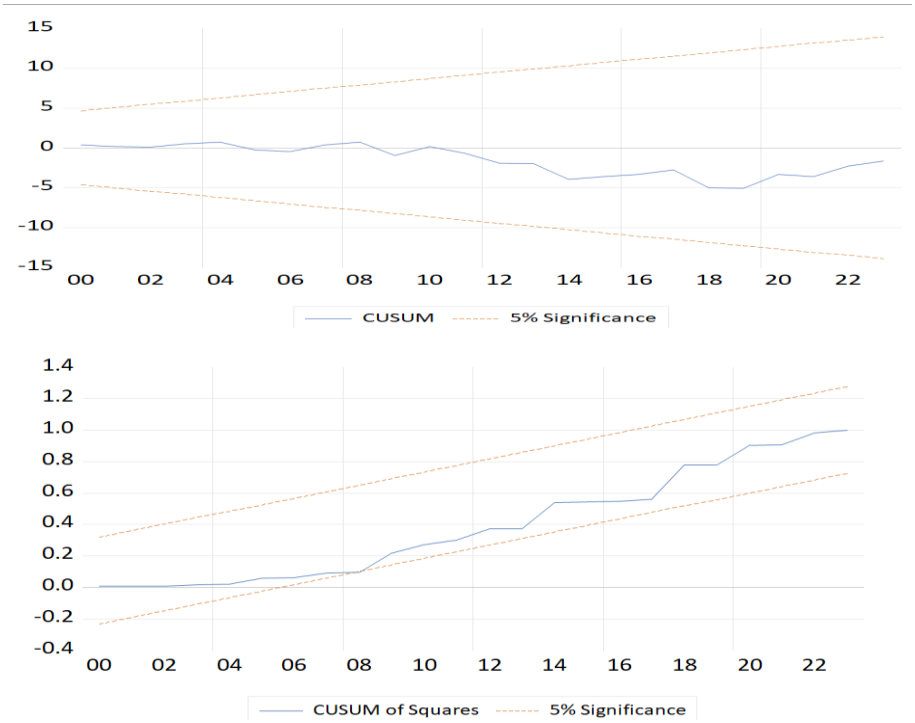


Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

4. Stability test:

The structural stability of the estimated coefficients of the error correction model of the distributed lag autoregressive model is achieved if the graph of the CUSUM and SQUARES OF CUSUM tests falls within the critical limits at the 5% level. Based on most studies, we applied the CUSUM and CUSUMSQ tests proposed by Brown and Dublin to ensure that the data used are free of any structural changes, one of the tests suggested by BROWN, DUBLIN and EVANS (1975) shown in the following figure must be used:

Figure 4: Stability test



Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

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From the figure above, we notice that the representation in both the CUSUM test and the CUSUM OF SQUARES TEST is within the limits at the 5% level, and thus we accept the stability of the model. It is noteworthy that the stability of the model is for a certain period at the end of the study period.

III.5.3 Estimating the Short-Run and Long-Run Relationship and the Error Correction Model

1. Estimating the Short-Run Relationship and the Error Correction Model:

The short-term relationship is estimated through the error correction model (ECM), which expresses the study variables in the form of a first-order difference filter, such that the error correction term is recent to only one time period, as an explanatory variable, through which it is possible to know the speed of adaptation of imbalances that occur in the short term to equilibrium in the long term, So if the error correction coefficient has a negative sign with a significant probability less than 0.05, it indicates that there is a long-term relationship, as the absolute value of the error correction coefficient is considered the speed of restoring the equilibrium state again. The results of testing the error correction model and the short-term relationship are shown in the following table:

Table 11: Estimate of the error correction model for the short-run relationship of the ARDL model

ARDL Error Correction Regression
Dependent Variable: D(FR)
Selected Model: ARDL(2, 1, 2)
Case 2: Restricted Constant and No Trend
Date: 07/19/25 Time: 12:52
Sample: 1990 2023
Included observations: 32

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FR(-1))	0.417358	0.082940	5.032065	0.0000
D(OILP)	0.472165	0.053148	8.883961	0.0000
D(TO)	14.23976	19.10076	0.745507	0.4632
D(TO(-1))	-50.74422	21.35404	-2.376328	0.0258
CointEq(-1)*	-0.197631	0.039570	-4.994484	0.0000

R-squared	0.942348	Mean dependent var	2.131875
Adjusted R-squared	0.933807	S.D. dependent var	15.49785
S.E. of regression	3.987300	Akaike info criterion	5.746707
Sum squared resid	429.2611	Schwarz criterion	5.975728
Log likelihood	-86.94730	Hannan-Quinn criter.	5.822621
Durbin-Watson stat	2.255258		

* p-value incompatible with t-Bounds distribution

Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

The relationship can be explained as follows:

- The error correction results indicate that the error correction coefficient cointeq (-1) = 0.19 is negative and statistically significant. This reflects the existence of a short-term equilibrium

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relationship between the study variables towards equilibrium in the long term, meaning that 19% of the error can occur in the short term and can be corrected in the long term. Through the above results that highlight the relationship in the short term, we also confirm that the study variables are co-integrated.

