

## RESEARCH ARTICLE

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## Analysis of demand and supply of industrial vessels for upstream oil and gas operations in Nigeria

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### Abstract

This study investigated demand of offshore Supply Vessels (OSVs) by midstream Oil and Gas (O&G) operators in Nigeria. The specific objective of the study was among other things, to estimate the coefficient of elasticity of offshore industrial vessel demand and supply in Nigeria upstream O&G sector relative to variations in crude oil production capacity in Nigeria's oil fields, number of operational oil wells, vessel spot market rates and per barrel oil prices. Data on OSV demand and supply, crude oil prices, oil production levels and operational oil wells were obtained from the Department of Petroleum Resources. The log-log constant elasticity model was used to analyze the data obtained. It was found that, a 1% increase in number of operational oil-wells (Wc) led to a 0.22% increase in the demand for industrial vessels for offshore O&G operations in Nigeria while a 1% increase in industrial vessel charter rates led to a 0.356% decrease in demand for industrial vessels in the offshore O&G sector in Nigeria. For each 1% increase in crude oil prices, demand for industrial vessels to service the transportation need of the Nigerian O&G sector increased by 0.477%. Recommendations were proffered on the basis of the research findings.

**Keywords:** Offshore-sector, Industrial-vessels, Demand.

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### 1. INTRODUCTION

Logistics support services are crucial operational elements in the lifecycle of upstream oilfields needed to guarantee the efficient and effective performance of the components elements of the oilfield, to ensure sustainable offshore operations from technical and economic standpoint. Offshore logistics operations which involve the procurement and supply on demand, of varied services, goods, works and products, required for offshore oil field operations; is a significant component of the oil and gas (O&G) sector logistics system. Studies by references [1] and [2] note that a sustainable O&G sector logistics system must meet the:

- (i) *Efficiency*: this involves the optimization of products and service delivery costs, and
- (ii) *Robustness*: This connotes the development of capacity for the maximization of outputs, elimination of delay in service and product delivery to and/or from upstream oil fields.

The procurement and supply of services, materials and products to upstream oil fields is usually implemented or achieved by the use of industrial supply vessels (OSVs), operated between the onshore Supply Base (OSB) and the location of the upstream oil field. The offshore O&G operators, which are the company responsible for O&G exploration and drilling operations, make demand for industrial vessels (OSVs) from ship owners and charterers, who in turn supply the needed tonnages as agreed in the preferred charter party [3]. The conditions of demand and terms of supply of OSVs for oil field operations in Nigeria are not completely different from global best practices but are influenced by the peculiar conditions and factors of Nigeria local oil field operations such as extent of production and oil well counts, prevailing OSV spot market charter rates, security and safety conditions, etc.

Reference [1] and [4] established that the

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offshore O&G sector over the years employ the use of varied industrial vessels types ranging Anchor Handling Tug and Supply (AHTS), Anchor Handling Tug (AHT), Line Handling Tug (LHT), Platform Supply Vessels (PSV), Dive Support Vessels (DSV), Fast Supply Intervention Vessels (FSIV), Crew Boats (CB), Security Escort Vessels (SEV) etc., the demand of the industrial vessel types by O&G sector and the supply is influenced by the same factors, such as the output of oil and gas resources (production level) and oil well counts operational at each point in time. For example, Reference [2] rated the predictability of demand for AHV, OSV and Crew boat industrial vessels types for upstream exploration and oil field development operations as low while their use for upstream production operations is high. The study also asserted that the rate of abandonment of AHV and Crew boats used for upstream O&G operations is low.

In a related study, reference [5] observed that factors such as crude production capacity of an oil field, spot market rates of industrial vessels, number of operational oil wells and oil filed in a region, level of development of oil field (initial exploration stage, development stage, crude production stage, etc.), global per barrel prices of crude oil, among other factors tend to influence the demand and supply of offshore industrial vessel types in a given region. The study however didn't investigate the extent of influence and directions of influence of each factor on the demand and supply of industrial vessels for servicing the logistics needs of the offshore O&G sector [5; 6 and 7].

