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The Asymmetric Impact of Oil Price Dynamics on Inflation in Brazil

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ABSTRACT

This study investigates whether oil price changes have asymmetric pass-through effects on inflation using Brazilian quarterly data from the first quarter of 2000Q1 through 2021Q4. It applies a nonlinear Autoregressive Distributed Lag (NARDL) model that can simultaneously decompose the price of oil into its partial sum of positive and negative components to account for both the short-run and long-run asymmetric behaviour of inflation. The empirical findings reveal that the pass-through of the oil price to inflation from the short to the long term has a nonlinear or asymmetric effect. It concludes that the monetary authority should consider the asymmetric effects of the inflation-oil price nexus.

Keywords: Brazil, Inflation, Asymmetries, Oil Price, Dynamics

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1. Introduction

The literature has extensively discussed oil price fluctuations as global phenomena due to their considerable economic consequences. A rise in oil prices boosts the income of oil-exporting nations, but it is unpleasant news for oil-importing nations (Lacheheb and Sirag, 2019). Because of their financial fragility and susceptibility to shocks from the outside world, emerging economies are particularly susceptible to changes in oil prices. Increases in oil prices cause an exorbitant cost of production that slows down economic activity and the surplus demand that results from this cuts prices. As a result, most central banks pursue price stability and inflation targeting to assess monetary policy performances (Sek, Teo, and Wong, 2015). Brazil has seen upward trends in oil production in recent times despite being one of the countries largely affected by the novel COVID-19 pandemic (see Figure 1). The average production since 2019 exceeds the 2.77 Mb/d produced by the United Arab Emirates. Currently, Brazil is the largest oil producer in Latin America having surpassed both Venezuela and Mexico, and seventh in the world with the largest recoverable ultra-deep oil reserve. The country's oil production is offshore (96.7%) with 73% controlled by the national oil company, Petrobras. Oil production contributes about 15 percent to GDP and accounts for most investments in the country. However, the recent global recession caused by the pandemic and Russia-Ukraine unrest has heightened the economic and political crisis in the economy. GDP slumped significantly and inflation skyrocketed, increasing from 3.21% in 2020 to 8.30% in 2021. Oil rents[1] (% of GDP) on the other hand remain at 2.04 with the highest value over the last 45years being 2.51 in 2006 and the lowest value being 0.09 recorded in 1970.

[1] Oil rents are the difference between the value of crude oil production at world prices and total costs of production.

The rapid swing in oil prices in recent times has spawned a great deal of concern, particularly regarding its effect on the inflation rate. To place this concern into perspective, Figure 2 graphs the oil price and consumer price inflation from 2000 to 2021 in Brazil. Evidence shows that irrespective of the lower oil price changes in later years, the inflation rate increased over time, taking a sharp rise in 2021. This continues to stimulate intense debate on the subject matter and has paved the way for further study. For effective policy implications to avert any impending oil crisis, the assessment of the oil price pass-through to the consumer price index must consider the underlying domestic factors, such as market dominance and fiscal controls (Lacheleb and Sirag, 2019). A plethora of studies have explored various mechanisms through which oil price shocks can influence macroeconomic indicators e.g., unemployment and labour market implications (see Davis and Haltiwanger, 2001; Papapetrou, 2001), stock market returns (Sadorsky, 2001; Cong et al., 2008). Similarly, the literature documents a glut of studies confirming the symmetric impact of oil price shocks on inflation (e.g., Hooker, 2002; Son, 2008; Lacheleb and Sirag, 2019; Karki and Risal, 2020; Deluna et al., 2021). Some empirical studies have also established the existence of an asymmetric relationship between oil price shocks and inflation rates (see e.g., Bala and Chin, 2018; Lacheleb and Sirag, 2019; Karki and Risal, 2020; Deluna et al., 2021). However, because of shifts in sectoral structures, a country's relative standing as an oil importer or exporter, the mix of taxes, etc., the repercussions differ from one country to the other (Lacheleb and Sirag, 2019). Therefore, it is crucial to comprehend the empirical relationship between the price of oil and inflation to adopt policies that take these shocks into account. In a study on the macroeconomic consequences of oil price shocks in Brazil and the United States, (Cavalcanti and Jalles, 2013) found that while inflation is still unpredictable, Brazil's output growth volatility is not affected by oil price shocks. Regarding this uncertainty, the study did not offer any in-depth analysis.