- The trade openness (TO) parameter has a positive and significant relationship with foreign reserves (FR), whereby when trade openness (TO) increases by 1%, it will lead to an increase in foreign reserves (FR) by 14.23%. This means that increasing the degree of trade openness leads to enhancing the flow of foreign currencies into the economy, through an increase in the volume of exports, which increases hard currency revenues, This, in turn, stimulates foreign investment as a result of a more liberal trading environment. It also leads to increased remittances and international financial transactions thanks to the liberalization of trade transactions. Therefore, trade openness represents an effective driver for strengthening international reserves and supporting financial and monetary stability, especially in developing countries that rely heavily on foreign currency inflows.
- The oil price parameter (OILP) has a positive and significant relationship with foreign reserves (FR), whereby when oil prices (OILP) increase by 1%, it will lead to an increase in foreign reserves (FR) by 0.47%. This reflects the vital role played by oil exports in forming international reserves, especially in rentier or oil-dependent countries, such as Algeria, As rising oil prices on global markets lead to increased export revenues, these revenues are directly injected into the central bank's foreign reserves. This contributes to strengthening financial stability and increasing the country's ability to confront external economic shocks and finance imports. Therefore, oil prices are a key factor in determining the size of the Algerian economy's foreign reserves.

2. Interpretation of long-term results: After confirming the existence of a long-term relationship, the long-term parameters should be obtained:

Table 12: Results of estimating long-run parameters ARDL

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OILP	1.342479	0.154163	8.708183	0.0000
TO	14.67028	79.36375	5.905341	0.0000
C	-2.632829	41.61921	-6.166203	0.0000

Source: Prepared by the researchers based on the outputs of the EVIEWS.13 program.

- **We note from the table above: Long-term results:**
  - The trade openness (TO) parameter has a positive and significant relationship with foreign reserves (FR), whereby increasing trade openness (TO) by 1% will lead to an increase in foreign reserves (FR) by 14.67%, where the effect was significant in the long run. This strong long-run effect indicates that policies that promote trade openness—such as reducing tariff restrictions, stimulating exports, Facilitating foreign trade — over time, leads to increased foreign currency inflows through export growth and expansion of the production base directed to foreign markets, in addition to attracting foreign direct investment, which has a positive

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impact on the balance of international reserves and improves the trade balance; This increases the central bank's ability to raise more foreign currency. Therefore, trade openness constitutes a strategic tool for enhancing financial sustainability and achieving monetary stability, especially when adopted within a long-term economic vision.

- The oil price parameter (oilp) has a positive and significant relationship with foreign reserves (FR), whereby when oil prices (oilp) increase by 1%, it will lead to an increase in foreign reserves (FR) by 1.34%, where the effect was stronger in the long term. This strong effect in the long term reflects the extent of the national economy's dependence on oil revenues, as oil is the main source of foreign currency. Therefore, Oil prices are a key determinant of foreign reserves, and the analysis highlights the importance of diversifying sources of income to reduce reliance on this one-way relationship.

IV Conclusion:

The impact of trade openness on Algeria's foreign exchange reserves during the period (1990–2023) is evident through a dual relationship characterized by variations depending on domestic and international economic conditions. Trade openness, especially during periods of high oil prices, contributed to increased foreign currency flows into the national economy, leading to a significant accumulation of foreign exchange reserves, It peaked during the oil boom years between 2003 and 2014. However, this positive impact remained fragile, as periods of declining oil prices and global economic crises, such as the 2008 global financial crisis and the 2020 COVID-19 pandemic, revealed the fragility of Algeria's trade structure, given its overreliance on hydrocarbon exports and the import of most of its needs. This imbalance led to a gradual erosion of foreign reserves, especially after 2014, this reflects that trade openness, despite its importance, does not achieve a sustainable impact unless it is accompanied by structural reforms aimed at diversifying the production and export base, improving the trade balance, and enhancing the competitiveness of national products.

Results and hypothesis testing:

- The results of the augmented Dickey-Fuller unit root test (Adf - AUGMENT DICKEY-FULLER) and the Philips-Perron (PP) test confirm the presence of a unit root at the level for the study variables series. Therefore, the study variables did not stabilize at the level. In contrast, after preparing the first difference, all study variables series stabilized at the first difference.
- Since the study variables were characterized by stationarity at degree I(1), the autoregressive model for lagged time lags (ARDL) was applied to achieve the condition of stationarity of the time series at the level or at the first difference.
- The joint integration test was proven using the Bounds Test methodology, as the value accompanying this test indicated that the calculated value of the F-statistic = 5.54 is greater than the critical values for the minimum limit at most levels of significance, Hence, the null hypothesis was rejected, which states that there is no mutually complementary relationship between the variables, i.e. the existence of a long-term equilibrium relationship between the study variables, the dependent variable, foreign reserves (FR), and the independent variables, trade openness (TO), and oil prices (OILP).

