Asymmetric impact of oil price and exchange rate on inflation in Algeria: Evidence from non-linear ARDL approach

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التأثير غير المتماثل لسعر النفط وسعر الصرف على معدل التضخم في الجزائر: أدلة تجريبية باستخدام النموذج غير الخطي للإنحدار الذاتي للفجوات الزمنية الموزعة المبطأة

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Abstract:
In this paper, we examine the asymmetric effects of both the world oil price and the exchange rate on inflation in Algeria using annual data from 1973 to 2021. In doing so, we employed the newly established Non-Linear Auto-Regressive Distributed Lag (NARDL) model to divide oil price and exchange rate fluctuations into positive and negative variations. The empirical results show that fluctuations in oil prices have an asymmetric effect on Algerian inflation in both the short and long term. More importantly, we discover that positive oil price increases have an asymmetrically greater effect on inflation than negative oil price changes. Furthermore, a rise in the Algerian dinar's depreciation is significantly increasing Algeria's inflation, whereas a decline in the exchange rate (the Algerian dinar's appreciation) fails to decrease inflation. Yet, the asymmetric impact of exchange rate fluctuations to inflation is only in the short run.

Keywords: Inflation, Oil price, Exchange rate, NARDL, Asymmetry

Jel Classification Codes : Q43, F31, E31, C22

ملخص:
تهدف هذه الورقة البحثية الى دراسة التأثير غير المتماثل لكل من تغيرات سعر البترول وسعرالصرف على معدل التضخم في الجزائر بالإعتماد على البيانات السنوية من 1973 الى 2021. لتحقيق الغرض من هذه الدراسة تم استخدام النموذج غير الخطي للإنحدار الذاتي للفجوات الزمنية الموزعة المبطأة (NARDL). النتائج التجريبية بينت وجود علاقة غير خطية بين تغيرات سعر النفط والتضخم في الجزائر في كل من المدى القصير والمدى الطويل. هذا وقد بينت النتائج أن التأثير غير المتماثل على التضخم كان أكبر في حالة ارتفاع سعر النفط مقارنة بإنخفاضه. فيمايخص صدمات سعرالصرف فإن نتائج الدراسة تشير الى أن الاستمرار في إنخفاض قيمة العملة يؤدي الى الرفع من سعر التضخم في الجزائر، بيما ارتفاع قيمة الدينار الجزائري ليس له تأثير معنوي في خفض التضخم. على كل حال النتائج أظهرت أن التأثيرغير المتماثل لتقلبات سعر الصرف موجود فقط على المدى القصير ويختفي على المدى الطويل.

الكلمات المفتاحية: التضخم، سعر النفط، سعر الصرف، النموذج غير الخطي للإنحدار الذاتي للفجوات الزمنية المبطأة، عدم التماثل

تصنيف JEL : C22, E31, F31, Q43

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1. Introduction:

One of the most crucial and desirable economic objectives is maintaining price stability for meaningful economic growth. Although the main objective of every nation's monetary and fiscal policies in both developed and developing countries is price stability, some nations may endure chronic or hyperinflation as well as extreme increases in inflation. On the other hand, certain nations may experience deflation and have a difficult time regaining their previous levels of domestic consumption. Assessing and comprehending the reaction of inflation to oil price fluctuations and exchange rate shocks is important and crucial in the domains of economics and finance because of the importance of low inflation and price stability for both improved resource allocation and financial stability in both developed and developing economies.

Actually, the link between fluctuations in oil prices and inflation has grabbed considerable attention from policymakers and researchers since the first oil crisis of the 1970s. The attention was drawn by the importance of oil to the global economy. Considering that oil is a fundamental raw material for manufacturing and service industries, its price may have a large influence on inflation. In particular, a higher oil price raises production costs, which results in decreased productivity since more expensive inputs are used, and leads to a decline in aggregate demand (Castro & Jiménez-Rodríguez, 2017). In general, substantial increases in oil prices and oil price volatility preceded the majority of economic recessions.