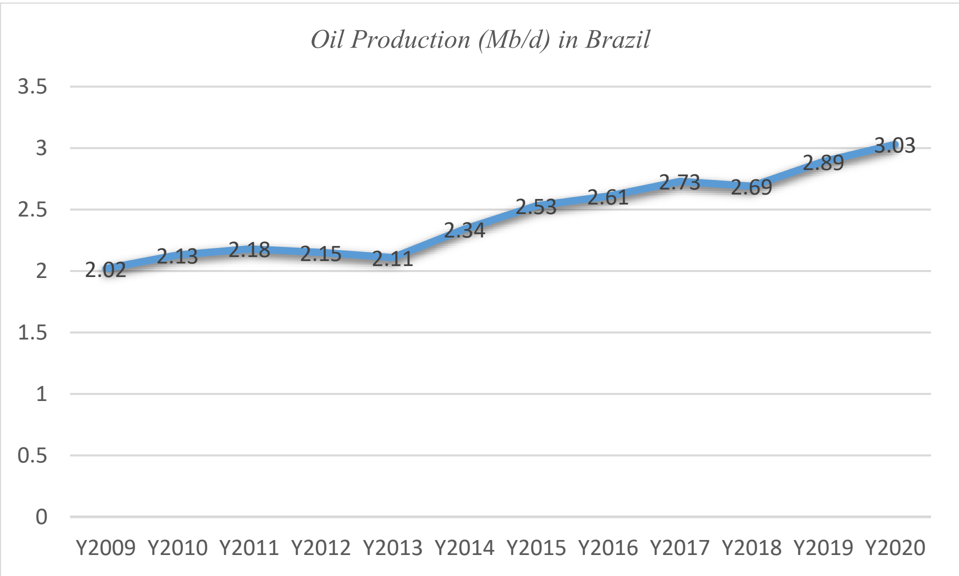

Figure 1: Oil Production (Mb/d) in Brazil
Source: Author using data from World Development Indicators

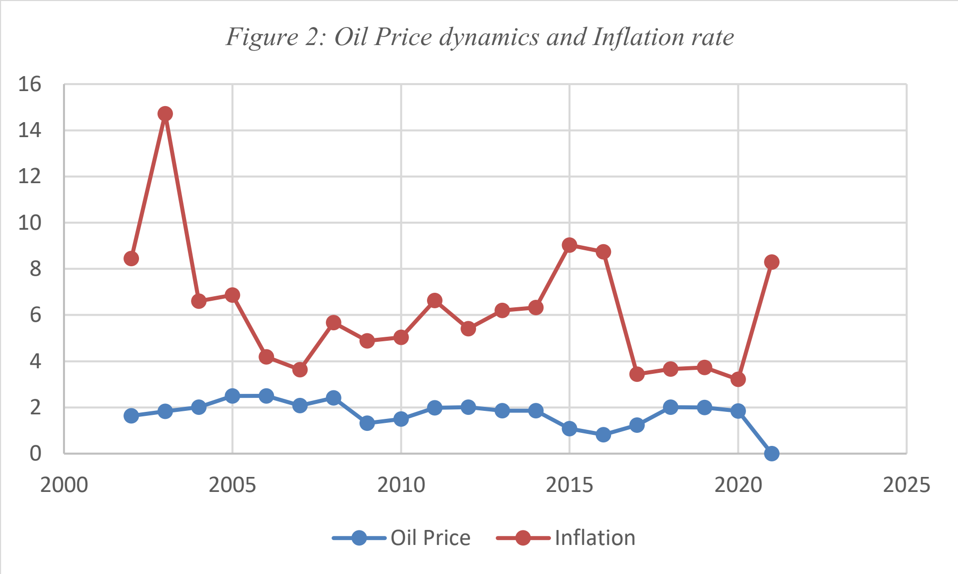

Figure 2: Oil Price dynamics and Inflation rate
Source: Author using data from World Development Indicators