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- **Accordingly, it can be emphasized that:**

  There is a joint integration relationship between the trade openness index and foreign exchange reserves in Algeria, during the period 1990-2023, at a significance level (a≤0.05)

- **Short-term results and error correction limit:**

  The error correction results indicate that the error correction coefficient cointeq (-1) = 0.19 is negative and statistically significant. This reflects the existence of a short-term equilibrium relationship between the study variables towards equilibrium in the long term, meaning that 19% of the error can occur in the short term and can be corrected in the long term. Through the above results that highlight the relationship in the short term, we also confirm that the study variables are co-integrated.

- The trade openness parameter (TO) has a positive and significant relationship with foreign reserves (FR), whereby when trade openness (TO) increases by 1%, it will lead to an increase in foreign reserves (FR) by 14.23%. This means that increasing the degree of trade openness leads to enhancing the flow of foreign currencies into the economy, by increasing the volume of exports, which increases hard currency earnings, this in turn enhances the stimulation of foreign investment as a result of a more liberal trading environment. It also leads to an increase in remittances and international financial transactions thanks to the liberalization of trade transactions. Therefore, trade openness represents an effective engine for strengthening international reserves; it supports financial and monetary stability, especially in developing countries that rely heavily on foreign currency inflows.
- The oil price parameter (OILP) has a positive and significant relationship with foreign reserves (FR), whereby when oil prices (OILP) increase by 1%, it will lead to an increase in foreign reserves (FR) by 0.47%. This reflects the vital role played by oil exports in forming international reserves, especially in rentier or oil-dependent countries, such as Algeria, as rising oil prices on global markets lead to increased export revenues, these revenues are directly injected into the central bank's foreign reserves. This contributes to strengthening financial stability and increasing the country's ability to confront external economic shocks and finance imports. Therefore, oil prices are a key factor in determining the size of the Algerian economy's foreign reserves.
- **Long-term results:**

  The trade openness (TO) parameter has a positive and significant relationship with foreign reserves (FR), whereby increasing trade openness (TO) by 1% will lead to an increase in foreign reserves (FR) by 14.67%, where the effect was significant in the long run. This strong long-run effect indicates that policies that promote trade openness—such as reducing tariff restrictions, stimulating exports, facilitating foreign trade — over time, leads to increased foreign currency inflows through export growth and the expansion of the production base directed to foreign markets, in addition to attracting foreign direct investment, which has a positive impact on the balance of international reserves and improves the trade balance, which increases the central bank’s ability to collect more foreign currency, Therefore, trade openness constitutes a strategic tool for enhancing financial sustainability and achieving monetary stability, especially when adopted within a long-term economic vision.

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- The oil price parameter (OILP) has a positive and significant relationship with foreign reserves (FR), whereby when oil prices (OILP) increase by 1%, it will lead to an increase in foreign reserves (FR) by 1.34%, where the effect was stronger in the long term. This strong effect in the long term reflects the extent of the national economy's dependence on oil revenues.
- Since oil is the main source of foreign currency, oil prices are a key determinant of foreign reserves. The analysis highlights the importance of diversifying sources of income to reduce reliance on this one-way relationship.
- **Accordingly, it can be emphasized that:**

  There is a short- and long-term impact between the trade openness index and foreign exchange reserves in Algeria, during the period 1990-2023, at a significance level ($a \leq 0.05$)

Appendices:

Appendix No. 01: ADF test results for the FR series

Null Hypothesis: FR has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.659281	0.7465
Test critical values:	1% level	-4.262735	
	5% level	-3.552973	
	10% level	-3.209642	

Null Hypothesis: FR has a unit root
Exogenous: Constant
Lag Length: 5 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.680026	0.4300
Test critical values:	1% level	-3.689194	
	5% level	-2.971853	
	10% level	-2.625121	

Null Hypothesis: D(FR) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.608409	0.0000
Test critical values:	1% level	-4.284580	
	5% level	-3.562882	
	10% level	-3.215267	

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Null Hypothesis: D(PR) has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.077570	0.0000
Test critical values:	1% level	-3.661661	
	5% level	-2.960411	
	10% level	-2.619160	

Appendix No. 01: ADF test results for the TO series

Null Hypothesis: TO has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.775391	0.2159
Test critical values:	1% level	-4.273277	
	5% level	-3.557759	
	10% level	-3.212361	

Null Hypothesis: D(TO) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.883309	0.0007
Test critical values:	1% level	-4.273277	
	5% level	-3.557759	
	10% level	-3.212361	

Null Hypothesis: D(TO) has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.30354	0.0010
Test critical values:	1% level	-3.653730	
	5% level	-2.957110	
	10% level	-2.617434	

Appendix No. 01: ADF test results for the OILP series

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Null Hypothesis: OILP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.258699	0.4435
Test critical values:	1% level	-4.262735	
	5% level	-3.552973	
	10% level	-3.209642	

Null Hypothesis: D(OILP) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.162167	0.0012
Test critical values:	1% level	-4.284580	
	5% level	-3.562882	
	10% level	-3.215267	

Null Hypothesis: D(OILP) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=8)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.292687	0.0000
Test critical values:	1% level	-2.639210	
	5% level	-1.951687	
	10% level	-1.610579	

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