Nigeria is oil rich Country with the most significant operational offshore oil and gas fields and upstream oil reserve in the West and sub-Saharan African region. The development of Nigerian oil fields and oil and gas sector with regards to ensuring optimality in the satisfying the logistics needs of the sector needs empirically based knowledge [6;8]. For example, obviously in line with the findings of reference [2], the demand and supply of industrial vessels for the logistics needs of the offshore O&G sector in Nigeria is similarly influenced by factors such as crude production capacity of the operational oil fields, spot market rates of industrial vessels, number of operational oil wells and oil filed in Nigeria, level of development of oil the fields, global per barrel prices of crude oil, among other factors. However, available literatures seem to have failed to provide acceptable knowledge and information of the extent and direction of the influences of these factors on the extent of supply demand cum supply of industrial vessels for servicing the logistics needs of the upstream O&G sector in Nigeria based on empirical evidence.

The aforementioned knowledge and information is necessary for the development of a knowledge based offshore oil and gas logistics economy in Nigeria. This

is because, the information is crucial to the major stakeholders in the upstream O&G sector in decisions related to oil and gas logistics. The upstream O&G operators (oil multinationals) in Nigeria, ship-owners (industrial vessels owners) interested in the Nigeria market, as well as ship brokers operating the region need the aforementioned empirically based knowledge for industrial vessel broking and chartering decisions in the Nigerian offshore O&G logistics sector.

This study is therefore conceived with the aim of investigating the significances, extents and directions of effects of crude oil production capacity in Nigeria's oil fields, number of operational oil wells, spot market charter rates of industrial vessels, and per barrel prices of crude oil on the demand and supply of industrial vessels in Nigeria offshore O&G logistics sector over the years.

The study objectives include:

(i) To determine the extent of effects of crude oil production capacity in Nigeria's oil fields, number of operational oil wells, spot market charter rates of industrial vessels, and per barrel prices of crude oil on the demand for industrial vessels by offshore O&G operators in Nigeria.

(ii) To estimate the coefficients of elasticity of Shipping tonnage (GRT) supplied to offshore O&G operators following variations in crude oil production capacity in Nigeria's oil fields, number of operational oil wells, spot market charter rates of industrial vessels, and per barrel prices of crude oil over the years.

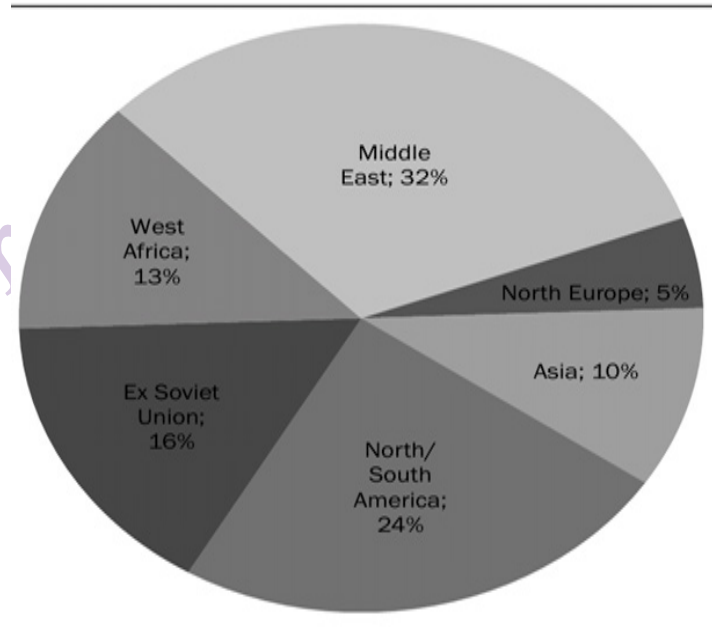
## 2.0 Literature Review

Studies by references [9] and [10] analyzed the demand for and supply of industrial vessel types operational in the global O&G logistics sector. The study was aimed at determining the Gross Registered Tonnage (GRT) and number of fleet size by type of vessel involved in the global offshore O&G logistics sector. The findings of the study reveal the dominance of AHTS and PSV industrial vessels types in the operational fleet demanded by the offshore O&G sector [9]. The study however did not proceed to determine the dominant factors that influence the preference the preference of the AHTS and PSV industrial vessel types over the period. The extent and significances of the effects of factors such as oil production capacity, oil well counts and spot markets rates of industrial vessels on the demand and supply of shipping tonnage to the global O&G sector operators were also not examined.

