Effects of production costs on manufacturing supply in Nigeria: An ARDL approach

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ARTICLE INFO	ABSTRACT
	The imperative of a functioning manufacturing sector has long been recognised in the economics literature. Manufacturing sector has been described as the driver of economic growth and a quick way out of underdevelopment. However, in recent times, there has been increasing cost of production which continue to affect manufacturing production in Nigeria. This study examined the effect of production costs on manufacturing output in Nigeria. The study is anchored on the conventional supply theory, after which, a time series regression model was specified for data covering 1981 to 2022. The ARDL estimation methodology was employed to estimate the equations in tandem with the results obtained from the unit root and cointegration tests. In order to confirm the accuracy of the model estimates, pertinent diagnostic tests were also performed. The result indicated that while government subsidy to manufacturing sector (as a negative cost) and government general capital stock have positive effect on manufacturing output, diesel price on the other hand, has a negative effect on manufacturing output in Nigeria.

1. Introduction

As noted by Meyer and Hassan (2020) and Signé and Johnson (2018), the manufacturing sector has gained widespread acceptance as the most important sector of an economy. This is because it not only offers employment opportunities for the largest number of people, but it also offers a rapid route out of underdevelopment. It is also commonly believed that a fast rate of industrial growth would create the much-needed means of reducing reliance on the foreign economy and make it easier to achieve the goals of the

country, which include raising real per capita income, creating more jobs, increasing the amount of raw materials sourced locally, and developing domestic industrial technology (Otalu & Keji, 2015).

Owing to the manufacturing sector's significant contributions, the Nigerian government has made considerable efforts to enhance the sector's current trajectory. The National Economic Empowerment Development Strategy (NEEDS) and the State Economic Empowerment Development Strategy (SEEDS), the National Development Plans, as well as the Rolling Plan of 1990–1992, have demonstrated the government's efforts in this direction. In a similar approach, a number of policy initiatives, including the creation of the Bank for Industry, the Import Substitution Industrialization (ISI) strategy, the Export Promotion Council, issuance of different tax holidays, establishment of Export Processing Zones, and industry incentives, have also been implemented by the Nigerian authority. Notwithstanding these endeavors, the manufacturing sector's performance remains unimpressive, and its contributions to the Nigerian economy continue to fall short of expectations.

In recent times, studies have shown that currency depreciation is detrimental to the industrial production of Nigeria, as noted by David et al. (2010). This is because the Nigerian manufacturing process is significantly dependent on imported capital goods and inputs. Since the liberalization of 1980s, Nigeria's manufacturing industry have faced several challenges, according to Ku et al. (2010). These included an over-reliance on oil as a source of income, inadequate infrastructure, shortage of trained workers, a lack of financial resources, and poor planning and management. Accordingly, Adofu et al. (2015) noted that the lack of adequate infrastructure hampers the manufacturing sub-sector in Nigeria from growing because most companies need power generators to run efficiently, which increases costs. Along with other problems including low foreign investment appeal, insecurity, and political instability, the situation has gotten worse as a result of recent rises in the price of fuel.

Furthermore, as there is currently inadequate data to support the various cost components' effects on manufacturing production in Nigeria, this study aims to investigate these effects by looking at the main cost of production variables in Nigeria. Therefore, the primary focus of this study is on the various cost items associated with manufacturing, such as the cost of (or interest rate on) manufacturing credits, the costs associated with obtaining manufacturing capital goods and costs associated with importing raw materials (in the form of real effective exchange rate depreciation), the cost of diesel for powering manufacturing plants and machinery (including generators), and the benefits (i.e. negative cost) in form of manufacturing grants and subsidies from the government are the main focus of this study.

2. Literature review

2.1 Conceptual review

Production is a general term for the process of converting inputs into outputs. Among the transformations are the transformation of raw materials into works in progress and of works in progress into finished commodities that are prepared for sale. Three categories of production—primary production, secondary production, and tertiary production. Manufacturing, on the other hand, may refer to either the extensive process of converting raw materials into completed products or the production of more complicated products through the sale of basic products to businesses that make products like household appliances, vehicles, and airplanes (Groover, 2010). According to Adofu et al. (2015), manufacturing is the process of creating products for use or sale using labor, machinery, chemicals, and biological and chemical formulas. It converts raw materials into final products, combining modern technology and human craftsmanship.

