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Asymmetric Adjustment Pass-Through of Oil Price on Transportation Costs

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ABSTRACT

This study examines the asymmetric effects of oil prices on transportation costs in Nigeria using monthly data from January 1995 to December 2023. Employing Threshold Autoregressive (TAR) and Momentum Threshold Autoregressive (MTAR) models, the analysis investigates nonlinear adjustment dynamics between oil prices and transportation costs. The results provide evidence of asymmetric cointegration under the MTAR model with a non-zero threshold. The findings indicate that increases in oil prices raise transportation costs, although the adjustment is relatively slower and statistically weaker, while decreases in oil prices lead to a stronger and faster adjustment toward equilibrium. Long-run estimates from the Dynamic Ordinary Least Squares (DOLS) model further reveal that oil prices, exchange rate and GDP per capita exert positive and statistically significant effects on transportation costs. In particular, exchange rate depreciation increases the cost of imported petroleum products, thereby amplifying transportation costs. These results highlight the importance of both direct fuel cost effects and indirect exchange rate pass-through mechanisms. To enhance transportation cost stability, policymakers should implement integrated measures addressing fuel price volatility, exchange rate fluctuations and energy supply constraints.

1. Introduction

Global energy consumption is rapidly increasing; transportation, industrial, and residential sectors of the economy consume the most gasoline. As a result, the supply of gasoline for both current and future

generations is jeopardized (Zohuri and Mossavar-Rahmani, 2024; Wang and Azam, 2024; Mitra et al., 2025). The transportation sector is the world's largest consumer of petroleum products, accounting for 58% of global final consumption in 2004, 52% in Iran in 2005, and more than 75% in the United States in 2006 (Department of Energy, 2007; Elekwachi et al., 2024). In Nigeria, transportation fuel accounts for more than 75% of total energy consumption, indicating that Nigerians rely heavily on gasoline to power their automobiles (Ehinomen and Adeleke, 2012). Until 2014, when fluctuations in oil prices began, resulting in a drop in gasoline prices in many countries, gasoline prices in some countries had always been rising, raising the cost of transportation. High international crude oil prices, petrol taxes, capacity bottlenecks in the refining process, and the withdrawal of petroleum subsidies are all factors that contribute to high gasoline prices in Nigeria. The petroleum industry is critical to the Nigerian economy because it generates the majority of the foreign exchange earnings and total revenue required for the country's socioeconomic and political advancement. Domestic refined oil prices are increasingly volatile, raising the prices of transportation, food, and other goods (Siddig, Aguiar, Grethe, Minor, and Walmsley, 2014; Agri, Mailafia, and Umejiaku, 2017; Jack and Jack, 2022). When subsidies were removed in 2012, domestic oil was priced at N141 per liter, but a complaint led to a reduction to N97. From 2015 to 2016, the price increased to N145, which is a relatively high amount, driving up the cost of transportation. Oil prices for premium motor spirits, automatic gas oil, and dual-purpose kerosene in Nigeria increased significantly from 3.25 kobo, 0.70 kobo, and 0.50 kobo, respectively, in 1990, to N145.00, N160.00, and N83.00, respectively, at the start of 2019. According to the administration, the elimination of subsidies forced changes in the prices of these goods. Because of the inability to meet local demand for the products, large quantities of these products must be imported (Gbenga and Omo-Ojugo, 2022). Most of this expansion occurred between 1990 and 2007, when domestic oil prices increased three times in a single year. One major issue caused by this was the fluctuation in transportation costs, which resulted in rising food prices. When oil prices rise, it affects goods, services, and transportation.