Studies by reference [1] analyzed the demand and supply of offshore industrial vessels by the O&G logistics sector relative the crude oil production capacity of most oil region regions in the World, including West African

Offshore O&G sector. Reference [1] note the importance of the West Africa O&G sector in the oil market with the region having a significant share of above 13% of global daily crude oil output. The study observed that as at 2018, the per barrel prices of oil was an equivalent of 159 liters, is around \$110, spot market rate for industrial vessels equally seem to take an upward trend relative to the increasing per barrel price. The daily global output of crude oil as at 2018 on the other hand was around 73,000,000 barrels with the West Africa offshore oil and gas sector accounting for about 9,000,000 of the output

[1]. Relative to the daily oil production capacity of the West African offshore O&G, the region was responsible for engaging about 12% of the world industrial vessel fleet for purposes of satisfying the logistics needs of the offshore O&G industry. These percentages confirm the level of importance of the West African O&G markets. Other global offshore oil and gas production locations that show matching levels of production in comparison to the world industrial fleet demand and utilization are shown in figure-1 below.



**Figure1 - Daily crude oil productions global locations**

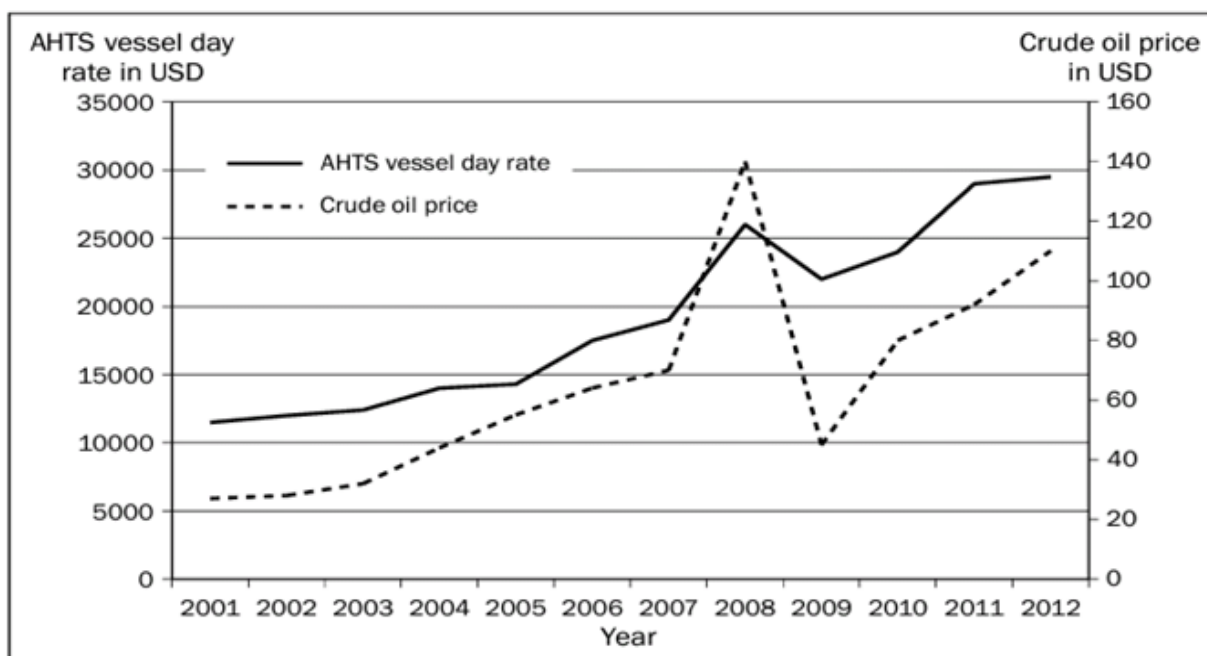
**Source:** Adapted from Reference [1]

The offshore industrial vessels market seems to mirrors the trends in crude oil exploration and production market, but it does not seem to draw comparison to trend and directions of per barrel oil prices. However, studies by reference [11] evaluated the relationship between crude oil price trends and charter rates for determinant offshore industrial vessel types such as AHTS. The study found that the existence of positive correlation between AHTS industrial vessel types for example and the directions of crude oil prices in the global market [11] and [12]. Figure-2 below provide evidence of the trend of daily charter rates for offshore industrial vessels and the trend of crude oil prices between 2001 and 2012; depicting the changes in the AHTS daily relative to changes in crude oil prices over the period.