The Nigerian manufacturing subsector is classified into the following sub-sector: Food, beverage, and tobacco; oil refining; cement; textiles, apparel, and footwear; wood and wood products; pulp, paper, paper and paper products; chemical and pharmaceutical products; non-metallic products; plastic and rubber products; electrical and electronic products; basic metal, iron, and steel; motor vehicles & assembly; and

other manufacturing (Central Bank of Nigeria, 2021). In this study, "manufacturing" is used to mean the processing of raw materials or parts into finished goods through the use of tools, human labor, machinery, and chemical processing. It is taken to be the mechanised conversion of inputs into a finished good.

Supply is another concept of interest in this study. Supply can be defined as the entire amount of a certain good or service that businesses are willing and able to provide for sale at a specific time and price. The behavior of current and prospective sellers (producers) of an item is represented by the supply function. Pindyck and Rubinfeld (2013) provides a concise definition of supply by characterising supply as the quantity of a good that producers are willing to sell at a given price, holding constant any other factors that might affect the quantity supplied. The quantity supplied can depend on other factors besides price. For example, the quantity that producers are willing to sell depends not only on the market price but also on their production costs, including wages, interest charges, and the costs of raw materials, among other factors (Pindyck & Rubinfeld, 2013).

Economists differentiate between production and supply: production is the transformation of inputs into outputs at a specific time, while supply refers to the quantity of output available for sale at a given time and price. Supply is calculated as production minus the change in inventory, which can be positive, negative, or zero. Three scenarios arise: when inventory increases, supply is less than production; when inventory decreases, supply exceeds production; and when inventory remains constant, supply equals production. In this study, however, the distinction is minimal, so supply is treated as approximately equal to production.

Production cost refers to any expense that a business incurs during the manufacturing or production process for its goods and services. Distinction is often made between all variants of cost items. Fixed costs are expenses that do not change with the amount of output produced. Variable costs are any expenses that change based on how much a company produces and sells. This means that variable costs increase as production rises and decrease as production falls. Variable costs may include items like the cost of purchasing materials for a product, hourly pay for employees, utility bills, advertising costs and credit card fees. To calculate the variable costs, you can add direct labor costs and direct material costs. Marginal cost, on the other hand, represents the increase in production cost that results from increasing production by a single unit.

2.2 Review of theories

Production theories start with theory of production function. Production function refers to the operational connection regarding firm input and output. It expresses a functional relationship between physical inputs (or factors of production) and output. Nicholson and Snyder (2008:150) state that the production function reflects the company's technical knowledge about how to use inputs to produce output.

Smith (1776), Steuart (1796), and Marshall (1890) were notably the first to popularise the theory of supply and lay the foundation for what has come to be known as the "law of supply." According to the law of supply, a direct relationship exists between the price of a good and the quantity supplied of that good. As the price of a good increases, sellers are willing to supply more of that good. Therefore, according to the law of supply, the price of a good is the primary determinant of the quantity supplied by a firm. The supply theory also takes into account the supply curve's shift factors. A non-price determinant's influence on supply will cause a shift in the overall supply curve. A shift in the supply curve has been attributed to a variety of factors, including the cost of inputs, technical advancements, and governmental regulations.

Other factors that have been theoretically identified as determinants of supply are production costs, including wages, interest charges, and the costs of raw materials, prices of other related goods, level of technology, and price expectation (Pindyck & Rubinfeld, 2013). Theories of supply have also recognized the importance of government interventions, as determinants of supply. Government interventions can take many forms, including environmental and health regulations, hour and wage laws, taxes, subsidies, land use regulations, etc.