Nigeria's economy has not yet advanced to the level of a developed country, due in part to a lack of fundamental economic transformation. A key factor is the lack of economic diversification, which has resulted in the economy's heavy reliance on crude oil as a source of income and as its primary export good, is a critical factor in this lack of economic advancement. Before the 1970s, Nigeria's exports were primarily non-oil, with agricultural products accounting for the vast majority. However, as global crude oil prices rose in the 1970s, non-oil export shares began to fall and have since remained at low levels. This is largely because oil exports are highly profitable, making them more profitable than non-oil commodity exports. As a result, there is now a significant reliance on the oil industry and the revenue generated by crude oil exports. Because of this reliance, the country faces difficulties when the price of crude oil, a key export good, falls on the global market (Moses, 2011; Bala, Chin, Ranjanee, and Ismail, 2017; Orji, Abubakar, and Ogbuabor, 2021). As a result, the government enacted several policies to boost non-oil exports and stabilize the economy. Despite these efforts, the performance and contribution of the non-oil exports sector have remained inadequate. The industry's performance has remained below full potential. Therefore, this research was carried out to determine the extent the current performance of the non-oil sectors can be improved.

Even though the retail price of gasoline in Nigeria and other OPEC member countries is low due to petroleum subsidies, the pump price of gasoline varies greatly from one country to the next due to the differences mentioned. Meanwhile, developing countries such as Nigeria encourage the excessive use of gasoline in the transportation sector, whereas other developed countries try to reduce their consumption of the fuel due to the emissions it produces. These countries provide energy subsidies to their citizens primarily to protect them from the commodity's significant price volatility and to keep the price of the good affordable (Aminu, Meenagh, and Minford, 2018). As a result, a good transportation system enlarges the market by allowing goods to be delivered to final consumers. An efficient transportation system facilitates mass production and distribution. During the colonial era, the Nigerian transportation network was built,

beginning with a railway and road system and later expanding to include a marine and aviation system (Bello, Maji, and Sanusi, 2016).

Table 1. Nigerian transport data

		Total	Per 1 mil inhabitants	Per km²
1	Roadways	195,000 km	855.70 km	21.11 cm
2	Railroads	3,798 km	16.67 km	0.41 cm
3	Waterways	8,600 km	37.74 km	0.93 cm
4	Number of Vehicles	13,500,000	59,241	14.61
5	Number of Airports	21	0.09	0.00002

Note: the data sets are Roadways 2019, Railroads 2014, Waterways 2011, Airports 2024

Table 1 shows the Nigerian transportation statistics, which include pipeline, railroad, river, and marine transportation. There are 195,000 kilometres of roads and highways. This is equivalent to 0.86 meters for the country's 227.88 million people. Nigeria is now rated 29th in the world. Asphalt roads account for 31 % of the total, or 60,000 kilometres. However, the nation's size and population density (about 247 persons per km²) must be considered. Despite having a smaller population, countries with fewer people living in the same or even bigger territory inevitably accumulate dramatically different numbers here and require transportation networks to connect remote parts. In 2021, there were 13.50 million automobiles in Nigeria, or around 0.06 per capita.

Despite a brief drop in the price of oil, the patterns indicated that transportation costs were increasing. Furthermore, the price of oil shows a strong positive and fluctuating trend during the study period. The movement suggests that the fluctuation in oil prices is linked to rising transportation costs in Nigeria. Oil prices volatility has taken center stage in the media globally, as higher oil prices are a drag on the world economy. The changes in oil prices affected transportation costs, as shown in Figure 1. The trends of oil prices and transportation costs between 1995 to 2023 were oil price trend exhibited fluctuation. Travelers tend to spend more at the stations because of increasing oil costs, which means we have less money to spend on other goods and services (Li, Timmins and Haefen, 2009; Allcott and Wozny, 2014).