The study observed that there occurred decline in daily charter rate of offshore AHTS industrial vessel type starting from the year 2009, following a significant decline in per barrel crude oil prices with the same period. Similarly, the period between 2010 and 2011 marked a period of dissatisfaction for majority of offshore supply vessel owners and charter brokers

following the continued decline in daily charter rates associated with declining trend in per barrel crude oil price in the O&G sector [11; 12; 13]. Most times, daily rates for most industrial vessel types were fixed below the breakeven point by the ship-owners to mitigate and/or avoid losses. This provides empirical support to the views of references [2] and [1 and 14], that there exist a positive correlation between the demand and supply of offshore industrial vessels and the trend of crude oil prices in the global O&G market.

Even though it is postulated in available literature that the trend in global oil prices, crude oil production level/output as well as counts of existing operational offshore oil wells have influences on the demand and supply of shipping tonnages to the offshore O&G sector; there exist knowledge gaps that available empirical studies have not addressed [15;16;17;18]. For example, the extents and significances of the joint and individual effects of crude oil production levels(output), counts of operational offshore oil wells and trend of global market crude oil prices on the demand for offshore industrial vessels has not been provided in available empirical literatures.



**Figure-2: relationship between oil prices and AHTS vessel daily charter rates 2001-2012**

Source: Chart Shipping S.L. Shipbrokers, Barcelona.

The influence of oil production outputs, industrial vessel charter rates, operational oil well counts and per barrel crude oil prices on the Gross Registered tonnage/shipping tonnage (GRT) supplied by ship-owners to the offshore O&G sector in Nigeria has also not been estimated before this time, in available empirical literature. As a result, an empirical knowledge of the elasticity of demand and supply of shipping services and shipping tonnage to O&G sector in Nigeria relative to variations in crude oil production levels, operational offshore oil well counts, crude oil prices and industrial vessel charter rates is lacking. The above knowledge gaps constitute the major motivations for this study and which it seeks solution to.

### 3.0 Data and Methods

The data obtained was analyzed using the log-log elasticity model corresponding to a multiple regression model in case in which, there is more than one (multiple) independent variable. It estimated the coefficient of elasticity of demand for offshore industrial vessels and the supply of shipping tonnages in GRT to the offshore O&G operators in the Nigerian maritime industry relative to the number of operational oil wells, oil production levels, industrial vessel rates and per barrel prices of crude oil. Data on OSV demand and supply of shipping tonnage, crude oil prices, oil production levels and operational oil wells were obtained from the Department of Petroleum Resources (DPR). Each dataset covered a period of 7 years from 2012 to 2018.

For purposes of determining the elasticity of the relationships, the log-log elasticity model in which the natural log of both sides of the equation is taken. In this case, the coefficients of regression become elasticity coefficients. We define the coefficient of elasticity mathematically as the ratio of percentage changes in for offshore industrial demand to percentage changes in operational oil wells, crude oil production, and industrial vessel charter rate and per barrel prices of crude oil. The coefficients of elasticity of supply of shipping capacity in GRT to offshore operators relative to changes in operational oil wells, crude oil production, industrial vessel charter rate and per barrel prices of crude oil was also estimated.

The model specification for the double-Log-linear (constant elasticity) is shown below:

$$\text{LogVDMD} = \beta_0 + \beta_1 \text{Log}W_c + \beta_2 \text{Log}C_{\text{rate}} + \beta_3 \text{Log}QTY_b + \beta_4 \text{Log}PR_{ba} \tag{3.2}$$

$$\text{LogGRT} = \beta_0 + \beta_1 \text{Log}W_c + \beta_2 \text{Log}C_{\text{rate}} + \beta_3 \text{Log}QTY_b + \beta_4 \text{Log}PR_{ba} \tag{3.3}$$

In the above double-log models, both coefficients of regression  $\beta_1$  and  $\beta_2$  -----  $\beta_4$  estimate the elasticity of industrial vessel demand and supply relative to changes in NUMBER OF operational oil wells, oil production level, industrial vessel average charter rate, and per barrel prices.

Where:

VDMD = demand for industrial vessels by operators

GRT = supply of shipping tonnage.in Gross Registered tonnage (GRT)

$W_c$  = Operational oil well counts

$C_{rate}$  = average industrial vessel charter/spot rate

QTY = extent of oil production/output

$\beta_1, \beta_2, \beta_3, \beta_4$  = coefficientS of regression = elasticity coefficients [18].

$\beta_0$  = Regression constant

Also note that, when the coefficient of elasticity is less than 1, the response is said to be inelastic. When it is greater than 1, it is said to be elastic; and when it is equal to 1, it is unit elastic. For example:

If  $\beta_1 < |1| \rightarrow$  inelastic response

If  $\beta_1 > |1| \rightarrow$  elastic

If  $\beta_1 = |1| \rightarrow$  unit elastic

The study used the methods described above to actualize the objectives of the study.