However, previous papers have shown that the influence of the price of oil, which is one of the most unpredictable prices, on the economy may differ depending on the structure of the economy and the extent to which it is dependent on oil. Countries that rely heavily on oil exports may be hit more by shifts in oil prices compared to those that are less reliant on oil. An increase in the price of oil, on the one hand, tends to benefit the net oil-exporting nation by increasing oil revenues and, therefore, national income. Whereas net oil importers often endure a recession owing to increased production and living costs and decreased investment levels (Salisu et al., 2017; Choi et al., 2018). Furthermore, the extreme collapse in the price of oil causes oil exporting nations to experience a decrease in their foreign earnings from overseas sales, which in turn results in a reduced national income and higher rates of inflation, while oil-importing nations may benefit from such a decline. However, it is empirically proven that regardless of the country's dependency on oil products, most nations are experiencing substantial inflation as a result of rising oil costs (Sek, 2017). Moreover, since not all countries that produce oil are also net exporters of oil, the impact of dramatic and sudden shifts in oil prices may be confusing for certain countries. As a net oil exporting country, petroleum products play a dominant role in the Algerian economy given the nation's strong dependency on the abundant oil resource revenue (Hannachi, 2013). This dependency on oil and gas earnings is the reason for the increasing ambiguity over how a shift in oil prices may influence the country's economy as a whole.

Algeria is a net oil exporting country, yet it is, at the same time, a highly importing country. Nevertheless, understanding the dynamics of inflation regarding the fluctuations in oil prices interferes with exchange rate changes. The nature of the reaction of inflation to the appreciation or depreciation of the currency rate differs between nations based on their reliance on imported inputs and commodities for production and consumption. If the country is too reliant on importing manufacturing inputs and goods, it will require a strong currency for price stability, or it will be greatly impacted by exchange rate fluctuations, especially depreciation. Exchange rate depreciation may cause the country's inflation rate to rise. Moreover, when the country experiences a depreciation in its currency, the price of imported items becomes more expensive while the cost of exported goods becomes less expensive.

Accordingly, this study attempts to show how the price of inflation in Algeria respond to the exchange rate and the price of oil asymmetrically, since both of these factors are important determinants for the inflation price. Moreover, this investigation adds to the existent literature by simultaneously decomposing the world oil price and exchange rate into their positive and negative components in the Algerian context.

Following this first introductory section, the rest of the sections of the work are organized in the following way: The second section presents a review of relevant literature, while the third one clarifies the model specification and how the data was collected. This will be followed by a fourth section that presents and discusses the estimated outcomes, including diagnostics and stability tests. In the last section, which is at the end of the paper, the conclusion and policy implications are given.

2. Literature Review:

The research on the influence of macroeconomic factors on inflation, such as oil prices and currency rates, is well documented. Different empirical studies have employed various variables, methodologies, samples, and data collection timeframes. Consequently, there are several analyses and views about the source of inflation that correspond to the nature of the country. The review of existing studies in this paper is launched with the studies that sought to prove the presence of a link among the cost of oil, exchange rates, and broad macroeconomic factors like inflation, regardless of the sign and direction of the nexus.

One of the first and most influential investigations in this regard is the study of (Hamilton, 1983) and (Mork, 1989) who looked into how fluctuations in oil prices affected broader economic indices. Their research revealed an adverse correlation between oil price fluctuations and output and pointed out that oil's vast variations are the cause of economic downturns in the US. Both the DSGE model of (Zhao et al., 2016) and various (MS) Markov Switching regime autoregressive models of (Cologni & Manera, 2009) demonstrate the same detrimental impact on output caused by fluctuations in the price of oil, although in different nations. Likewise, long-run oil price variations have harmfully affected output, according to (Akinsola & Odhiambo, 2020). To find that result, they used the panel-Auto Regressive Distributed lag technique on a panel including seven low-income nations located in sub-Saharan Africa (SSA) that import oil.

Contrarily, (Du et al., 2010) analyzed how the price of oil affected China's macroeconomic determinations based on monthly data spanning 1995–2008. They used the VAR methodology and both linear and nonlinear specifications of oil prices. Their results from the nonlinear specification indicated that raising the price of oil was a contributor to increasing inflation as well as economic growth. Similarly, (Gao et al., 2014) investigated the degree to which swings in oil prices affected US energy consumer prices by using monthly United States data from 1974M01 through 2014M07. They made the discovery that the shocks in the price of oil had increased the energy consumer price index in the US.

From the perspective of single-country research, a number of country-specific publications have assessed how inflation reacts to the oil price fluctuations. (Ibrahim, 2015) investigated the link between the two variables using the Nonlinear Autoregressive Distributed Lags framework for the period between 1971 and 2012. For that purpose, he used Malaysian food price inflation to find significant empirical proof of the linear influence of variations in oil prices on food inflation only in the short term. (Lacheheb & Sirag, 2019) investigated the link between Algerian inflation and oil prices employing yearly data that spans over 44 periods (1970-2014). They used the Nonlinear Autoregressive Distributed Lags method and pointed out that the link between the variables of interest was found to be asymmetrical, although the fact that increases in oil prices have a strong effect on Algerian inflation than decreases in oil prices.