Given the recent rapid growth in oil production in Brazil and the adverse global economic shocks emanating from the pandemic and Russia-Ukraine upheaval, this study further interrogates the oil price dynamics and the inflation rates nexus to ascertain the clear-cut asymmetric effect. The current study uses the non-linear autoregressive distributed lag (NARDL) model recently developed by Shin, Yu, and Greenwood-Nimmo (2014), for the asymmetric analysis. This makes the study one of the few to use a more current econometric methodology to examine the oil price-inflation nexus in an oil-exporting nation. This strategy is most suitable because it considers potential long- and short-term imbalances in the relationships between the price of oil and the rate of inflation. The paper continues with the following structure. Section 2 highlights a review of the literature on the subject matter. Section 3 features the methodology and data source with results and discussions presented in section 4. Section 5 concludes the study with the main findings and policy recommendations.

2. Literature Review

Most studies on inflation dynamics use linear time-series models, which are unable to account for the possibility of asymmetric impacts (see Long and Liang, 2018). However, (Lim, Siong, and Trinugroho 2020) discovered that shifts in oil prices had a protracted, asymmetric impact on Indonesian producer inflation. Studies such as (Sek 2017; Bala and Chin, 2018; Lacheleb and Sirag, 2019) observed similar long-run relationships. Other studies such as Ibrahim (2015), Wong and (Shamsudin, 2017; and Lim et al., 2020) found short-run asymmetric effects but not in the long run in their respective studies. These outcomes demonstrated the necessity of utilising an asymmetric technique to investigate the connection between the price of oil and inflation. There has been a mixed bag of impact so far.

A study of country groups revealed different relationships. (Cunado and de Gracia, 2005), for example, examined the asymmetric effects of oil price dynamics and economic production on inflation in Japan, Thailand, South Korea, Malaysia, and the Philippines. Except for the Philippines, their findings indicated that for four of them, the oil price-inflation asymmetry relationship was present. (Long and Liang, 2018) also showed this when investigating the pass-through effects of oil prices on inflation in China. They examined both the symmetric (ARDL) and asymmetric (NARDL) effects and found that global oil price changes have a long-run asymmetric effect on China's inflation, but no symmetric impact.

In general, (Nasir et al., 2020) contend that the dynamics of important macroeconomic variables including trade, currency rates, and monetary policy rates, as well as shocks to the price of oil, are susceptible to the inflation rate. For instance, (Bala and Chin, 2018) found an asymmetric relationship between oil price volatility and inflation in African nations that trade oil. According to an extensive study by (Nasir, Huynh, and Yarovaya, 2020), fluctuations in oil prices have an asymmetric effect on inflation for economies that export oil but a symmetric effect on economies that purchase oil. (Sek, 2017) claimed that oil-importing economies experience a symmetric impact over time because of their heavy reliance on oil. Regarding monetary policy, a study by (L'opez-Villavicencio and Pourroy, 2019) found that nations implementing inflation targeting (IT) see a larger pass-through effect of the oil price on inflation than non-IT countries. They added that when the pass-through is greater, IT can lessen the impact of oil price asymmetry on inflation.

(Nasir, and Vo (2020), Balcilar et al., 2020; Pharm et al., 2020) have also shown evidence of asymmetric exchange rate pass-through on inflation. For instance, research by (Pharm et al., 2020) showed that there is a long-lasting asymmetric exchange rate influence on inflation in countries like Indonesia and Singapore, a short-term asymmetric effect for the Philippines, and no asymmetric effects for Thailand and Malaysia. Even though their conclusions for Malaysia differ from the preceding analysis by (Wong and Shamsudin,2017) both analyses agree that real GDP and exchange rate have a long-run asymmetric impact on inflation. It is clear from the ensuing debate that the literature is inconclusive regarding the asymmetric impact of macroeconomic determinants of inflation. It is obvious that it differs among sectors, local economies, and geographic areas, and that it could change with time. There are three unique additions that this study makes. The first step is to build the dynamic error correction model (ECM) linked to the asymmetric long-run cointegrating regression, which incorporates the simultaneously decomposed positive and negative partial sums of oil price as regressors and produces the NARDL of inflation. Second, it adopts a utilitarian bounds-testing technique, similar to (Pesaran, Shin, and Smith , 2001), to investigate the presence of a stable long-run connection valid enough to prove asymmetric cointegration regardless of the order, I(0), I(1), or mutually cointegrated. Finally, it describes asymmetric cumulative multipliers that may be used to determine how much of a nonlinear adjustment result from positive and negative shocks to the regressors. This enables an intuitive description of how the system will move to a new steady state after being perturbed.

