

# The Significance of Stock Management to Jet Fuel Supply using Partial Least Squares

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## ABSTRACT

Operational and commercial efficiency at a jet fuel depot are vital indices for a jet fuel marketer toward ensuring maximum business productivity. In Nigeria, jet A-1 aviation fuel scarcity is a yearly challenge that periodically triggers jet fuel price increase, air fare price hike and flight cancellation. The causes of the scarcity have been ascribed to the challenges facing jet fuel supply process. In this study, the significance of each of the seven jet fuel depots of a fuel marketer to the overall business performance is analysed using structural equation modelling to evaluate the historical sales and stock data. Historical stock data contain hidden patterns and knowledge that can be acquired and applied in operational decision making processes. The effect of each depot on business performance is classified using the significance and path coefficient result obtained from the partial least squares model implemented on historical stock data. The analysis reveals the significance of adequate stock level via supply chain management, and this creates an opportunity for directing management policies and decisions at less significant depots based on the data-mined knowledge acquired. An overall model  $R^2$  value of 0.902 was achieved. This study emphasises the relevance of quality data even in the aviation fuel industry.

**Keywords:** Business Performance Analysis, Supply Chain Management, Partial Least Squares, Fuel Scarcity, Jet A-1 Aviation Fuel, Data Pattern Recognition

**JEL Classifications:** C53, N77, O25, Q3

## 1. INTRODUCTION

The aviation sector offers economic benefits in diverse forms; it creates job opportunities for thousands of people and also enables fast transportation of cargo and people both within a nation, and across nations. This facilitates easy movement of skilled labour and cultural exchanges (Oxford-Economics, 2012). In Nigeria, air transportation used to be perceived as an elite mode of transportation due to the high cost of air travel as compared with road transportation. As the aviation industry grew with more operators and investments into the sector, the cost of air transportation reduced due to the competition and increased operational efficiency (Ayra et al., 2014). Currently, 22% of global carbon dioxide emission comes from transportation (Hombach et al., 2018) while about 10.6% of global greenhouse

gas generation is ascribed to air transportation (Gössling et al., 2017) and this portend a growing threat to the environment.

Domestic aircraft in Nigeria runs on civil grade jet A-1 fuel which must be free from contaminants to prevent fuel related flight risks (Adekitan et al., 2018; Adekitan, 2018; Lee, 2006), and also jet fuel must be properly handled to curtail the associated health risks (Carlton and Smith, 2000). Market fluctuations in the price of jet fuel is one of the major factors that determine the cost of flight ticket, as commercial airlines will adjust their ticket price based on their business cost and operational realities. Expenses on fuel constitute about 30% of an airlines direct operating cost (Ayra et al., 2014), and also jet fuel accounts for about 20% of an aircraft's weight (Adekitan, 2018), this makes jet fuel a vital operational component that must be adequately managed to maximise an airlines productivity and profitability.

The estimated population of Nigeria is 193,392,517 (NBS, 2016), and this creates a readily available supply of passengers for air travel. Though the patronage may be readily available, but the ability of the aviation sector to meet demand is often the major source of concern. The aviation industry in Nigeria has suffered many woes with a number of airlines, both local and international closing shop due to their inability to meet rising business challenges, and particularly in 2016 due to the economic recession, two indigenous airlines were declared insolvent and placed under receivership. The debt profile of most airlines fall majorly under aircraft maintenance, fuel expenses and labour related debts.

Aircraft maintenance cost is quite significant because of the mandatory, periodic aircraft maintenance requirement which unfortunately is carried out in foreign countries because of the lack of facilities to adequately deploy same in Nigeria; thereby costing airlines hard earned foreign currency, noting the fact that the official exchange rate of 1 United State Dollar (USD) is 360 Nigerian Naira. Jet fuel supply contract between an airline, and jet fuel depot operators is often a delicate arrangement due to the volatility of crude oil and jet fuel price (Asaleye et al., 2019; Gershon et al., 2019), and the desire of both parties to maximize profit. For most international airlines, a fixed contract arrangement is usually preferred, in which a fixed price of jet fuel is agreed via jet fuel hedging for the duration of the contract and the contract can only be renegotiated in extreme cases. This is usually feasibly due to the fact that the contracts are often in very stable currencies like USD or Euro. For most local airline operators, “pay as you buy” or “be billed as you buy but pay after some days (e.g. 30 days)” are the common contract arrangements due to fluctuations in the value of the Nigerian Naira on which the contracts are based. Foreign exchange fluctuation is a major cause of soaring prices of jet fuel in Nigeria, which has manifested in challenging operational realities for the airlines and customer frustration due to jet fuel scarcity and cancellation of flights (Onuah and Akwagyiram, 2016).