Regarding cross-country studies, (Salisu et al., 2017) evaluated the impacts of oil price fluctuations on inflation by using a panel dataset consisting of countries that were either net oil-buyers or net oil-sellers. By employing Dynamic Panel Data models in their investigation, they found that countries with higher oil imports experience more inflation over the long term than countries with lower oil exports. Moreover, they revealed that the nonlinear influence of oil prices on inflation is more clear and proven for nations that export oil. Another work conducted by (Choi et al., 2018) using a chosen sample of 72 various economic level nations for the period 1970–2015 revealed asymmetric effects, with oil price increases having a bigger influence than decreases in the sample that was selected. Recently, the oil price uncertainty-inflation asymmetric relationship was assessed by (Nusair, 2019) in the Gulf Cooperation Council. The relationship was determined using the Nonlinear Autoregressive Lags approach and the Pooled Mean Group (PMG) model. According to the findings, favorable oil prices fluctuations exert a greater influence on inflation in GCC countries than negative ones do. Furthermore, the asymmetry effect is more significant for Gulf Cooperation Council (GCC) countries in the long term, although the impact of oil prices on inflation is a limited one.

Several studies have been conducted in an effort to shed light on the sort of the link that exists between the currency exchange rate and inflation. (Ghosh, 2014) revealed in a large panel dataset including 137 countries that exchange rate depreciation increases inflation in developed economies, developing markets, and low-income nations. (Köse & Ünal, 2021) studied how the price of oil, oil price volatility, the labor expense, and the exchange rate affected Turkish inflation between March 1988 and August 2019 on a monthly basis. They analyzed the data using an ((SVAR) method, which stands for Structural Vector Autoregression. They came to the end that the impact of oil prices and price uncertainty varies across time. Hence, in the first few months of the investigation, the effect was found to be small, but it grew in the following months. Moreover, it was found that the largest factor influencing inflation in Turkey was the exchange rate. (Hossain & Arwatchanakarn, 2017) found that the appreciation of the Thai currency cuts inflation significantly. Using the Vector Error Correction (VECM) model, Azerbaijan's inflation, oil prices, and exchange rate link were investigated by (Mukhtarov et al., 2019) from 1995 to 2017. The results proved the presence of the variables' long-term association and demonstrated that the oil price changes and the currency exchange rate affect Azerbaijan's inflation positively.

3. Methodology & data:

3.1. Model specification:

Although the standard ARDL approach put forward by (Pesaran et al., 2001) makes it possible to assess the long-run links between time series variables, the model only assumes a linear relationship exists between the variables, and is unable to take into account the potential for asymmetries existing in the connection between the variables of interest. In light of this, and given the discussion in the literature pertaining to the asymmetric control variables-inflation nexus, this analysis employs the (NARDL) method, which is a nonlinear extension of the standard linear Shin's et al. (2014) ARDL model. The NARDL model is intended to detect and evaluate asymmetries that exist in the long- but also short-run, while retaining all of the characteristics of the standard ARDL method.

To begin with, considering the primary purpose of this research, which is to figure out how the price movements in oil markets and exchange rate fluctuations affect the inflation rate in Algeria, we followed the literature reviewed and specified the general linear mode as following:

$$INF_t = \beta_0 + \beta_1 OP_t + \beta_2 EX_t + \beta_3 M2_t + B_4 Y_t + e_t \quad (1)$$

Where INF is tracked by the CPI, the consumer price index, EX is the exchange rate, OP is the crude oil price, M2 is the money supply as a percentage of GDP, Y denotes the output gap, which is determined by subtracting the log of real GDP from its Hodrick-Prescott-filtered trend. The output gap assesses how changes in real GDP affect inflation. β_i represents the long-run coefficients vector.

Equation (1) may be adjusted and expanded to a long-run asymmetric equation as follows:

$$INF_t = \varphi_0 + \varphi_1 OP_t^+ + \varphi_2 OP_t^- + \varphi_3 EX_t^+ + \varphi_4 EX_t^- + \varphi_5 M2_t + \varphi_6 Y_t + \varepsilon_t \quad (2)$$

Where φ_0, φ_1,..., φ_6 are long-run coefficients that will be estimated in the model. In Equation (2), OP_t^+, OP_t^-, EX_t^+, EX_t^- serve as a representation of the asymmetrical component of the ARDL model. By introducing both the up- and down sides of oil price changes, represented by OP_t^+ and OP_t^- respectively, the asymmetrical influence of oil prices on inflation is expressed. The asymmetric effect of exchange rate, on the other hand, may be reflected by adding the positive movements in exchange rate EX_t^+, which signal exchange rate increases (currency depreciation), and adding EX_t^- as the negative movements in the currency exchange rate, which signal the exchange rate decreases (currency appreciation).