3. Methodology

The analyses of asymmetric theories or nonlinear models arise from the inability of the linear models to explain the economic shocks in the United States owing to oil price dynamics (Herrera et al., 2011). The challenge is that the standard time series models i.e., VAR, ARDL, and VECM assume that the long-run effect is explained by the symmetric linear combination of nonstationary stochastic regressors (Deluna et al., 2021). Thus, their inability to capture the potential asymmetric dynamics among the variables resulted in the development of the NARDL by (Schorderet, 2004) and later advanced by (Shin et al., 2014).

3.1 The Model

Consider the following long-run asymmetric regression model:

$$y_t = \alpha^+ x_t^+ + \alpha^- x_t^- + \varepsilon_t \tag{1}$$

Where y_t and x_t are assumed I(1) variables and x_t is decomposed into x_t^+ and x_t^-, the partial positive and negative sums of x_t respectively around a certain zero threshold:

$$x_t^+ = \sum_{i=1}^{t} \Delta x_i^+ = \sum_{i=1}^{t} \max(\Delta x_i, 0) \tag{2}$$

$$x_t^- = \sum_{i=1}^{t} \Delta x_i^- = \sum_{i=1}^{t} \min(\Delta x_i, 0) \tag{3}$$

This helps to differentiate between the positive and negative dynamics in the growth rate of x_t. The stationary linear combination of the partial sum components in (1) can be defined as:

$$z_t = \delta_0^+ y_t^+ + \delta_0^- y_t^- + \delta_1^+ x_t^+ + \delta^- x_t^- \tag{4}$$

Notice that when z_t is stationary then y_t and x_t are 'asymmetrically cointegrated' and (1) can be estimated if $\delta_0^+ = \delta_0^- = \delta_0$ and $\alpha^+ = -\delta_1^+/\delta_0$, $\alpha^- = -\delta_1^-/\delta_0$.

Since the focus is on dynamic model, we augment the ARDL model popularized by Peseran et al., (2001) to develop a flexible dynamic parametric framework (see Shin et al., 2014; Deluna et al., 2021) that depicts the combined long- and short-run asymmetries as follows:

$$y_t = \sum_{i=1}^{p} \emptyset_i y_{t-1} + \sum_{j=0}^{q} (\theta_j^+ x_{t-j}^+ + \theta_j^- x_{t-j}^-) + \epsilon_t \tag{5}$$

Where y_t is the respondent variable, x_t is a K x 1 vector of multiple regressors representing the partial positive and negative sums of x_t such that $x_t = x_0 + x_t^+ + x_t^-$. The $\emptyset_i$ coefficient is the autoregressive parameter, $\theta_j^+$and θ_j^- represent the asymmetric distributed-lag parameters, and ϵ_t is the idiosyncratic error component assumed to be independent and identically distributed *(iid)* and defined over $N(\mu = 0, \sigma_\mu^2)$. We can write the dynamic ECM of the NARDL specified in (5) as follows:

$$\Delta y_t = \rho y_{t-1} + \psi^+ x_{t-1}^+ + \psi^- x_{t-j}^+ + \sum_{i=1}^{p-1} \emptyset_i \Delta y_{t-1} + \sum_{j=0}^{q-1} \left(\theta_j^+ \Delta x_{t-j}^+ + \theta_j^- \Delta x_{t-j}^-\right) + \epsilon_t$$

$$= \rho \xi_{t-1} + \sum_{i=1}^{p-1} \emptyset_i \Delta y_{t-1} + \sum_{j=0}^{q-1} (\theta_j^+ \Delta x_{t-j}^+ + \theta_j^- \Delta x_{t-j}^-) + \epsilon_t \tag{6}$$

Where $\rho = \sum_{j=1}^{p} \emptyset_i - 1$, $\theta_j^+ = \pi_0^+ + \varpi \Lambda_j$ and $\theta_j^- = \pi_0^- + \varpi \Lambda_j$ for $j = 1, \ldots . q-1$. The p and q are the lag orders for the dependent and independent variables, respectively. The error correction term $\xi_t = y_t - \beta^+ x_t^+ - \beta^- x_t^-$ is the nonlinear error correction term (ECT) and $\beta^+ = \frac{-\psi^+}{\rho}$ and $\beta^- = \frac{-\psi^-}{\rho}$ are the respective long run asymmetric parameters.