Table1 above shows that the descriptive statistics of data collected for the study indicating the demand of industrial vessels, the supply of shipping tonnage (Gross Registered Tonnage GRT) of industrial vessels supplied, the average industrial vessel charter rate, the average number of operational oil wells ( $W_c$ ), the barrels of crude oil produced by operators and crude oil prices per barrel over the period covered in the study. The result indicates that the average number of industrial vessels demanded by offshore oil and Gas (O&G) operators over the period covered in the study 1638.71 vessels per annum with stand deviation of 339.54 while an average of 532471.00 GRT was supplied to the operators over the same period.

The result also indicates that the average charter rate per day for the industrial vessels relative the quantity supplied is 9547.57USD per annum with standard deviation of 4247.82 when the average crude oil price per barrel over the period is 73.70USD

**4.0 Results and Discussion**

**Table-1: Descriptive Statistics of OSV Demand and Supply of Shipping Tonnage, Oil Production levels, OSV Charter rate and Per Barrel Prices of Crude Oil**

	N	Range	Minimum	Maximum	Sum
VDmd	7	948.00	1224.00	2172.00	11471.00
GRTa	7	532471.00	336450.00	868921.00	4377829.00
Wc	7	109.00	72.00	181.00	1049.00
Crat	7	11000.00	5000.00	16000.00	66833.00
QTYb	7	341278190.00	519000000.00	860278190.00	4854744645.00
PRba	7	69.67	44.82	114.49	515.93
Valid N (listwise)	7				
Descriptive Statistics					
	Mean		Std. Deviation		
VDmd	1638.7143		339.54073		
GRTa	625404.1429		195757.70441		
Wc	149.8571		48.40258		
Crat	9547.5714		4247.82391		
QTYb	693534949.2857		125608303.84377		
PRba	73.7043		28.13919		
Valid N (listwise)					

Source: Author’s calculation

per annum with standard deviation of 28.14. The offshore O&G operators produced an average of 693534949.29barrels per annum with standard deviation of 1256083030.84. The trend of demand for industrial vessels in offshore O&G sector in Nigeria is depicted by the figure3 below

Table2 below provides empirical evidence of the relationship between offshore industrial vessel demand and the charter rate, crude oil prices per barrel,

quantity of crude oil resources produced and oil well counts ( $W_c$ ) in Nigeria over the period covered in the study. The coefficient of correlation which measures the degree of correlation between the demand for industrial vessels in Nigerian offshore O&G sector and the vessel charter rates, oil well count, crude oil prices and quantity of crude oil produced by operators over the period is 0.99. This indicates the existence of about 99% positive correlation between demands