The airlines at 1 time accused jet fuel marketers of maximizing profits at the detriment of the airline operators because the price of jet fuel is not regulated by the Government and each licensed jet fuel marketing company is free to determine its selling price. Although, the validity of this allegation is debatable, but from the jet fuel marketers end, a number of prevailing economic and operational challenges exist that influences their selling price such as the high cost of importation, challenging importation logistics, depreciation of the naira, in-land transportation cost of jet fuel across states, fuel tax, high cost of imported spares and equipment and so forth. The availability of any product e.g. jet fuel at the demand node depends to a great extent on adequate supply chain management for timely and cost effective distribution (Barbosa-Póvoa et al., 2018; SteadieSeifi et al., 2014).

Evidence-based studies are vital for optimal operational business decisions. In this study, the operation of a jet fuel marketer running jet fuel depots in 7 different states in Nigeria is analysed to determine the contribution and the significance of each of the depots to the overall performance of the company using structural equation modelling (SEM) by analysing depot operational data on sales volume, opening stock, jet fuel losses

and daily product receipt over a period of 6 operational months. Running inefficient depots only increase operational cost which ultimately increases the selling price of jet fuel. By analysing jet fuel depot performance data, a jet fuel marketer will be equipped with relevant information to make quality decisions on the factors affecting depot performance such as the volumetric allocation to each depot and ultimately the profitability of each depot based on the importance of the depot to global corporate operational performance.

## 2. KEY BUSINESS PERFORMANCE INDEX OF A JET FUEL DEPOT

In the study by (Kazemi and Szmerkovsky, 2015), a model was developed for ensuring optimal distribution of downstream petroleum products in order to minimize operational and transportation cost by systematically programming the interface of distribution nodes and demand centres via appropriate transportation modes. This emphasizes the need to ensure operational and economic efficiency at each product depot in a petroleum product supply chain to ensure maximum productivity via tactical and strategic supply chain planning (Fernandes et al., 2014).

Jet fuel marketers have to manage a number of operational factors in order to minimize expenses which would ultimately be transmitted to the selling price of jet fuel. Most of the jet fuel marketers have airfield depots in major airports across the states in Nigeria. The sales volume and profitability of each depot vary depending on the operational costs, licensing fee at the airport, the cost of transporting jet fuel to the airfield depot from shore depots which are usually in another state, the number of airlines that run flight to the state, the number of passenger movements at the airport, etc. Hence, marketers must ensure that any jet fuel imported into the country and stored for into plane operations is of the right quality at all the points in the value chain (Adekitan, 2018), and also ensure that it is appropriately distributed across all its operating airfield depots based on the significance of the depots contribution to the company’s productivity in terms of sales, profit and product losses.

The operation of a jet fuel depot is affected by multi-dimensional factors that determine its performance, industry reputation among potential customer airlines and ultimately its profitability. In the aviation sector, safety is of top-notch requirement both in the air, on ground and in every third party support services (Adekitan, 2018). The safety record of a jet fuel marketer is vital for operational success, and it plays a key role in jet fuel contract sourcing. Airlines typically declare fuelling contract bids open on various industry platforms, and potential jet fuel marketers in such regions are invited to bid. The submitted bids are analysed based on registration and incorporation documents, the nature of fuelling insurance available, jet fuel pricing and premiums, safety records, affiliations with recognised technical partners, the mode of billing, credit terms etc. To be viable for contract success a jet fuel operator must ensure operational success by implementing an effective safety management system, efficient supply and

distribution network, adequate maintenance, and a functional and global best practice compliant jet fuel depots that will pass the periodic regulatory inspections, both local and international.