2.3 Empirical review

Enu et al. (2013) investigated the effects of selected macroeconomic indicators on manufacturing production in Ghana. The ordinary least squares estimation technique was applied to time series data of 21 sample size due to the unavailability of data. The study found that real petroleum prices and the real exchange rate have negative impacts on manufacturing production, while imports of goods and services and government spending have positive impacts. Ajudua and Ojima (2016) analysed the determinants of output in the Nigerian manufacturing sector from 1986 – 2014. Gross capital formation, bank credit to manufacturing sector, lending rate, employed labor force, foreign direct investment, manufacturing capacity utilisation rate and foreign exchange rate were used as explanatory variables and were regressed on manufacturing sector output. The unit root test based on the Augmented Dickey-Fuller approach was conducted to test for stationarity among variables. The Johansen Co-integration test was also employed to test for long-run equilibrium relationships among the variables and the Granger Causality test was conducted to ascertain the causal relationship between the variables while the stability test was also conducted to check for the long-run stability of the variables employed. The study found a significant relationship between the explanatory variables employed and the output of the manufacturing sector in Nigeria during the period studied. Agrawal and Jain (2018) examined the effects of institutions, goods market efficiency, hiring and firing practices and flexibility on manufacturing and service production and exports in 130 countries, using data sourced from the World Bank's World Development Indicators (WDI), the International Monetary Fund (IMF), UNESCO and the Global Competitiveness Report of 2016 - 2017. The study found that institutional variables related to education and technology are significant for manufacturing. Also, Infrastructure significantly determines exports. The coefficients of Tertiary enrollment gross percentage were positive for services and negative for manufacturing. David-Wayas et al. (2018) included more variables in the evaluation of the effects of some selected macroeconomic variables (viz; domestic private investment, government capital expenditure, exchange rate, foreign direct investment, consumer price index, credit to manufacturing sector and prime lending rate) on manufacturing productivity in Nigeria from 1981 to 2015. Employing the OLS estimation method, the study observed that exchange rate and government capital expenditure have negative effects on manufacturing productivity, while the prime lending rate, domestic private investment, consumer price index, credit to the manufacturing sector and foreign direct investment have positive effects on it. Edet et al. (2022) investigated the effect of electricity supply on manufacturing output in Nigeria, using data from 1980 to 2019. The framework adopted was the endogenous growth model production function with key variables affecting manufacturing sector output, such as the exchange rate and technology. Using the ARDL method of estimation, the study revealed that electricity supply has a negative and insignificant relationship with the manufacturing sector output. Conversely, technology had a positive and significant relationship with manufacturing sector output in the short run.

3. Methodology

This study is anchored on the supply theory. In the theory of supply, price is the primary determinant of the quantity of output produced and supplied by firms in the manufacturing sector. Therefore, holding other factors constant, "p" will determine how much of the good will be supplied, i. e. S(P). The theory of supply also considers a shift in the supply curve. Theoretically, any change that raises the quantity that firms wish to produce at any given price shifts the supply curve to the right and vice versa for any change that lowers the quantity supplied. These factors includes production costs, technology, and prices of related goods.

Items of Costs of Production (CP): These refer to prices of inputs into production, including manufacturing wages and costs of capital like interest rate, rent paid on land, prices of raw materials and exchange rate. A change in the prices of inputs of production, given the own-price of output and other factors, will cause a shift in supply curve to the left if the costs increase and to the right if it fall. Changes

in production taxes also fall into this category, while changes in production subsidies and manufacturing grants are regarded as the opposite. The study highlights some cost of production-related determinants of manufacturing production. However, due to non-availability of data on wage cost and cost of other factor inputs that should have otherwise been included, the study limits itself to cost of credit proxied by real interest rate, cost of imported capital goods and raw materials proxied by real effective exchange rate depreciation, cost of diesel and government spending on manufacturing sector as a negative cost. These are explained below.

(a)   Cost of Diesel (DP): With the incessant epileptic power supply in Nigeria, diesel-using generators, therefore, serve as an alternative facility for getting energy for manufacturing firms in Nigeria. Thus, an increase in diesel prices, with the attendant increase in the cost of production in manufacturing industries, is expected to have a negative effect on manufacturing production in Nigeria. In their respective studies, Chiputyani (2019) looked into the effects of diesel prices on manufacturing output and found that the cost of diesel had a negative effect on the output.

(b)   Real Effective Exchange Rate Depreciation (REXCR): Exchange rate should affect the costs of imported capital goods and raw materials and, as such, it is included as one of the shifters of the supply curve, being an element of the cost of production category. In a country where the bulk of manufacturing inputs are imported, a depreciation in the real effective exchange rate would increase the cost of inputs in real terms so that, holding all other factors constant, it should lower manufacturing output. In support of this, in their respective studies, Sola et al. (2013) and Ajudua and Ojima (2016) found that exchange rate depreciation has a negative effect on manufacturing output.