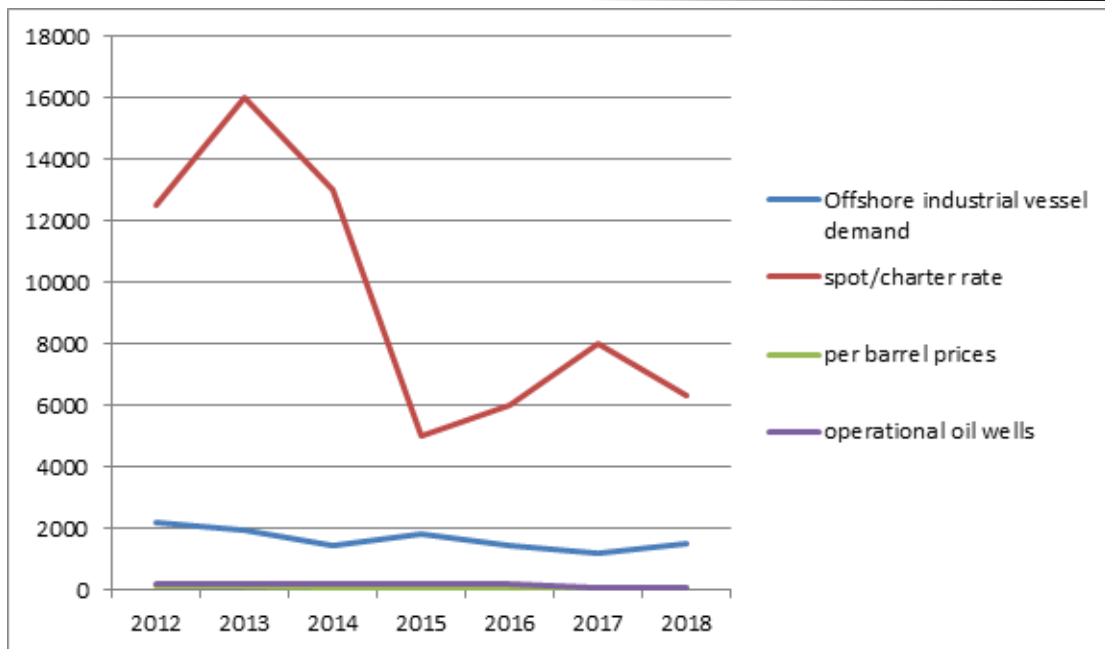


Figure-3: Line graph depicting the trend of industrial vessel demand and supply, spot/charter rates, per barrel prices and Operational oil well counts between 2012 and 2018.

Source: Prepared by the Author

Table2: Coefficient of Elasticity of Demand for Industrial Vessels Relative to Variations in Oil Production levels, Average OSV Charter rate and Per Barrel Prices of Crude Oil and Operational Oil Wells in Nigeria Offshore O&G Sector

	Mean	Std. Deviation	N			
LogVsu	7.3836	.20413	7			
LogWc	4.9500	.39968	7			
LogCrate	9.0777	.45023	7			
LogQTYb	20.3428	.18514	7			
LogPRba	4.2426	.35834	7			
Model Summary <sup>b</sup>						
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	
1	.991a	.982	.945	.04792	2.117	
ANOVA <sup>a</sup>						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.245	4	.061	26.713	.036b
	Residual	.005	2	.002		
	Total	.250	6			
Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-5.589	2.728		-2.049	.177
	LogWc	.220	.058	.431	3.796	.036
	LogCrate	-.356	.084	-.786	-4.226	.042
	LogQTYb	.644	.147	.584	4.374	.048
	LogPRba	.477	.109	.837	4.358	.049

Source: Author's calculation

for industrial vessels in the offshore O&G sector, the vessel charter rates, oil-well counts, crude oil prices and quantity of crude oil produced by operators.

The relationship between the demand for industrial vessels in the offshore O&G sector in Nigeria and the explanatory variables of vessel charter rates, oil-well count, crude oil prices and quantity of crude oil produced by operators is as shown below:

$$\text{LogVDMD} = -5.589 + 0.220\text{Log}W_c - 0.356\text{Log}C_{\text{rate}} + 0.644\text{Log}QTY_b + 0.477\text{Log}PR_{ba} \quad (3.4)$$

The implication is that a 1% increase in number of operational oil-wells ( $W_c$ ) led to a 0.22% increase in the demand for industrial vessels for offshore O&G operations in Nigeria while a 1% increase in industrial vessel charter rates led to a 0.356% decrease in demand for industrial vessels in the offshore O&G sector in Nigeria. Similarly, a 1% increase in the quantity of crude oil produced by operators led to 0.644% increase in demand for offshore industrial vessel supply in the Nigerian O&G sector. For each 1% increase in crude oil prices, demand for industrial vessels to service the transportation need of the Nigerian O&G sector increased by 0.477%.

This implies that the demand for industrial vessels by offshore O&G operators in Nigeria increase in the same direction with increase crude oil prices, crude oil output/production and oil-well count while it decreases with increase in spot/charter rates of industrial vessels. This corroborates the findings of reference [6] that increasing transportation cost leads to decreasing trend in demand for transportation. The result provides empirical evidences for operators in the development of policies to guide industrial vessel chartering decisions in the offshore O&G sector in Nigeria.

The  $r^2$  which measures the explanatory power of the model is 0.982. This implies that the quantity of crude oil and gas resources produced charter rates of industrial vessels, crude oil prices and number of operational oil wells explains about 98% of variations in the demand for industrial vessels in the offshore O&G sector in Nigeria.

The t-test of significance of the effects of the explanatory variables shows an f-score of 26.71, p-value of 0.036 and alpha value of 0.05. Thus we conclude that there are significant effects of the explanatory variables on the demand for industrial vessels in Nigerian offshore O&G sector.