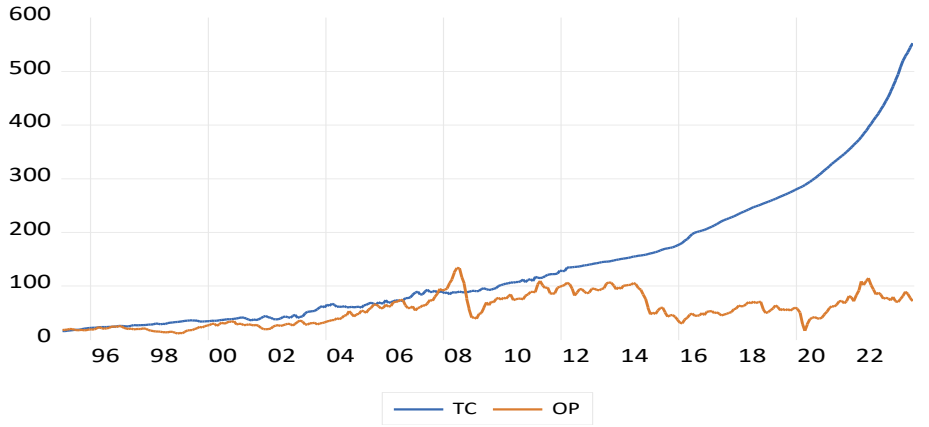


Figure 1. Trends of oil prices and transportation costs in Nigeria
Source: National Bureau of Statistics and OPEC Databases

The transport costs incurred the burden of an increase in domestic oil prices and indeed the insurgency and banditry that have recently bedeviled the northwestern and northeastern parts of the country,

respectively are also contribute to high prices, which are mostly in the food-producing areas of the country, especially during the national festivals of Christmas and the New Year holidays (Iwayemi and Fowowe, 2011). The shortage of refined oil products increased the price of petroleum products, which causes the increasing transportation costs and affects the non-oil sub-sector of the economy. When the petroleum products price decreases, the transportation costs and non-oil sub-sector remain stagnant and refuse to adjust back to the normal equilibrium.

The motivation for this study stems from the critical role of oil prices in shaping transportation costs and, consequently, economic activity. Despite extensive literature on oil prices–transport costs linkages, most studies assume a linear relationship, overlooking the potential asymmetry in price transmission. In practice, transport operators may adjust fares upward quickly following oil prices hikes but delay reductions when oil prices fall. Such asymmetric behavior can have significant implications for inflation dynamics, household welfare, and policy interventions. Therefore, this study seeks to investigate the asymmetric effects of oil prices fluctuations on transportation costs using advanced econometric techniques, providing insights relevant for both policymakers and industry decision-makers.

2. Literature Review

Cost-push inflation theory accurately demonstrates how rising oil prices raise transport costs, causing broader inflationary pressures across economies. With a focus on what extent oil prices fluctuations pass through transportation sectors via direct and indirect mechanisms. The framework explains how rising input prices (production costs) cause an increase in general prices. This theory demonstrates how increases in important operating expenses, such as fuel prices, can raise transportation costs, consequently influencing the larger economy (Ricci and Black, 2005). Direct Mechanisms, oil as the primary input of production, and the theory of oil prices have a direct impact on transportation costs since fuel (diesel, petrol, or jet fuel) is a significant operational expense in most modes of transportation, including road, air, marine, and rail. Higher oil prices boosted fuel expenses, which led to greater transportation costs, while lower oil prices cut fuel and transportation costs. Many transportation systems, including road, rail, air, and maritime, rely heavily on oil. When oil prices rise, the cost of producing transportation services increases because rising fuel expenses account for a large amount of operational costs (Dutta et al., 2024). The pass-through effect of oil costs from transportation industries results in increased operational costs for customers due to rising freight charges, ticket pricing, or delivery fees. The level of this passthrough is determined by the elasticity of demand for transport services (inelastic demand for critical products leads to greater direct cost transfers). Higher transportation expenses increase the cost of moving commodities across supply chains. This effect contributes to rising prices for goods and services throughout the economy, particularly for those with significant transportation costs (Inegbedion, 2020).

2.1 Empirical review

Randheer, AL-Motawa and Vijay (2011) claim that in today's globalized world, public transportation services necessitate careful attention to the level of service provided. The transportation system can accurately forecast economic progress. It acts as a driver of economic growth by creating jobs, improving the efficacy and efficiency of other firms, and encouraging national investment and development. Dubé, Rosiers, Thériault and Dib (2011) used a spatio-temporal study of changes in property prices and a quasi-experiment technique and difference-in-differences (DID) estimator. The study assesses the impact of rapid bus transportation (RBT) implementation in Quebec City, Canada. According to the findings, using public transportation has a positive social impact on urban environments by increasing access to employment opportunities and service infrastructure while decreasing travel costs. The development and implementation of transportation policies is complicated by both public authorities and transportation providers. Because public authorities and transit providers have competing agendas, regulation is critical, especially in the absence of competition.