(c)   Real Interest Rate (RINT): A real interest rate increase ought to have reducing effect on the output of manufacturing sector. The interest cost (in monetary terms) of borrowing to finance a manufacturing concern rises when interest rate too rise, thereby causing manufacturing supply to fall. Conversely, a fall in interest rate should have the opposite effect through this same channel. The cost of capital or interest rate, is included in this study and it is postulated to have a negative effect on the manufacturing output.

(d)   Government Spending on Manufacturing Sector (GOVS): Government intervention in the form of spending on the manufacturing sector is considered in this study. Such government spending in form of grants and subsidies to manufacturing sector are regarded as negative (or opposite of) production costs to the firms. Therefore, it is expected that the more these incentives are available to firms in the manufacturing sector, the more these firms can produce and supply. Thus, government spending on manufacturing sector is expected to have a positive effect on manufacturing production. However, it is to be noted that some studies, including Sokunle et al. (2017), estimated the effect of government incentives on manufacturing production in their studies and found that the effect of it on manufacturing output is not discernable. Due to the difficulty of getting data on government subsidy to manufacturing sector in Nigeria, this study used recurrent spending on manufacturing sector in its stead.

3.1 The model

Combining all the variables stated above and presenting the relationship in a functional model gives Equation (1) below:

$$MS = f (DP, REXCR, RINTR, GOVS, CONT) \qquad (1)$$

where: MS = manufacturing output, DP = diesel price, REXCR = real effective exchange rate, RINT = real interest rate, GOVS = government subsidy to manufacturing sector, CONT = is used to represent the control variables of the study, which, in this case is price of manufacturing output (PO) and public sector capital stock (PSCS). This is presented econometrically and in a log-linearised form in Equation (2) below.

$$lnMst = \beta 0 + \beta 1 lnPOt + \beta 2 lnDPt + \beta 3 lnREXCRt + \beta 4 lnRINTt + \beta 5 lnGOVSt + \beta 6 lnPSCSt + Ut. \qquad (2)$$

Equation (2) is estimated for manufacturing sector in Nigeria. Following the discussion of the directions of the effects of the variables above, the apriori expectations of the directions of the effects are as mathematically stated as; $\beta 2$, $\beta 3$, $\beta 4 < 0$ and $\beta 1$, $\beta 5$, $\beta 6 > 0$

3.2 Estimation technique

The actual data analysis begins with pre-estimation test, particularly, descriptive statistics, unit root test, and cointegration test. Concerning unit root test, this study adopts the Augumented Dickey Fuller unit root test procedure (with constant and trend) for individual variables to provide evidence on whether the variables are stationary at level (I(0) series) or at first difference (I(1)series). Cointegration test is then carried out to examine the presence of longrun relationship between the variables of the study after which, this study uses an ARDL regression method for regression. The post-estimation tests used in this work are multicollinearity test, autocorrelation test, non-normality of distribution of the residual test, and stability test. This study employs time series data for Nigeria over a period of 41 years (1981-2022). The data on the variables of the study are sourced from World banks' World Development Indicator updated in 2023 and Central Bank of Nigeria (CBN)'s Annual Statistical Bulletin (2023). The data are real 2010 constant basic Naira values.

4. Discussion of findings

4.1 Descriptive analysis

In this section, the variables of the study are described in terms of their mean, median, standard deviation, maximum, minimum and coefficient of variation. These are presented in Table 1 below.

Table 1: Descriptive Statistics

Variable	Mean	Median	Std-Dev.	Maximum	Minimum	Coeff. of Variation
MS	4,277.90	3,585.02	1,347.24	6,684.22	2,898.47	0.32
DP	74.05	24	137	817.85	0.2	1.85
GOVS	105.53	12.25	152.8	488.49	0	1.45
P^O	81.36	37.71	102.99	412.95	0.48	1.27
PSCS	43,996.91	19,258.76	50,178.94	212,750.60	658.68	1.14
RINT	0.36	3.67	14.1	18.18	-65.86	39.17
REXCR	147.16	101.04	114.37	536.91	49.78	0.78

Source: Author's Computation, 2025.
Explanatory note: The number of observation for PSCS is 39 while, for all other variables, it is 42.