To address the likelihood of non-zero contemporaneous correlation between the regressors and the residuals in (6) we define the data generation process of $\Delta \mathrm{x}_t$ as:

$$\Delta \mathrm{x}_t = \sum_{j=1}^{q-1} \mathrm{C}_j \Delta x_{t-j} + \mu_t \tag{7a}$$

Where $\mu_t \sim iid(0, \sum \mu)$, with $\sum \mu$ a $k \ x \ k$ positive definite covariance matrix. Also, ϵ_t is expressed conditionally in terms of μ_t as:

$$\epsilon_t = \emptyset \mu_t + v_t = \emptyset\left(\Delta \mathrm{x}_t - \sum_{j=1}^{q-1} \mathrm{C}_j \Delta x_{t-j}\right) + v_t, \qquad \mathrm{cor}(\epsilon_t, v_t) = 0 \tag{7b}$$

Substituting (7b) into (6) and rearranging we obtain the nonlinear ECM as follows:

$$\Delta y_t = \rho \xi_{t-1} + \sum_{i=1}^{p-1} \emptyset_i \Delta y_{t-1} + \sum_{j=0}^{q-1} (\theta_j^+ \Delta x_{t-j}^+ + \theta_j^- \Delta x_{t-j}^-) + v_t \tag{8}$$

3.1.1. The Asymmetric Dynamic Multipliers

The cumulative dynamic multiplier effects of x_t^+ and x_t^- on y_t are estimated as :

$$\left.\begin{aligned} m_k^+ &= \sum_{i=1}^{n} \frac{\partial y_{t+i}}{\partial x_t^+} = \sum_{i=1}^{n} \kappa_i^+ \\ m_k^- &= \sum_{i=1}^{n} \frac{\partial y_{t+i}}{\partial x_t^-} = \sum_{i=1}^{n} \kappa_i^- \end{aligned}\right\} \tag{9}$$

where $n = 0,1,2,\ldots$ when $n \to \infty, m_k^+ \to \alpha^+$ and $m_k^- \to \alpha^-$.

3.2 Empirical Model

Following (Lacheleb and Sirag, 2019) and (Deluna et al., 2021), the empirical model specifying the asymmetric relationship effect of oil price dynamics on inflation and other controls is given as:

$$\Delta Inf_t = \alpha + \rho Inf_{t-1} + \varphi_1 OilP_{t-1}^+ + \varphi_1 OilP_{t-1}^- + \varphi_2 ExR_{t-1} + \varphi_3 IntR_{t-1} + \varphi_4 MS_{t-1} + \sum_{i=1}^{p-1} \emptyset_i \Delta Inf_{t-1} + \sum_{j=0}^{q-1} (\theta_j^+ \Delta OilP_{t-j}^+ + \theta_j^- \Delta OilP_{t-j}^-) + \sum_{i=0}^{q} \theta_{1i} \Delta ExR_{t-i} + \sum_{i=0}^{q} \theta_{2i} \Delta IntR_{t-i} + \sum_{i=0}^{q} \theta_{3i} \Delta MS_{t-i} + \epsilon_t \quad (10)$$

Where *inf* refers to inflation, *OilP* is oil price, *ExR* is exchange rate, *IntR* is interest rate, and *MS* is money supply.