An investigation into the significance effects of the individual variables also shows t-score of 3.796, 4.226, 4.374 and 4.357 respectively for number of operational offshore oil well ( $W_c$ ), charter rate of industrial vessels,

quantity of crude oil produced and per barrel price respectively with respective p-value of 0.036, 0.042, 0.048 and 0.049. Since the respective p-values are each less than the alpha value of 0.05, we conclude that each of the explanatory variable which include the number of productive oil wells, the charter rate of offshore industrial vessels, the quantity of crude oil produced and the per barrel prices has significant effects on the demand for industrial vessels by offshore O&G sector operators in Nigeria. However, the directions of the magnitude of the effects of the explanatory variables on the demand for offshore industrial vessels in Nigeria vary, as earlier discussed.

The have implications of the operations of industrial vessels owners and brokers in Nigeria. This is because, in line with the findings of the study, the extent of business performance of industrial vessel owners and brokers in Nigeria is significantly influenced by the demand for industrial vessels by offshore O&G operators in Nigeria. This is subsequently influenced by the number of operational oil wells, charter rate of industrial vessels, quantity of crude oil and gas resources produced from the wells and per barrel prices of crude oil prevailing in the market. Offshore O&G operators, industrial vessel owners and ship broker need to have adequate knowledge and understanding of this empirical relationship, in order to improve the performances and profitability. Table 4.2 below examines the GRT of vessels supplied to the offshore O&G operators in Nigeria over the period covered in the study.

Table3 below provides empirical evidence of the relationship between the Gross Registered Tonnage (GRT) of offshore industrial vessel supply in Nigerian O&G sector and the charter/spot rate of industrial vessels, crude oil prices per barrel, quantity of crude oil resources produced and number of operational or productive oil wells in Nigeria over the period covered in the study. The coefficient of correlation which measures the degree of correlation between the GRT of industrial vessels supplied by ship-owners in the Nigerian offshore O&G sector and the vessel charter rates, oil well counts, per barrel crude oil prices and quantity of crude oil produced by operators over the period is 0.898. This indicates the existence of about 90% positive correlation between the GRT of industrial vessels supplied in the offshore O&G sector, the vessel charter rates, the number of operational oil wells, crude oil prices and quantity of crude oil produced by operators.

The relationship between the GRT of industrial vessels supplied to the offshore O&G sector in Nigeria and the industrial vessel charter rates, the counts of operational oil wells, per barrel crude oil prices and

**Table-3: Coefficient of Elasticity of Supply of Shipping Tonnage to Offshore O&G Sector Operators Relative to Variations in Oil Production levels, OSV Charter rate and Per Barrel Prices of Crude Oil and Operational Oil Wells in Nigeria**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson	
1	.898a	.807	.422	.25811	2.634	
ANOVA <sup>a</sup>						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.558	4	.139	7.094	.034b
	Residual	.133	2	.067		
	Total	.691	6			
Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.947	14.692		-.201	.860
	LogW <sub>c</sub>	.105	.313	.124	.336	.769
	LogC <sub>rate</sub>	-.971	.454	-1.288	-2.139	.016
	LogQTY <sub>b</sub>	.965	.792	.526	1.218	.347
	LogPR <sub>ba</sub>	1.158	.589	1.222	1.964	.019

a. Dependent Variable: LogGRT<sub>aggre</sub>

quantity of crude oil produced by operators is as shown below:

$$\text{LogGRT} = -2.947 + 0.105\text{LogW}_c - 0.971\text{LogC}_{\text{rate}} + 0.965\text{LogQTY}_b + 1.158\text{LogPR}_{ba} \quad (3.5)$$

The implication is that a 1% increase in number of operational oil wells in Nigeria oil fields led to a 0.105% increase in the GRT of industrial vessels supplied by ship operators to the offshore O&G operations in Nigeria while a 1% increase in industrial vessel charter rates led to a 0.971% decrease in the GRT of industrial vessels supplied to the offshore O&G sector in Nigeria. Similarly, a 1% increase in the quantity of crude oil produced by operators led to 0.0965% increase in the GRT of offshore industrial vessel supplied to meet the needs of the Nigerian upstream O&G sector. For each 1% increase in per barrel crude oil prices, the GRT of industrial vessels supplied to service the transportation need of the Nigerian O&G sector increased by 1.158%.

This implies that the supply of industrial vessels to the offshore O&G operators in Nigeria increase in the same direction with increase per barrel prices of crude oil, crude oil output/production and number of operational oil wells while it decreases with increase in spot/charter rates of industrial vessels. This corroborates the findings of reference [6] that increasing transportation cost leads to decreasing trend in demand

for transportation. The result provides empirical evidences for offshore O&G operators, industrial vessels owners and ship brokers in the development of policies to guide industrial vessel chartering decisions in the offshore O&G sector in Nigeria.