The results in Table 1 indicates that the mean of manufacturing output (MS) over the period of study was 4,77.90 billion naira, with a median value of about 3,585.02 billion naira and a standard deviation of 1,347.24 billion naira while the maximum value was 6,684.22 billion naira and the minimum value was 2,898.47 billion naira. The mean price of diesel (DP) was 74.05 naira, a median value of 24.0 naira, and a standard deviation of 137.0 naira with the minimum and maximum values of 0.20 and 817.85 naira, respectively. In the same vein, the mean government subsidy to manufacturing sector (GOVS) in the period under study was 105.53 billion naira, with a median value of 12.25 billion naira, a standard deviation of 152.80 billion naira and the maximum and minimum production were 488.49 billion and 0.00 billion naira,

respectively. The mean index of manufacturing price (PO) over the period of study was 81.36, with a median value of about 37.71 and a standard deviation of 102.99 while the maximum value of the index was 412.95 and the minimum value was 0.48.

Similarly, in Table 1, General public capital for Nigeria over the studied period had a mean value of 43,996.91 billion naira, a median value of 19,258.76 billion naira, and a standard deviation of 50,178.94 billion naira with the minimum and maximum values of 658.68 and 212,750.6 billion naira, respectively. The mean real interest rate in Nigeria in the period under study was 0.36 percent, with a median value of 3.67 percent, a standard deviation of 14.10 percents and the maximum and minimum production were 18.18 percent and -65.86 percent, respectively. Finally, index of real effective exchange rate has a mean value of 147.16, with a median value of 101.04 and 114.37, the minimum and maximum index for real effective exchange rate in the period were 49.78 and 536.91, respectively. The last column of Table 1 records the coefficients of variation (coeff. of var.) for each variable of the study. The co-efficient of variation (CV) is a statistical measure of the relative dispersion of data points in a data series around the mean. In Table 1, the variables with the highest volatility, in descending order, were RINT, DP, GOVS, PO, PSCS, REXCR and MS with 39.17, 1.85, 1.45, 1.27, 1.14, 0.78 and 0.32 coefficients of variation respectively.

4.2 Unit root and co-integration tests results

This section is on the results of preliminary tests to ensure the validity of the outcome of the regression analysis. It is made up of two parts. Part one is on the unit root test result while part two is on the result of the co-integration test. The result of the unit root test conducted on the variables using the Augmented Dickey-Fuller (ADF) is presented and discussed. Table 2 reports the summary of the unit root test result for the variables of the study.

Table 2: ADF Unit Root Test

Variable	Level		First Difference		Overall Conclusion on the Order of Integration
	Statistic	P-value	Statistic	P-value	
lnMS	-1.53	0.69	-4.75	0.00	I(1) Series
lnDP	-0.46	0.89	-4.31	0.00	I(1) Series
lnGOVS	1.45	0.99	-5.84	0.00	I(1) Series
lnP^O	-1.93	0.32	-2.86	0.04	I(1) Series
lnPSCS	-1.37	0.59	-3.62	0.03	I(1) Series
lnRINT	-4.69	0.00			I(0) Series
lnREXCR	-2.99	0.04			I(0) Series

Source: Author's Computation, 2025.

Explanatory note: MS = Aggregate Manufacturing Output, PO = Own Price, DP = Diesel Price, GOVS = Government Subsidy to Manufacturing, PSCS = Public Sector Capital Stock, RINT = Real Interest Rate, REXCR = Real Effective Exchange Rate Index, CMS = Credit to Manufacturing Sector, A P-value of 0.05 and above is taken to mean that variable has unit root and is, thus, not stationary. The prefix "ln" indicates that the variables are in their natural logarithm.

From Table 2, and based on the aforementioned decision rule, the results show that both RINT and REXCR are stationary at the chosen 5% significance level, while all other variables featuring in the table are stationary only at the first difference. Similarly, the tests reveal that all the variables that are not stationary at level become stationary after first differencing judging from their respective test statistics' p-values that are now less than 0.05. From the above, it is thus concluded that the model has variables that have unit roots and others (RINT and REXCR) that are stationery, i. e. the variables featuring in each model are a combination of both I(0) and I(1) series. The implication of this for co-integration is that the Johansen co-integration procedure is not applicable in this case and, therefore, the study has to resort to the

Autoregressive Distributed Lag (ARDL) Bounds co-integration test approach, the outcome of which is presented and discussed below.