3.3 Estimation Procedure and Data

The study uses quarterly time series data from 2000Q1 to 2021Q4. Inflation is the consumer price index, the official exchange rate is determined by the local currency units per the U.S. dollar, and the money supply is the total amount of money available outside of banks. The short-term interest rate—the rate on 91-day Treasury bills—is the interest rate found in the IMF's International Financial Statistics. The spot price of Brent, Dubai, and West Texas Intermediate measured in U.S. dollars per barrel is the oil price information, which Index Mundi obtained and published from the World Bank. We test for unit root using the Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) testing techniques. The stationarity test is performed because the ARDL/NARDL excludes all variables that can be integrated of order two, preventing any I (2) series among the model's variables. The reasoning behind this is that whereas the lower limit critical values assume that all variables are *I (0)*, the upper bound assumes that all variables are *I (1)* (see Pesaran, Shin, and Smith ,2001). The study uses the Akaike Information Criterion (AIC) to determine the ideal lag time and the Wald bound-test to determine the short-run and long-run asymmetries. The asymptotic critical bounds reported by (Pesaran et al., 2001) are used as the foundation for the F-statistic. Thus, c ointegration is present when the F-statistic is greater than the upper bound. The study estimates the asymmetric multipliers to investigate the rate of transmission from the initial equilibrium to the new steady state and validates the NARDL bounds-test assumptions using post-estimation diagnostic tests. Thus, the NARDL should be homoscedastic, normally distributed, and serially independent. The Lagrange Multiplier test, Jarque-Bera test, and White test, respectively, are employed in the paper to get these results. The NARDL CUSUM and CUSUM squares (SUMSQ) derived evaluate the stability of the model.

4. Empirical Findings and Discussion

Table 1 presents the results of the unit root test. Both the ADF and PP confirm that all the series are stationary at the first difference, indicating that the variables are *I (1).* This provides the warrant to perform a cointegration test. Table 2 presents the results of the asymmetric cointegration test between oil price and inflation. We can observe that there is evidence of cointegration since the F-statistic 5.21 is greater than the upper bound at all significant levels. This shows that there is an asymmetric long-run relationship between oil price and inflation.

Table 1.
Unit Root Test

Variables	ADF		PP		AIC
	Level	1st Diff	Level	1st Diff	Optimal Lag length
Inf	-0.47126	-2.7854**	-0.95719	-36.207***	3
Oil Price	-2.0845	-4.4337***	-8.9644	-60.687***	1
ExRate	-0.9448	-4.7583***	-3.9654	-82.743***	2
IntRate	-2.6576	-4.4212***	-15.844	-43.206***	1
MS	-3.401*	-4.494***	-30.19***	-84.222***	4

*Note: ** $p < 0.05$, *** $p < 0.01$. Both the ADF and PP test the null of nonstationary against the alternative hypothesis of stationary. Inf is the inflation rate, ExRate is the exchange rate, IntRate is the interest rate, and MS is the money supply. Optimal Lag length selections follow the Akaike Information Criteria AIC*

Table 2.
Asymmetric Bound Cointegration Test

Model Specification	F-Stats	Critical Bounds		Conclusion
		Lower	Upper	
Nonlinear	5.21	3.94	5.043	cointegration

Note: The null hypothesis is no level relationship. The cointegration follows the Pesaran, Shin, and Smith (2001) test. Critical bounds are the 5% significance level

The short-run asymmetric effects of oil price on inflation are displayed in Table 3. A statistically significant level of 5% is reached by the error correction term, which shows the rate of convergence at 68.63%. This rate of inflation convergence is quicker than the rates of food price inflation observed in Malaysia (Abdlaziz et al., 2016) and Indonesia (Ibrahim, 2015) but slower than that of the Philippines (Deluna et al., 2021). The result in Table 3 also reveals the persistence of inflation in Brazil as depicted by the significance of the lag of inflation. It also shows that oil price pass-through is a significant determinant of inflation in Brazil. The positive partials show that inflation respond swiftly to increase in oil price. It can be observed that a partial increase in oil price leads to 0.7929% increase in inflation each quarter. However, it takes time for a partial reduction in oil price to reflect in a decrease in inflation as shown by the negative partials. Thus, from Table 3, a partial fall in oil price did not see immediate fall in inflation but after some quarters. These findings support the empirical works of (Lacheheb and Sirag, 2019) and (Deluna et al., 2021) that consumer prices in developing and emerging economies are more sensitive to increases in oil prices but less sensitive to decreases in oil prices. Previous studies such as (Karantininis, Kostas, & Persson, 2011; cited by Deluna et al., 2021), suggest that the interaction between businesses' cost structures, market power, and price adjustment costs may be the cause of the short-run asymmetry of oil price to inflation. Table 4 presents the results for the long-run estimates. It shows that changes in oil prices influence inflation over the long term as well. The study finds that in the long run, a partial increase in oil price further increases the inflation rate by 1.6219%. Similarly, a partial decrease in oil price leads to a fall in inflation by 1.4498%. It could be inferred that there is a direct asymmetric impact of oil price changes on inflation in the long run. This long run asymmetric pass-throughs of the oil price on inflation are consistent to the findings of (Cunado& de Gracia, 2005; Ibrahim, 2015; Deluna et al., 2021). The Wald Test in Table 5 confirms that indeed there is an existence of short-run and long run asymmetric relationship between inflation and oil price dynamics. The observed asymmetries hint that when oil prices rise quickly relative to drops, it suggests the existence of price maker power and the spread of profiteering schemes (Meyer and Cramon-Taubadel, 2001; Lim et al., 2020). Brazil is an oil-producing nation; therefore, a higher oil price would enhance export income and raise GDP. However, inflation in consumer prices would also follow, primarily because most commodities in the supply chain employ oil products as their primary input. In other words, production is closely related to the price of crude and refined oil. Consequently, any increase in the price of crude oil might both raise Brazil's export revenue and worsen the country's economic situation by driving up the cost of goods, especially imported goods. Therefore, it requires regulation and increased market monitoring to correct the inflation response to changes in the price of oil. Fuel subsidies, according to (Baharumshah et al., 2017), are a beneficial policy for reducing inflation brought on by rising oil prices. However, this recommendation might not be effective without the use of advanced technology to fulfil the required quality standards and quantity.