Furthermore, Jenny (2013) a transportation system is good and reasonable, depending on the quality of public transport and the movement of goods with reasonable traveling fare. Setyawan (2014) used a 66 X 66 classification of domestic transactions based on producer prices to study the impact of fuel price increases on the economic sector in Indonesia. Specifically, the effects of 10%, 20%, and 30% increases in fuel prices on the economy. The transportation industry, according to the estimate, would suffer greatly because of rising fuel prices. The government should protect industries that bore the brunt of the increase in fuel prices.

Olaniyi (2016) used a survey tool to examine how the fourth industrial revolution has affected transportation in poor countries. Social integration, geographical interaction, and economic goals are all fundamental to transportation and cannot be separated from it. The fourth industrial change or shift, which can also be viewed as a sudden fundamental change in industrial organization, replaces the first, second, and third industrial changes. The fourth industrial revolution will raise the bar for developing countries in terms of developing reliable and efficient modes of transportation, as well as investing more in technology transfer, which will benefit the local manufacturing industry and agriculture.

Adeniran and Adeniran (2017) examined the passenger demand on international air travel to use regression analysis to analyse the relationship between demand for international travel in Nigerian airports and economic variables. According to the findings, the independent variables and unaccounted-for variables can explain 91.2 % of the dependent variable. The study discovered a strong relationship between changes in consumer inflation, the value of the naira against the dollar, GDP, and yearly international passenger traffic.

Researchers Olaniyi and Oniru (2017) examined the transportation sectors in the six named developed nations (Japan, Germany, India, China, Egypt, and South Africa) to reach that reasonable conclusion using a qualitative instrument of analysis. Train travel, according to the findings, outperforms all other modes of transportation in the developed nations studied. One of the suggested improvements is to the efficiency of the Nigerian transportation system. Oluwaseyi and Olaniyi (2018) the passenger satisfaction was assessed. The study used surveys and on-site observation to collect the necessary data at the Akure and Owo Park terminals during the investigation. Passengers at both terminals were given questionnaires totalling one hundred and twelve (112). The research applied gap analysis to generate descriptive statistics. According to the findings, transportation costs are among the major dissatisfactions of passengers on board.

Oluwakoya and Obasa (2020) examined the potential issues and recommendations in Nigerian and British transportation administration. The study compares the scope and mode of transport administration in Nigeria and Britain using panel regression analysis. The strategy includes a search for documentation on the transportation administration's policy interventions in both countries. The paper investigates the issues and difficulties associated with poor transportation administration, particularly in Nigeria, and makes pertinent recommendations to improve transportation administration for regional economic growth. Ajemunigbohun (2024) found that uninsured motorists in metropolitan Lagos, particularly commercial drivers, tend to exhibit riskier driving behaviours such as speeding and reckless driving, which pose significant threats to pedestrian safety.

The study of Olorunfemi and Adeniran (2020) looked at how the quality of road transport affected urban people's contentment in Nigeria's Kogi state. The survey research design and systematic sampling technique were used in the study to collect primary data from 1215 respondents via questionnaire, which was then analysed using regression analysis. It was discovered that poor road maintenance affects both the comfort of the passengers and the transportation rate charged for each journey. The availability of a transportation plan influences both the per-trip cost of transportation and the level of comfort in a road vehicle. Nafiu, Hassan and Alogwuja (2020) Researchers investigated Kogi State's public transportation system and

discovered that, apart from transportation service, other factors are highly correlated with reported passenger pleasure.

Although several studies have examined the relationship between oil prices and transportation costs, most have assumed a symmetric and linear adjustment process, implying that transport costs respond equally to both increases and decreases in oil prices. However, transportation markets often display asymmetric price transmission due to market rigidity, fuel pricing policies, and differences in cost pass-through behaviour. Moreover, much of the existing literature focuses on developed economies or aggregate global data, with limited attention given to oil-dependent developing countries such as Nigeria, where exchange rate volatility and fuel import dependency can amplify these effects. Additionally, few studies have integrated exchange rate dynamics or employed nonlinear econometric models like the Momentum Threshold Autoregressive (MTAR) approach to capture these asymmetric adjustments (Bala et al., 2017; Bala et al., 2021). This gap highlights the need for country-specific and model-based analyses that can reveal the true nature of the asymmetric effects of oil prices fluctuations on transportation costs and their broader economic implications.