4.3 Co-integration test

The Autoregressive Distributed Lag (ARDL) Bounds test co-integration approach is necessitated by the nature of the variables of the study, which in this case, are, a combination of I(0) and I(1) series, with the dependent variable being I(1). The results of the Autoregressive Distributed Lag Bounds co-integration test for the model of the study is presented here. The null hypothesis under the ARDL Bounds test methodology is that there is no co-integration or long-term relationship between each dependent variable and its explanatory variables. The computed F test statistic is to be compared with the upper and lower critical values of the Bound test series (viz; I0 and I1, respectively) at the chosen significance level, which is 0.05 in the present study. The null hypothesis that there is no co-integration is to be rejected if the F-statistic is higher than the upper bound critical value. On the other hand, the null hypothesis of no co-integration is to be accepted if the computed F test statistic is less than the lower critical value, while the existence of co-integration is inconclusive if the computed F statistic lies between the lower and upper bound critical values. The model using this approach is encapsulated in Equation (3)

$$\Delta lnMS_t = \infty_0 + \sum_0^k \infty_{1_i} \Delta lnMS_{t-1} + \sum_1^k \infty_{2_i} \Delta lnPO_{t-1} + \sum_0^k \infty_{3_i} \Delta lnDP_{t-1} +$$

$$\sum_0^k \infty_{4_i} \Delta lnREXCR_{t-1} + \sum_1^k \infty_{5_i} \Delta lnRINT_{t-1} + \sum_1^k \infty_{6_i} \Delta lnGOVS_{t-1} \sum_1^k \infty_{7_i} \Delta lnPSCS_{t-1} +$$

$$\psi_1 ECT_{t-1} + \mu_t \qquad\qquad (3)$$

In the first case, whereby co-integration is found to exist, both the long-run and short-run estimates of the equation are applicable. In the other two cases, whereby co-integration is confirmed to be absent or the co-integration test is inconclusive, only the short-run estimates are applicable. Regarding the decision rule, a model is adjudged to be co-integrated if the F-statistic is greater than I1 (upper bound critical value) at 5% significance level while a model is adjusted not to be co-integrated if the F-statistic is less than Io (lower bound critical value) at 5% significance level. The test is inconclusive if the F-statistic falls between the lower and upper bounds.

Table 3: ARDL Bound Test Results

Dependent Variable	F-Statistics	5% Significance Level		Remark
		Lower Bound I₀	Upper Bound I₁	
lnMS	4.81	2.04	3.24	Co-integrated

Source: Authors' Computation, 2025

Explanatory note: MS = Aggregate Manufacturing Output, If F-statistic > I1, the null hypothesis of no co-integration is rejected and the conclusion is that both the dependent and independent variables share a long-run relationship. If the F-statistic < I0, the null hypothesis of no co-integration is accepted and the conclusion is that both the dependent and independent variables share no long-run relationship while the result is inconclusive if F statistic I1 < F > I0. The number of observation is 38. The prefix "ln" indicates that the variables are in their natural logarithm.

As can be seen from Table 3, the computed F-statistics for the regression model (lnMS) being 4.81 is greater than the upper critical bound of 3.24, so that it is concluded that the dependent variable in model shared a long-run relationship with its explanatory variables (i.e. they are co-integrated). Therefore, both the short-run and long-run ARDL estimates are applicable.

4.4 Results of the regression analysis

In this section the ARDL estimates of the model is as presented in Table 4. A coefficient is considered to be statistically significant if the p-value of its computed test statistic is less than or equal to 10% critical significance level. For the sake of brevity, only the long-run estimates are reported in the table. The variables are in their logarithm form and, hence, they are to be regarded and interpreted as elasticities of supply.