The dynamic multipliers in Table 5 show that a change in the global oil price transfers to the domestic price level in the short run, at a rate of 0.08%, and at 1.95% in the long run. This is in line with (Ibrahim, 2015), who discovered that it takes longer lengths of time—between 6 and 7 years—before an initial adjustment in the price of oil is completely realised in the domestic price level. It is also consistent with the findings of (Lacheheb and Sirag, 2019) who also reveal that an increase in oil price takes about 4 – 5 years to be fully transferred to the local price level.

Table 3.
Asymmetric Short-run Estimates

Variable	Short-Run Coefficients
$\Delta Inf_{t-1\ (ECT)}$	-0.6863**
	(0.3548)
ΔInf_{t-1}	-0.4889***
	(0.1422)
$\Delta OilP^{+}$	0.7929***
	(0.2146)
$\Delta OilP^{+}_{t-1}$	-0.4016
	(0.2229)
$\Delta OilP^{-}$	0.3802**
	(0.1765)
$\Delta OilP^{-}_{t-1}$	-0.7088**
	(0.2652)
ΔExRate	-0.8343***
	(0.1321)
ΔIntRate	0.1588***
	(0.044)
ΔMS	-0.0003***
	(0.0054)

Note: ** *$p < 0.05$,* *** *$p < 0.01$. The ECT is the error correction term. Standard errors in parenthesis*

Table 4.
Asymmetric Long-run Estimates

Variables	Long-Run Coefficients
$\Delta OilP^{+}$	1.6219**
	(0.6850)
$\Delta OilP^{+}_{t-1}$	0.1119
	(0.3773)
$\Delta OilP^{-}$	-1.4498**
	(0.7070)
$\Delta OilP^{-}_{t-1}$	0.7778
	(0.4279)

Note: ** *$p < 0.05$,* *** *$p < 0.01$. The positive and negative long-run coefficients are captured by* $\hat{\beta} = \frac{\widehat{-\psi}}{\rho}$*. Standard errors in parenthesis*

Table 5.
Asymmetric Test and Multiplier Effect

	F- Statistic		Multiplier Effect	
	Short-Run	Long-Run	Short- Run	0.0008
Wald-Test	10.0629***	42.1063***	Long-Run	0.0195

Note: The null hypothesis of the Wald is symmetric relationship. The multiplier shows the rate of transmission of oil price change from the short run to the long run

4.1 Post-Estimation Diagnostic Test

To avoid spurious regression estimates, the appropriate diagnostic tests are conducted and summarized in Table 6 and Figure 3. From Table 6, the F-statistic is significant at 1% indicating that all explanatory variables are significantly different from zero. The error term is normally distributed, serially independent, and homoscedastic. The cumulative sum (CUSUM) and Cumulative sum of squares (CUSUMSQ) presented in Figure 3. indicate that the coefficients of the asymmetric model are stable and significant at 5% throughout the sample period since the stability line (blue colour) lies well inside the 5% critical boundaries.