3. Methodology

The empirical methodology is divided into stages; firstly, the study specified the model, conducted descriptive statistics tests, and unit root tests to determine the non-stationarity or integration characteristics. Since the variables are non-stationary integrated, the study looked for a long-run relationship. In the second section, following the discovery of cointegration, the study used dynamic ordinary least squares to further assess the long-run coefficient, level of significance, and sign of each variable with dynamic ordinary least squares (DOLS). The study also employs Enders and Granger's asymmetric cointegration tests, which assume that symmetry adjustment processes are ineffective in the presence of asymmetric adjustments (Enders and Siklos, 2001).

The study draws its conclusions from the pertinent literature analysis and decides to utilize a model by Ibrahim and Chancharoenchai (2014). We substitute the food price for the transportation costs. Lastly, the model shows the following variables: Transportation price (TP) as the dependent variable, oil prices (OP) and the official exchange rate (EXR) and real gross domestic products (GDP) as independent variables.

$$TP = f(OP, EXR, GDP) \tag{1}$$

Where: TP denotes transportation costs, EXR denotes the Naira exchange rate to the US dollar, OP denotes the oil prices and GDP denotes the economic growth. The study develops the following econometric model to examine the asymmetric effects of oil prices on transportation costs.

$$ln\,T\,P_t = \alpha_0 + \beta_1\, ln\,O\,P_t + \beta_2\, ln\,E\,XR_t + \beta_3\, ln\,G\,DP_t + \varepsilon_t \tag{2}$$

α_0 is the constant parameter, $\beta_1, \beta_2, \beta_3$ are vectors of independent variables to be estimated ε_t is the respective error term in the equations.

3.1 Asymmetric threshold (TAR and M-TAR)

The logic behind the asymmetric threshold method is that when the variation occurring above the threshold level exceeds the variation occurring below the threshold level, TAR can detect a deep cycle process, while M-TAR can detect abrupt sequential movement. Enders and Siklos threshold is useful especially when the series has a higher velocity, more directed towards one direction than another. The threshold could be either zero or more than zero. Chan (1993) recommends checking for all possible thresholds and estimating them if they are more than 0. The threshold is based on the least residual sum of

squares (RSS). Before doing a cointegration test, the long-run equation will be developed using the Ordinary Least Squares (OLS) technique. The residuals obtained from the OLS regression will be tested. The threshold cointegration requires that the residuals of the variables are stationary at the level. The residuals in future regressions are calculated using the $p1$ and $p2$ estimates.

$$\Delta\varepsilon_t = Itp1\varepsilon_{t-1} + (1 - I_t)p2\varepsilon_{t-1} + \varepsilon_t, \quad (3)$$

The Heaviside indicator function extracts the residuals ε_t from equations (2) and (3) into equations (4) and (5) for additional estimation when there is a white-noise disturbance.

$$I_t = \begin{cases} 1if\,\varepsilon_{t-1} \geq \tau \\ 0if\,\varepsilon_{t-1} \leq \tau \end{cases} \quad TAR\ model, (4) \qquad M_t = \begin{cases} 1if\Delta\varepsilon_{t-1} \geq \tau \\ 0if\Delta\varepsilon_{t-1} \leq \tau \end{cases} \quad MTAR\ model, (5)$$

The threshold value τ detected

The equation tested by:

$$\Delta\varepsilon_t = Itp1\varepsilon_{t-1} + (1 - It)p2\varepsilon_{t-1} + \sum_{i-1}^{p-1}.\gamma t\Delta\varepsilon_{t-1} + \varepsilon_t \quad (6)$$

When the adjustment coefficient is greater or less than the threshold, the TAR model records deviation from equilibrium over time or at a particular level, whereas MTAR represents the accumulation of variance changes over time. $p2\varepsilon_{t-1}$.