The R<sup>2</sup> which measures the explanatory power of the model is 0.807. This implies that the quantity of crude oil and gas resources produced, spot/charter rates of industrial vessels, crude oil prices and quantity of operational oil wells explain about 81% of variations in the supply of GRT of industrial vessels in the Nigerian offshore O&G sector.

The test of significance of the effects of the explanatory variables shows an f-score of 7.094, p-value of 0.034 and alpha value of 0.05. Thus we conclude that there is a significant effect of the explanatory variables on the GRT of industrial vessels supplied to the Nigerian offshore O&G sector over the years.

An investigation into the significance of the effects of the individual explanatory variables also shows t-score of 0.336, 2.139, 1.218 and 1.964 respectively for the number of operational offshore oil well, charter rate of industrial vessels, quantity of crude oil produced and per barrel price of crude oil with respective p-value of 0.769, 0.016, 0.347 and 0.019. The spot/charter rate of industrial vessels and per barrel prices of crude oil has respective p-values of 0.016 and 0.019 at alpha values of 0.05. This implies that each of spot/charter



rate for industrial vessels and per barrel crude oil prices had significant effect on the GRT of industrial vessels supplied by ship operators to the offshore O&G sector in Nigeria over the period covered in the study. Since the number of operational oil wells and quantity of crude oil produced has respective p-values which is each less than the alpha value of 0.05, it implies that each of quantity of crude oil produced and the number of operational oil wells has no significant effects on the GRT of industrial vessels supplied by ship owners to the offshore O&G sector operators in Nigeria. This finding corroborates the law of supply which posits that prices increases motivate suppliers to supply higher quantities of products.

However, the directions of the magnitude of the effects of the explanatory variables on the supply of industrial vessel GRT in Nigeria vary, as earlier discussed. It has implications of the operations of industrial vessels owners and brokers in Nigeria. This is because, in line with the findings of the study, the extent of business performance of industrial vessel owners and brokers in Nigeria is significantly influenced by the demand and supply of industrial vessels. This is subsequently influenced by the number of operational oil wells, spot/charter rate of industrial vessels, quantity of crude oil and gas resources produced from the wells and per barrel prices of crude oil prevailing in the market. Offshore O&G operators, industrial vessel owners and ship broker need to have adequate knowledge and understanding of these empirical relationships, in order to improve the performances and profitability of their businesses.

## 5.0 Conclusion

The study concludes in line with the objectives and findings of the research that for each 1% increase in number of operational oil wells in Nigeria's offshore O&G sector, the demand for industrial vessels by the sector increased by 0.22% while it decreased 0.356% for each 1% increase in industrial vessel spot/charter rates. Each 1% increase in the quantity of crude oil produced by operators led to 0.644% increase in demand for offshore industrial vessels in the Nigerian O&G sector while for each 1% increase in crude oil prices, the demand for industrial vessels to service the transportation need of the Nigerian O&G sector increased by 0.477%.

The quantity of crude oil and gas resources produced charter rates of industrial vessels, crude oil prices and number of operational oil wells in Nigeria upstream sector explains about 98% of variations in the demand for industrial vessels in the offshore O&G sector in Nigeria.

In a similar manner, each 1% increase in number

of operational oil wells in Nigeria oil fields led to a 0.105% increase in the GRT of industrial vessels supplied by ship operators to the offshore O&G operations in Nigeria while each 1% increase in industrial vessel charter rates led to a 0.971% decrease in the GRT of industrial vessels supplied to the offshore O&G sector in Nigeria. Each a 1% increase in the quantity of crude oil produced by operators led to 0.0965% increase in the GRT of offshore industrial vessel supplied to meet the needs of the Nigerian upstream O&G sector and each 1% increase in per barrel crude oil prices, the GRT of industrial vessels supplied to service the transportation need of the Nigerian O&G sector increased by 1.158%. The quantity of crude oil and gas resources produced, spot/charter rates of industrial vessels, crude oil prices and quantity of operational oil wells explain about 81% of variations in the supply of GRT of industrial vessels in the Nigerian offshore O&G sector. There is a significant effect of the explanatory variables on the GRT of industrial vessels supplied to the Nigerian offshore O&G sector over the years.

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