Table 6.
Post-Estimation Diagnostics

Diagnostic	Test Statistic
F-Statistic	4.496***
Jarque-Bera Normality test[a]	0.9674
Breush-Godfrey Serial Correlation LM test[b]	2.6306
Heteroskedasticity (ARCH) test[c]	1.8447

Note: ** *$p < 0.05$,* *** *$p < 0.01$. [a]The null hypothesis is that there are normally distributed errors. [b]The null hypothesis is there is no serial correlation in the residuals up to the specified order. [c]The null hypothesis is no heteroskedasticity*

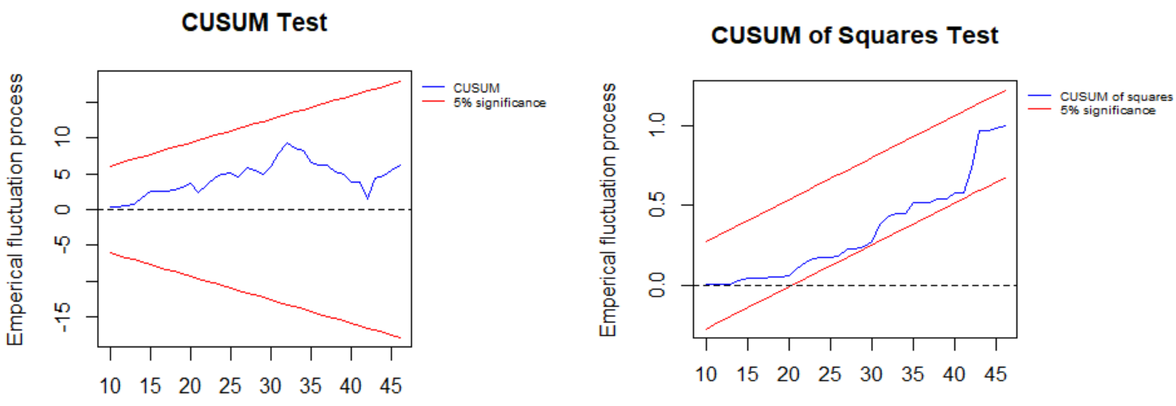

Figure 3: CUSUM and CUSUMSQ of the inflation NARDL model
Source: Author's anthology

5. Conclusion

Policymakers and macroeconomists are both concerned about the recent volatility in the price of oil, which has prompted more analysis and discussion of the effects on key macroeconomic variables like consumer inflation. Since the primary goal of monetary authorities is to keep inflation under control, understanding the empirical relationship between oil prices and inflation rates is very crucial. This study employed a modern methodology—the nonlinear ARDL model recently proposed by (Shin et al., 2014)—to analyse how changes in the price of oil affect inflation in Brazil. To capture both the short-run and long-run asymmetric behaviour of inflation, it concurrently breaks down the price of oil into its partial sum of positive and negative components. This contributes to the body of research on the nexus. The empirical findings confirm that the asymmetric impact of oil prices on inflation in the short- and long-runs exists. Particularly in the long run, a partial change in oil price tends to have a direct impact on inflation. On the contrary, it takes time for a partial decrease in oil price to reduce inflation in the short run.

The current paper draws the following conclusions from a policy standpoint. First, it is plausible that market power exists in the Brazilian market given the evidence demonstrating a direct correlation between rising oil prices and inflation. Asymmetric price behaviour is typically explained by this market power, and the adjustment is anticipated to occur more quickly in the upward direction (Meyer and Cramon-Taubadel, 2004; Lacheheb and Sirag, 2019). Additionally, the evidence of the short-run asymmetries between changes in the price of oil and inflation show that higher prices frequently persist long after the oil price has dropped following the initial rise. Even when this is expected to adjust asymmetrically, a critical examination is still necessary. In view of this, monetary authorities should consider strengthening and monitoring market prices covering the supplies of consumer goods (including imports, wholesale, and retail) through anti-profiteering policy implementation. Additionally, it is strongly advised that productive technology be adopted in the home market to maximise the advantages of low-cost oil products to produce a favourable balance of payments through a decrease in imports.

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