The symmetric and no-cointegration null hypothesis is determined by the F-statistic $P1 = P2 = 0$, and F-equal $P1 = P2$ respectively.

3.2 Data

The analysis was based on secondary monthly data on transportation CPI, oil prices, exchange rate, and real GDP per capita. All statistics were compiled from the Central Bank of Nigeria 2024 Annual Statistical Bulletin. The data is accessible from January 1995 to December 2023. The variables have been transformed to natural logarithms.

4. Findings

Table 2. Data description

Variable	Description	Measurement unit	Source
TP	Transportation CPI	CPI 2010	Central Bank of Nigeria 2024 Annual Statistical Bulletin
OP	Crude oil prices	USD	
EXR	Official exchange rate	Naira/USD	
GDP	Real GDP per capita	Constant USD	

Table 2 presents the descriptive statistics of the variables in the research, which comprise transportation costs (TP), oil prices (OP), exchange rate (EXR), and gross domestic product per capita (GDP), respectively. The transportation costs, oil prices, exchange rate, and GDP per capita have an average value of 94.5303, 56.1631, 136.2520, and 3.0411, respectively, within the period of 1995M1 to 2023M12. Their maximum and minimum values include transportation costs of 255.4400 and 15.9400, oil prices have 145.0000 and 11.0000, and exchange rates have 4.7911 and 1.4611 for GDP per capita. The standard deviation value of 64.5420, 41.8244, 75.4796, and 1.1711 for transportation costs, oil prices, exchange rate,

and GDP per capita implies lower deviation from their estimated mean values. This study considers skewness and kurtosis to determine the symmetry of the data. Each variable has a skewness value of zero, while the kurtosis value is close to three. According to this, the variables must be roughly regularly distributed (Gujarati and Porter, 2009). A Jacque Bera test statistic was used to determine whether the data's skewness and kurtosis matched a normal distribution. If the likelihood of the Jacque Bera statistic is less than 0.05, the data for the variable are assumed to be non-normally distributed. All the variables have a Jacque Bera probability of zero, and this is confirmation of the not normally distributed variables.

Table 3. Descriptive statistics

	TP	OP	EXR	GDP
Mean	94.5303	56.1631	136.2520	3.0411
Median	84.0200	40.0000	130.7200	2.9111
Maximum	255.4400	145.0000	309.7300	4.7911
Minimum	15.9400	11.0000	22.0000	1.4611
Std. Dev.	64.5420	41.8244	75.4796	1.1711
Skewness	0.7954	0.8668	0.6273	0.1104
Kurtosis	2.6263	2.6449	3.5817	1.5020
Jarque-Bera	32.0446	37.5792	22.9512	27.5118
Probability	0.0000	0.0000	0.0000	0.0000
Sum	27224.75	16175.00	39240.58	8.7513
Sum Sq. Dev.	1195549	502044	1635089	3.9324
Observations	288	288	288	288

4.1 Unit root test

The study employed two most recommended unit root tests, namely Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP), to assess the nature of stationarity of the variables. The results are presented in Table 3, which indicates that the transportation costs (TP) and oil prices (OP), exchange rate (EXR) and gross domestic product (GDP) were found to be non-stationary at the level but became stationary after first differencing. These findings suggest that the variables in the model exhibit different orders of integration. The Engle and Siklos Asymmetric cointegration tests were run to confirm the order of integration being confirmed.

Table 4. Unit root

	Level				**F-difference**			
	ADF		**PP**		**ADF**		**PP**	
	Constant	& Trend	Constant	& Trend	Constant	& Trend	Constant	& Trend
$lnOP$	-0.8066	-3.9469**	-0.7722	-3.8155**	-19.5482***	-19.5149***	-19.7682***	-19.7336***
	(0.8153)	(0.0115)	(0.8249)	(0.0170)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$lnTP$	-1.3546	-2.2678	-1.3906	-4.1379**	-18.4327***	-18.4769***	-18.4327***	-18.4769***
	(0.6045)	(0.0040)	(0.5870)	(0.0062)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$lnEXR$	-1.6009	-1.9323	-1.6050	-1.9858	-16.4534***	-16.4529***	-16.4538***	-16.4529***
	(0.4808)	(0.6349)	(0.4787)	(0.6062)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$lnGDP$	-1.4335	-1.4130	-1.3217	-2.2866	-14.2150***	-14.4337***	-16.8484***	-16.8290***
	(0.5658)	(0.8554)	(0.3135)	(0.1770)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Note: *** 1% significance level and ** 5% significance level