The values of $OP_t^+, OP_t^-, EX_t^+ and\ EX_t^-$ are generated by computing:

$$OP_t^+ = \sum_{t=1}^{t} \Delta OP_t^+ = \sum_{t=1}^{t} \max(\Delta OP_t, 0) \quad (3)$$

$$OP_t^- = \sum_{t=1}^{t} \Delta OP_t^- = \sum_{t=1}^{t} \min(\Delta OP_t, 0) \quad (4)$$

$$EX_t^+ = \sum_{t=1}^{t} \Delta EX_t^+ = \sum_{t=1}^{t} \max(\Delta EX_t, 0) \quad (5)$$

$$EX_t^- = \sum_{t=1}^{t} \Delta EX_t^- = \sum_{t=1}^{t} \min(\Delta EX_t, 0) \quad (6)$$

The link between rising global oil prices and the CPI is represented by φ_1, while the association between the inflation rate and falling oil prices is captured by φ_2. We hypothesize that the expected signs of φ_1 and φ_2 are to be positive for both of them, but with different magnitude ($\varphi_1 > \varphi_2$) ((Ibrahim, 2015)(Lacheheb & Sirag, 2019)). The inflation and currency depreciation relationship is presented by φ_3 and expected to be positive, and the inflation and currency appreciation relationship is captured by φ_4 and predicted to be negative.

Equations (2) are rewritten in an unconstrained error correction form to fit the nonlinear autoregressive distributed lag model (NARDL) to the corresponding ARDL bound test (Pesaran et al. (2001); Shin et al. (2014)) as follows:

$$\Delta INF_t = \alpha_0 + \alpha_1 INF_{t-1} + \alpha_2 OP_{t-1}^{+} + \alpha_3 OP_{t-1}^{-} + \alpha_4 EX_{t-1}^{+} + \alpha_5 EX_{t-1}^{-} + \alpha_6 M2_{t-1} + \alpha_7 Y_{t-1} + \sum_{i=1}^{p} \gamma_{1i} \Delta INF_{t-i} + \sum_{i=0}^{q} \gamma_{2i} \Delta OP_{t-i}^{+} + \sum_{i=0}^{m} \gamma_{3i} \Delta OP_{t-i}^{-} + \sum_{i=0}^{n} \gamma_{4i} \Delta EX_{t-i}^{+} + \sum_{i=0}^{r} \gamma_{5i} \Delta EX_{t-i}^{-} + \sum_{i=0}^{s} \gamma_{6i} \Delta M2_{t-i} + \sum_{i=0}^{u} \gamma_{7i} \Delta Y_{t-i} + \mu_t \quad (7)$$

Where Δ represents the model variables' first difference operator, while γ_{1i} to γ_{7i} are the coefficients for the short-run, and p, q, m, n, r, s, u represent the lag periods of the dependent variable and each independent variable, respectively. In equation (7), the negative and positive short-term asymmetric impacts of oil price fluctuations are represented by γ_{2i} and γ_{3i} respectively, while, $\frac{-\alpha_2}{\alpha_1}$ and $\frac{-\alpha_3}{\alpha_1}$ respectively capture both the positive and negative long-term coefficients of oil. Additionally, the short-run nonlinear effects of positive and negative exchange rate variations are given by γ_{4i} and γ_{5i} respectively, while positive and negative long-term exchange rate coefficients are computed as $\frac{-\alpha_4}{\alpha_1}$ and $\frac{-\alpha_5}{\alpha_1}$, respectively.

The study adopts (SBIC) criteria to determine the appropriate lag selection. As suggested by (Pesaran et al., 2001) and following the recommendations of (Shin et al., 2014), and in order to determine if the model exhibits long-term associations, we employ the Wald test with the bound test approach. This is done by comparing the alternative hypothesis with the null hypothesis, the latter being claims that no cointegration relationship exists ($\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = 0$). When the F-statistic is greater than the maximum limit of the boundary value, the null hypothesis is rejected, and we may conclude that the alternative hypothesis is true. On the other hand, we can draw the conclusion that there is no cointegration association between the variables if the estimated value of the F statistic falls below the minimum limit of the boundary values, which would mean that the null hypothesis could not be rejected. However, when the estimated F-statistic falls between the minimum and maximum boundaries, the result is unclear. The model specification of Equation (7) is finalized by conducting post-estimation diagnostic tests to check that the NARDL procedure's critical assumptions are fulfilled.