Table 4: Results of the Long-Run ARDL Regression

Variable	Coeff	Std-Error	T-Statistic	P-Value
$\ln P^O$	0.711	0.368	1.933	0.062
$\ln DP$	-0.27	0.253	-2.075	0.029
$\ln RINT$	0.004	0.005	0.712	0.482
$\ln ECXCR$	-0.014	0.12	-0.113	0.911
$\ln GOVS$	0.002	0.001	2.221	0.034
$\ln PSCS$	1.135	0.101	11.252	0
$ECT_{(t-1)}$	-0.304	0.13	-2.33	0.021
Jarque-Bera Test for Residual Normality	0.099			0.953
Breusch-Pagan-Godfrey test for Autocorrelation (Chi-Squared)	0.357			0.703
The Breusch-Pagan for Heteroscedasticity (Chi-Squared)	1.073			0.404
R-Squared	0.872			
F-Statistics	12.39			0

Source: Authors' Computation, 2025

Explanatory note: MS = Aggregate Manufacturing Output, PO = Own Price, DP = Diesel Price, GOVS = Government Subsidy to Manufacturing, PSCS = Public Sector Capital Stock, RINT = Real Interest Rate, REXCR = Real Effective Exchange Rate Index. A p-value below 0.05 signifies that the estimate is significant.

Prior to going into further detail, the ARDL model is thoroughly evaluated using diagnostic tests, namely the CUSUM test for stability, the Breusch-Godfrey LM test for autocorrelation, the Jarque-Berra test for residuals normality, and the Breusch Pagan-Godfrey test for heteroskedaticity

In Table 4, the estimated JB test statistics for the model is 0.099, with a corresponding p-value of 0.953 which implies that the JB test statistics is not statistically significant as such the model is not bedevilled with the problem of non-normality in the distribution of its residuals. As regards the autocorrelation test, the Breusch-Pagan-Godfrey test is used to examine whether an autocorrelation issue exists in the study. As shown in Table 4, the estimated Breusch-Pagan-Godfrey test statistic for the model is 0.357 with a corresponding p-value of 0.703, which implies that the test statistic is statistically insignificant, and thus the conclusion is therefore that the model does not suffer from the problem of serial correlation among error terms. The Breusch-Pagan LM test is also used to determine whether the heteroscedasticity problem exists. Also in Table 4, the estimated F-statistics of the Breusch-Godfrey LM test for Heteroskedasticity for the model is 1.073, with a corresponding p-value of 0.404, which implies that the test statistic is not statistically significant and therefore the regression model does suffer from the problem. Finally, the model's stability was tested using the recursive test. The model is stable if the recursive (CUSUM) graph demonstrates that the model line is situated between the two 5%-significance level lines. If otherwise, the model is not. The

regression estimate, as shown below, is within the CUSUM bounds, which means that the regression estimates are stable over the study period. This is shown in Figure I below.

The performance of each explanatory variable in the estimated model reported in Table 4 is discussed below as follows.

The coefficient of ECT_{t-1} captures the speed of adjustment of short-run disequilibrium towards long-run equilibrium, and it is required that the coefficient must be negative, less than unity in absolute value and statistically significant for there to be short-run adjustment towards long-run equilibrium. It is found that these requirements are fully met in model estimate. This is because the coefficients of the ECT_{t-1} in Table 4 is -0.304, with p-value of 0.021. This means 30% of the disequilibrium in the shortrun model are adjusted each period to produce a long-run equilibrium.

Own price (PO) has a coefficient of 0.711 and a P-value of 0.062. This implies that at the 5% significance level, the effect of own-price is not significant on manufacturing production in Nigeria, however, when compared, at a 10% significance level, own price exert a significant effect on manufacturing supply in Nigeria. Similarly, the coefficients of index of real effective exchange (REXCR) and real interest rate (RINT) are -0.014 and 0.004 respectively, with P-values of 0.911 and 0.482. This result shows that, at the 5% significance level, both REXCR and RINT do not have an effect on manufacturing sector production in Nigeria.