4.2 Asymmetric cointegration test results

The Enders and Siklos (2001) test were applied to determine the existence of asymmetric cointegration, in contrast to the conventional symmetric methods such as the Johansen-Juselius and Engle-Granger procedures. The results are shown in Table 4. We used optimal of two lagged differences in all the regression residuals, and a Monte Carlo simulation was used to determine the critical values at the 5% significance level. The F-equal and F-joint statistics in the Threshold Autoregressive (TAR) model with a threshold value of 0 were 0.0203 and 5.2113, respectively; both were below the critical values of 2.6809 and 8.4679 at the 5% level. This suggests there is absence of cointegration. The ideal threshold value was then determined using Chan's (1993) method, and it turned out to be 0.1351. The F-joint statistic of 0.3508 was still below the 5% essential value of 5.3827, indicating that cointegration was still not found. Furthermore, the study estimated the Momentum Threshold Autoregressive (MTAR) model using a threshold value of 0. The F-equal and F-joint statistics were 0.9796 and 0.5708, respectively, both below the critical values of 3.7152 and 9.0794 at the 5% significance level. Therefore, the null hypothesis of no cointegration could not be rejected. However, when applying Chan's threshold selection method, the MTAR model yielded F-equal and F-joint values of 15.0425 and 18.9809, which exceed the corresponding Monte Carlo critical values of 8.1820 and 10.7002 at the 5% level. This indicates the presence of cointegration under a non-zero threshold. These results justify further analysis to determine whether the cointegration relationship is symmetric or asymmetric.

Table 5. TAR and MTAR cointegration and asymmetric cointegration results

	TAR	**TAR consistent**	**M-TAR**	**M-TAR consistent**
	-0.0812 (0.0350)	-0.1016 (0.0389)	-0.0983 (0.0296)	-0.2270 (0.0413)
	-0.0885 (0.0380)	-0.0714 (0.0343)	-0.0387 (0.0531)	-0.0017 (0.0317)
$Lags$	2	2	2	2
	0	0.1351	0	0.0166
$F-equal$	0.0203	0.3508	0.9796	15.0425**
$F-joint$	5.2113	5.3827	5.7087	18.9809**

Note: ** 5% significance level

The study found that changes in oil prices do influence transportation costs, and the speed of adjustment is not necessarily constant over time. This conclusion is supported by the MTAR-consistent model, where the F-equal statistic exceeds the 5% critical value derived from the Monte Carlo simulation, indicating asymmetric adjustment. Table 4 presents the results of the asymmetric cointegration tests using the TAR, TAR-consistent, MTAR, and MTAR-consistent models. Standard F-statistics were employed to test the null hypothesis of symmetric adjustment ($H_0: \rho_1 = \rho_2 = 0$) against the alternative hypothesis, which allows for asymmetric adjustment dynamics.

4.3 Dynamic ordinary least squares result

The long-run coefficients were estimated using the Dynamic Ordinary Least Squares (DOLS) approach, which is illustrated in the equation below. The findings show that oil prices, GDP per capita, and exchange rates all have a positive and statistically significant effect on transportation costs. Specifically, a 1 % increase in oil prices, GDP per capita, and the exchange rate leads to long-run increases in transport costs of 0.4676 %, 1.0709 %, and 0.1226 %, respectively. Oil prices and GDP per capita are significant at the 1 % level, but the exchange rate is significant at the 5% level. The R-squared value of 0.9795 indicates that these three variables explain around 98 % of the variation in transport costs, with the error term accounting for the remaining 2 %.

$$lnTP_t = -6.0495 + \underset{(4.7453)}{0.4676\, lnOP_t} + \underset{(4.8461)}{1.0709\, lnGDP_t} + \underset{(2.0475)}{0.1226\, lnEXR_t} + \mu_t$$
$$R^2 = 0.9795$$