3.2. Data source and description:

To achieve the goal of this study and explore the impacts of oil prices on Algerian inflation, this study uses yearly data that spans over 48 periods (1973-2021). The availability of data is the only factor in selecting a time frame. The macroeconomic data is extracted from the World Development Indicators of the World Bank. The inflation rate as captured by the consumer price index (CPI) is the explained variable of our research (denoted INF). Concerning the endogenous variables, as the principal independent variables of this study, we include the Brent crude oil price based on US dollar per barrel (denoted OP), exchange rate in the local currency (denoted EX). Control variables were also added to the estimation, in order to evaluate the effect that fluctuations in real GDP have on inflation, we take into account the output gap that was determined using the Hodrick-Prescott (HP) filter (denoted Y). Additionally, to account for the monetary policy impact, we also include the level of the money supply as a ratio of GDP (denoted M2).

4. <u>Empirical results & discussion:</u>

4.1. Pretests (Unit root test)

Given the requirement of the bounds testing procedure that no variable integrated in order 2 should be involved in the analysis, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are performed to ensure the stationarity of all the variables and to establish their degree of integration. The stationarity tests are based on the assumption that the series has a unit root

(Lebdaoui, 2013). If we reject the null hypothesis, we can establish the stationarity of our series. This step helps to guarantee that the NARDL model criteria of having a combination of I(0) and I(1) variables but no variable integrated at level two or above is met. Table 1 provides the outcome of our unit root tests.

Taking into cognizance the intercept as well as the trend properties, stationarity tests show that the ADF test at a 10% significance level can't accept the alternative hypothesis of the unit root when the data are in level with the exception of exchange rate and output gap, but the alternative hypothesis is accepted when the data are at first difference and reveal the stationarity of all variables at 1 % level of significance and therefore I(1) Furthermore, the PP outcomes demonstrate that the null hypothesis of the unit root can not be accepted for every variable in their first differences at 1% significance level, implying that all the variables are integrated of order one I(1). Nevertheless, output gap appears to be stationary in level with only intercept. Since both the ADF and PP tests showed consistency and determined that there is no I(2) variable, the prerequisite for moving to the bounds testing process has been met.

4.2. Bounds test for cointegration:

Modeling a nonlinear or asymmetric nexus using a symmetric model may result in erroneous results and misleading economic policy decisions, which makes it interesting to examine and assess a series' linearity and whether it seems to have been created by a nonlinear model or a linear one (Nusair & Olson, 2021). Following (Husaini & Lean, 2021) specification, we account for asymmetries in the behavior of Algeria's inflation rate by estimating equation (7) for the bound test procedure. This study used (Pesaran et al., 2001)'s bounds test to determine whether or not a long-run relationship existed between the model's different variables. Table (2) exhibits bounds test results, which show that the estimated F-statistic (7.887) surpasses the maximum bound of the critical values with 1% significance. This result confirms that the model's variables do, in fact, have a long-run relationship. Therefore, Algeria satisfies the requirements to proceed with the NARDL model for long-term and short-term inflation.

4.3. Estimation results

Given that the model shows evidence of a cointegration relationship, we investigate how inflation reacts to oil prices and the exchange rate upward or downward movements in Algeria. As a result, following the literature, this investigation estimates the short- and long-run models with a maximum lag length of four. However, table 3 displays the NARDL short-run model estimation, whereas the results of the computed NARDL long-term model and the asymmetric tests are shown in tables 4 and 5, respectively.

The adjustment toward long-run equilibrium is supported by the calculated error correction term coefficient (denoted ECT), which has a negative sign and a statistical significance level of 1%, as displayed in table 3. So nearly 59.1% of instability is corrected within a year. Also, the findings in the table (3) show that the earlier values of inflation have a significant positive impact on its present value.

As mentioned earlier, it should be recalled that the potential nonlinear short-run impacts of increasing and dropping global price of oil on Algerian rate of inflation is dealing with in the model equation. Given the NARDL model findings, upward movements in oil prices have a greater influence on the CPI than negative ones. The oil price rise coefficients are showing the anticipated positive signs and have significant effects on Algerian inflation. Also, a reduction in oil price positively influences domestic inflation with the expected signs.