On the other hand, the results in Table 4 show that government subsidy to the manufacturing sector (GOVS) as a negative cost, diesel price (DP) and government general capital stock (PSCS) have coefficients of 0.002, -0.271 and 1.135 respectively, with P-values of 0.034, 0.029 and 0.00. These mean that GOVS, DP and PSCS have effects on manufacturing sector production in Nigeria. While the effects of GOVS and PSCS are both positive, DP on the other hand, has a negative effect on manufacturing production in Nigeria. In terms of elasticity of supply, the results show that the supply of manufacturing output with respect to public capital stock (PSCS) is elastic because the coefficient of PSCS is greater than unity in absolute value in the model. On the other hand, the supply elasticity of manufacturing output with respect to government subsidies to the manufacturing sector (GOVS) and diesel prices (DP) is inelastic because the coefficients of GOVS and DP in the regression estimate are both less than unity in absolute terms.

5.   Conclusion and recommendations

In this study, the effects of cost of production on manufacturing output in Nigeria were examined for the period from 1981 to 2022 using the theory of supply as the theoretical framework and the ARDL regression approach. The dependent variable, aggregate manufacturing output, was regressed on a number of cost of production variables, which include real effective exchange rate appreciation (REXCR), real interest rate (RINT), diesel price in constant naira (DP) and government subsidy to manufacturing (GOVS) as a negative cost. The control variables employed are own price (PO) and public sector capital stock (PSCS). The data on the variables of the study were sourced from the CBN's Annual Statistical Bulletin, the World Bank's World Development Indicators database and the IMF's Public Investment and Capital Stock Database.

The findings derived from the ARDL long-run estimates showed that while government subsidies to the manufacturing sector (GOVS) and public sector capital stock (PSCS) have positive effects on manufacturing production in Nigeria, diesel prices (DP) has a negative effect on manufacturing production in Nigeria. The effects of each of the real interest rate (RINT), real effective exchange rate (REXCR) and manufacturing own price (PO) were not significant on manufacturing production in Nigeria.

It is therefore recommended that policymakers in Nigeria in a bid to improve the manufacturing sector's performance, should pay key interest on GOVS, PSCS and DP. In particular, more subsidies should be issued to the manufacturing sector, as this helps alleviate the effect of the growing cost of production in the sector and improve the sector's performance. Similarly, investment in public capital in the form of

infrastructural facilities (i.e., road, rail line development, electricity, provision of potable water systems, improved health facilities, etc.) by the federal and state governments in Nigeria is encouraged as this will facilitate improved manufacturing activities. Finally, being that diesel prices has negative effect on manufacturing production, it is recommended that the authorities place key interest in the monitoring of diesel price changes to curtail excessive diesel price increments.

Acknowledgements

The authors would like to acknowledge the support of the lecturers of the Department of Economics and Development Studies, Kwara State University, Malete.

Conflict of interest statement

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

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Appendix

A. CUSUM test for stability
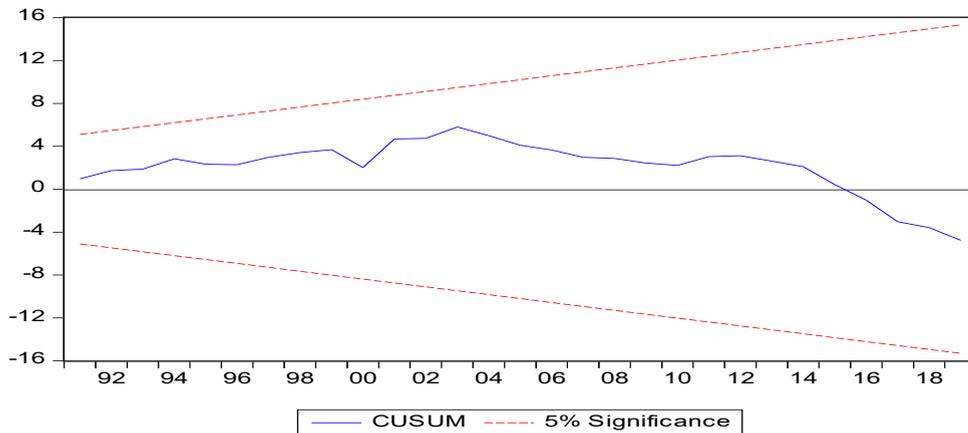
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Authors' contributions

The conceptualization of the research together with data collection, and other resources were handled by Hamdalat Toluwalase Aremu, the investigation, methodology, software acquisition and formal analysis was done by Abdulmalik Tope Sheriff while, project administration, supervision, validation, visualisation, writing and editing were done by Ridwan Olamilekan Dauda.