4.4 Asymmetric error correction modeling result

The asymmetric error correction adjustment is estimated using the momentum threshold value in both the MTAR and MTAR-consistent models. The study uses a general-to-specific approach, a commonly used technique to guarantee the most accurate and efficient prediction of asymmetric error correction dynamics, to ascertain the optimal lags. The findings, which are shown in Table 5, show that the influence of oil prices on transportation costs are asymmetrical, indicating that changes in oil prices have different effects on transportation costs. According to the findings, the price of oil has an uneven impact on transportation costs. According to the study, when oil prices fluctuate, transportation costs rise at a faster rate, and the MTAR-consistent model predicts a 2.27% rate of adjustment. The positive adjustment coefficient is statistically insignificant, whereas the negative adjustment is significant. Meanwhile, a decline in oil prices has a major, unfavorable impact on transportation costs. The MTAR-consistent model predicts an adjustment speed of 48.46% at a 5% significance level. This conclusion is in line with the actual, current reality in Nigeria. Oil prices have a favorable impact on transportation costs when they rise, but when they fall, they have a negative impact and cause the economy to revert to normal equilibrium. The results disagree with those of Aziz and Dahalan (2015) and Kriskkumar and Naseem (2019). This is not shocking because diverse methodologies were employed in these investigations. The ASEAN-5 nations—Indonesia, Malaysia, the Philippines, Singapore, and Thailand—were studied by Aziz and Dahalan (2015) using a panel VAR model. Overall, the findings imply that the ASEAN-5 scenario will have an asymmetrical effect. The R-square value of 0.7796 showed that variations in the oil prices, the value of the local currency, and the GDP per capita, respectively, were responsible for the R^2 of 0.7796 indicates that approximately 78% of the variation in transportation costs are explained by the model, respectively, of changes in transportation costs in Nigeria. The estimated value F-statistic 9.8280 is statistically significant at the 1 % level, which suggests that in the overall model, the rise in transportation costs over the research period was caused by increases in the oil prices, the exchange rate, and the GDP per capita.

Table 6. Asymmetric error correction result

	MTAR-consistent
λ^+	-0.0227 (-0.1962)
λ^-	-0.4846** (-2.5897)
$R2$	0.7796
$Dw - statistic$	2.1062
$B - G$	(0.5754)
$B - P - G$	(0.3619)
$J - B$	(1.4896)
$F - statistics$	9.8280***

Note: *** 1 % significance level and ** 5% significance level

The diagnostic tests of serial correlation, heteroscedasticity, and normality were all reported in the lower part of Table 5. From the serial correlation test, heteroscedasticity, and normality, all the estimated coefficients given in parentheses were statistically insignificant. This implies that the acceptance of the null hypothesis for serial correlation problems, the heteroscedasticity problem, and the normality problem, respectively. That means the estimated coefficients were not associated with serial correlation, heteroscedasticity, and normality problems.

5. Recommendation

Based on the findings, policies should aim to stabilize transportation costs by addressing both direct and indirect effects of oil prices fluctuations. The government should implement measures to cushion the impact of rising oil prices, such as fuel price stabilization mechanisms and investment in local refining capacity to reduce dependence on imports. Ensuring exchange rate stability is crucial, as depreciation increases import costs and drives up transport expenses. Promoting energy-efficient technologies, alternative fuels, and transparent pricing mechanisms will help ensure that reductions in oil prices are effectively transmitted to consumers. Overall, an integrated approach combining energy policy, exchange rate management, and regulatory oversight is essential to minimize the asymmetric impact of oil prices shocks on Nigeria's transportation sector and maintain economic stability.

Data Availability

Data are available from the Central Bank of Nigeria (2024 Statistical Bulletin).

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Not applicable.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contributions

Rabiu Maijamaa**:** Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Data Curation, Writing – Original Draft.

Umar Bala: Investigation, Writing Review & Editing, Supervision.

Murtala Garba: Project administration, Funding acquisition, Visualization.

Disclosure of AI Use

AI tools were not used in the preparation of this manuscript.

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