On the other hand, a brief look at the exchange rate coefficients in the Model does provide hints on asymmetric response of Algerian inflation. The outcomes in table 3 show that depreciation of the Algerian dinar (EX+) significantly affects inflation in the two previous years with a positive relationship. But, the appreciation of the dinar's price (EX-) in the preceding lag two year has decreased inflation. However, an appreciation influence of the Algerian dinar to inflation vanished in the long-term. Moreover, the increase in money supply has been identified as a significant contributor to increase inflation in Algeria since evidence shows that the calculated coefficient is statistically significant at the 1 % level. Furthermore, in accordance with economic theory, the computed coefficients of output gap have the expected positive sign and are statistically significant at the 1% level, showing that a positive output gap has caused inflation.

Tables (4) and (5) illustrate the outcomes of the long-run model and asymmetric tests, respectively, with the magnitude of the reaction of inflation to both the exchange rate fluctuations and oil price swings on inflation divided into negative and positive changes. The nonlinear impact of oil price is evident in the long-run. Both upwards and downwards oil movements are proved to be inflationary. This outcome is in line with the outcomes of (Sek, 2017) and (Husaini et al., 2019). In addition, the magnitude of the reaction to upward oil price movements is stronger than that to negative ones. This result infers that consumer price index (CPI) is more sensitive to a rise in global price of oil than a decline. The Wald test result shows that positive oil shocks impact inflation differently than negative shocks over the long- term. These results demonstrate that disregarding asymmetry and non-linearity in estimating the association linking inflation, exchange rates, and oil prices may result in misleading outcomes.

As far as the long-run estimation is concerned, our results unveal that exchange rate depreciation, which reflects a decline in the currency's value, is highly inflationary at 1% significance level, while the reduction in currency exchange rate, which refers to the Algerian dinar' appreciation, does not have a significant inflation reaction. The short-term asymmetry of exchange rate changes' effects on inflation is displayed via the Wald test. This effect is only temporary, though, it will be corrected in the long-term.

4.4. Post-estimation diagnostic tests

The consistency and reliability of the estimated model are determined using the post-estimation diagnostic tests. These tests include the Portmanteau test for serial correlation, Breusch/Pagan test for heteroskedasticity, and Ramsey RESET test for the specification error, Jarque-Bera test for error normality, and the value of the coefficient in the normalized cointegration equation to figure out if the long-term relationship is important as an error correction mechanism for short-term disequilibrium. Table (6) summarizes the outcomes of post-estimation tests.

The adjusted R-square coefficient denotes that the control variables could justify 76 % of the movements in the explained variable. Additionally, the error ECT coefficient is statistically at 1 % level of significance and negatively signed, which gives more support for the presence of long-run associations between the variables in the estimated model. In terms of model good fit, the F-statistic demonstrates a strong match and is statistically significant at the 1 % level.

Furthermore, the diagnostic tests for NARDL assumptions about the error term have achieved the desired econometric properties. The finding of the Portmanteau check for the presence of serial autocorrelation indicates the absence of autocorrelation in the error term. The result of the Breusch/Pagan check shows that the residual has no heteroskedasticity problem, as the p value exceeds the 1% level of significance. Similarly, Ramsey RESET test results show failure to establish specification errors in the model, and the error terms follow the normal distribution. Overall, the proposed model is found to have accurate specifications, as evidenced by the diagnostic test, as well as the coefficient estimates that have been shown to be both accurate and unbiased.

4.5. Stability test

Using the Cumulative Sum of Recursive Residuals (CUSUM) and the Cumulative Sum of Square of Recursive Residuals (CUSUMQ), this research assesses the stability of the short-term and long-term coefficients. When the recursive residual of the model (blue line) falls withing the two crucial boundaries, the model is said to be stable. Fig. 1 exhibits the square tests of both CUSUM and CUSUM, that indicate that the inflation NARDL model coefficients are steady at the 5% significance level for the time period under investigation (1973-2021).

5. Conclusion & policy implications:

This research examines the asymmetries in the reactions of inflation to the global price of oil and the Algerian currency exchange rate, respectively, in the Algerian context. The asymmetric NARDL model established by (Shin et al., 2014), which is one of the leading approaches employed in the existing literature, is used to assess the short-run and long-run effects of the global oil price and Algerian exchange rate on inflation using annual data from 1973 to 2021. This research established that through the negative and positive movements in the oil price and the currency exchange rate and downwards, asymmetries in the short-run and long-run are introduced into the paper model.

This investigation has some important findings. First, it reveals that an increase in the price of oil results in a considerably bigger influence on Algerian inflation than a decrease in the price of oil in the long-run and the short-run. This might be explained by the relevance of oil as production inputs, since higher oil prices would raise the relative cost of energy inputs, raising the cost of production in many nations and hence boosting global inflation if rising oil prices persisted. Consequently, the global oil-induced inflation ultimately passed through to Algeria through imports. The second conclusion is that the oil price has a substantial long-run positive association with inflation, whereas the short-run outcomes are mixed. The third finding is that the estimated results show strong proof of long-run asymmetry, with both upward and downward changes in oil prices exerting an inflationary effect in Algeria. More precisely, while the results suggest that rising oil prices are significant and inflationary, they demonstrate that falling oil prices are barely significant. However, the findings suggest that the transmission effect of the oil price on Algeria’s inflationary pressures is complete. Fourth, it reveals that the movements in the exchange rate are significantly affecting the inflation in the short-term. Fifth, the findings show that, in the long run, while exchange rate depreciation has a large influence on inflation, exchange rate appreciation has no effect. This is due to the large reliance of Algeria, as a net oil exporting country, on hydrocarbon revenue for its foreign exchange incomes. Hence, when the price of oil falls, usually the country experiences an exchange rate depreciation, which causes imports to become more costly. Finally, the empirical findings reveal that the influence of exchange rate fluctuations on Algerian inflation is partial and that exchange rate fluctuations have a nonlinear short-run effect on inflation.

This investigation has some important policy implications to offset the adverse impacts of changes in the oil price and exchange rate fluctuations in Algeria. The policymakers may combat inflation through strengthening the Algerian Dinar and using contractionary monetary policy. A strong currency boosts export competitiveness by lowering the cost of imported inputs. This leads to another policy implication, which is the importance of economic diversification. As mentioned earlier, Algeria lacks economic diversification since it mainly relies on hydrocarbon export earnings. Therefore, Algeria has to implement structural reforms and major policy changes that will advance the growth of the non-oil trading industry, stimulate the growth of the private sector, and increase the efficiency of the public sector.

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-Appendix:

Table (1): Unit root test results

Variable	ADF test			PP test		
	Level		First difference	Level		First difference
	Trend	No trend	No trend	Trend	No trend	No trend
INF	-2.675	-2.406	-5.355***	-2.617	-2.350	-6.420***
OP	-2.469	-1.707	-5.660***	-2.315	-2.406	-6.366***
EX	-4.142**	0.915	-4.419***	-1.725	1.099	-4.409***
M2	-1.417	-1.019	-4.878***	-1.078	-0.583	-5.804***
Y	-3.348*	-3.461**	-5.216***	-3.106	-3.168**	-7.214***

Note: The symbols *, **, and *** mean that the null hypothesis was not accepted at the 1%, 5%, and 10% significance levels, respectively. SBIC is used to choose the number of lags for the ADF test. By using the Barlett Kernel Spectral estimating approach, Newey-West Bandwidth automatically chooses the bandwidth for the PP test. Regarding the ADF and PP tests, the 1%, 5%, and 10% critical values are, respectively, -4.161, -3.506, and -3.183 for the test with intercept and trend, and -3.574, -2.923, and -2.599 for the test without trend and only intercept.

Table (2): Results of the bounds test for nonlinear cointegration

F - statistics	1% significance level		Conclusion
	Minimum bound I(0)	Maximum bound I(1)	
7.887	3.74	5.06	Cointegration

Note: Critical values are obtained from Pesaran et al. (2001) assuming unrestricted intercept and no trend (Case III).

Table (3): Nonlinear ARDL Short-run Estimates for Algerian Inflation

Variable	Coefficients	Standard Errors
INF_{t-1} (ECT)	-0.591***	0.211
ΔINF_{t-1}	0.560***	0.149
ΔINF_{t-2}	0.445***	0.156
ΔINF_{t-3}	0.341**	0.138
ΔOP^{+}	0.226***	0.063
ΔOP^{+}_{t-1}	0.101**	0.047
ΔOP^{+}_{t-2}	0.092*	0.054
ΔOP^{+}_{t-3}	0.133	0.158
ΔOP^{-}	0.166***	0.041
ΔOP^{-}_{t-1}	0.130**	0.098
ΔOP^{-}_{t-2}	-0.033	0.168
ΔOP^{-}_{t-3}	0.115	0.138
ΔEX^{+}	0.398	0.477
ΔEX^{+}_{t-1}	0.487*	0.273
ΔEX^{+}_{t-2}	0.677	0.537
ΔEX^{+}_{t-3}	0.366	0.732
ΔEX^{-}	-0.159	0.401
ΔEX^{-}_{t-1}	-0.772	0.796
ΔEX^{-}_{t-2}	-1.242*	0.651
ΔEX^{-}_{t-3}	0.367	0.732
M2	0.261**	0.105
Y	-0.916***	0.221
Constant	27.908***	8.025
Observations	46	
R-squared (Adjusted)	0.764	

Note: *, **, and *** imply significance at 10%, 5% and 1% levels, respectively.

Table (4): Nonlinear ARDL Long-run Estimates for Algerian Inflation:

	NARDL long-run Estimates	
Variables	Estimated Coefficients	P Values
OP^{+}	0.382**	0.043
OP^{-}	0.281*	0.087
EX^{+}	0.673***	0.005
EX^{-}	-0.269	0.136

Note: *, ** and, *** denote significance at 10%, 5% and 1% levels, respectively.

Table (5): Results of the Asymmetry test (Wald test F-statistics)

Variables	Asymmetry test	
	F- statistics	Conclusion
LR-OP	6.879	Asymmetric
SR-OP	2.084 ns	Symmetric
LR-EX	2.368 ns	Symmetric
SR-EX	5.368	Asymmetric

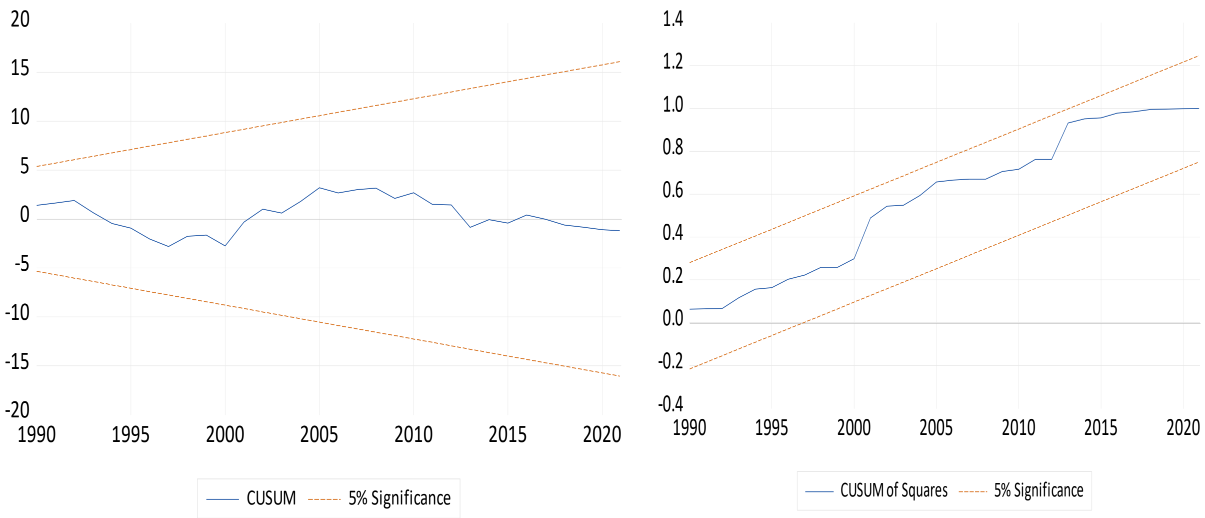
Note: LR-OP and LR-EX stand for the Wald check for the long-term symmetry of the null hypothesis for the respective variables. SR-OP and SR-EX stand for the Wald test for the short-run symmetry null hypothesis for each variable.

Table (6): Post-estimation diagnostic test results

Diagnostic test	Test statistic
Adjusted R-squared	0.76
F-test	7.887
Error Correction Term	-0.941 ***
Portmanteau test	21.19 ns
Breusch/Pagan heteroskedasticity test	0.748 ns
Ramsey RESET test (F-stat)	0.684 ns
Jarque-Bera Normality test statistics	0.395 ns
CUSUM test	Stable
CUSUMQ test	Stable

Note: *, **, and *** imply significance at 10%, 5%, and 1% levels, respectively; ns denotes not significant. The null hypothesis of the diagnostic test reported in the table is that there is no autocorrelation up to the stated order, there is no heteroskedasticity, there are no model specification errors, and the residuals are normally distributed.

Fig. 1. CUSUM and CUSUM Square for the model's stability



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