Product scarcity is generally bad for business, and unfortunately jet fuel scarcity and the consequential flight disruptions has been the norm in Nigeria for many years now. During the period of scarcity, any operator that is lucky to have enough reserve when competitors are low or empty on stock, automatically becomes the king and is free to determine pricing at will. Situations where other jet fuel marketers with zero stock are unable to import or source the product directly from major shore depots, and are therefore forced to buy from competitors that have product at an increased price and then resell to the airlines at a further increased price as played out several times. For business success, stock management is vital in jet fuel operations. Apart from technical and safety alertness level some of the key metrics that defines a jet fuel depot's operational status are identified as follows:

### 2.1. Opening Stock

The measured volume of jet fuel available at a jet fuel depot is determined daily by tank gauging techniques (Adekitan and Omoruyi, 2018), the jet fuel content of both the fixed storage tanks within the bund walls, mobile bowsers and fuel truck tanks are determined every morning for documentation purposes. The jet fuel volume available at a depot on each day determines the sale it can support, although this depends on customer airline request or the availability of existing fuelling contracts.

### 2.2. Closing Stock

This is the actual measured volume of jet fuel available at a jet fuel depot, at the close of work each day. It is the opening stock less other factors plus any jet fuel delivered to the depot during the day.

### 2.3. Net Stock

This is the anticipated mathematically calculated stock level based on stock computing formulas deployed to factor in sales, receipt, dead stock, etc.

### 2.4. Stock Variations

Stock variations is difference between the measured stock and the net stock. It typically indicates product losses or gain during jet fuel transfers and receipts and might be a pointer at product theft, equipment and tank leakage and incomplete loading from shore depots.

### 2.5. Product Receipt

A jet fuel marketer can import jet fuel into the country and store them at privately owned or rented shore depots, or may buy directly from major shore depots. The jet fuel is transported via tanker trucks called Bridger receipt vehicles (BRV) to airfield depots. The volume of jet fuel discharged by the BRV at the airfield depot is recorded as received product.

### 2.6. Product Transfer

Situations may arise in which a depot with abundant product is recording low sales, the jet fuel at such depots may be transferred to other depots where demand is high.

### 2.7. Sales

This is the volume of jet fuel sold at the airfield by the bowser operators to an aircraft and officially signed off by the pilot as the actual volume received. The sales figure will be used by the sales team to develop an invoice for the airline.

## 3. DEPOT PERFORMANCE ANALYTICAL MODEL USING STRUCTURAL EQUATION MODELLING

Analytical models are vital for performance analysis, and this has found application in aviation (Eshtaiwi et al., 2017). In the study by (Bernroider and Schmöllerl, 2013), Partial Least Squares (PLS) model was developed to evaluate the effect of technological, environmental, and organisational culture and practices on the overall performance of information technology related companies. In this study, the contributory stock related performance of seven airfield jet fuel depots of a fuel marketer in Nigeria to the overall performance of the business is analysed using PLS approach to SEM (Ringle et al., 2015). The stock related data of the seven depots for a 6 month period were analysed to identify the importance of each one of them at the depot level to the global performance of the business. The unidirectional relationship between parameters was evaluated in order to determine the significant predictors of the overall business performance (Maroof et al., 2019). The following input parameters were initially considered Closing Stock, Net Stock, Stock Variations, Product Receipt, Product Transfer, and Sales for each of the depots, and with each progression in the analysis parameters having covariance issues were dropped on per depot case bases in compliance with standard SEM analysis procedure. The global performance is measured using the Total Daily Sales, Total Daily Receipts, and Total Daily Losses across all the depots as reflective constructs. The final model developed is shown in Figure 1.

## 4. RESULTS AND DISCUSSION

For exploratory business research analysis and studies where little to nothing is known about the theoretical, parameter data relationship and where predictive accuracy is desired, PLS is a suitable option for analysis (Haenlein and Kaplan, 2004; Hwang et al., 2010; Wong, 2010; Wong, 2013). The impact of the indicators with a loading  $>0.4$  but  $<0.7$  on the average variance extracted (AVE) and composite reliability (CR) were studied. If there is no effect on the AVE and CR when the indicator is deleted, then the indicator is retained but if the AVE and CR increased then the indicator is permanently deleted from the model (Sujit and Rajesh, 2016). Eventually, for the outer model, the strength of each indicator was adjudged, and the acceptable limit of 0.6 and an ideal value of 0.7 (Hair et al., 2012) was applied (Chin, 1998). Using 5000 subsamples, the significance of the model was determined using bootstrapping algorithm. The path coefficient (loadings), the significance and the t-value of each path of the indicators is reported in Table 1.

As shown in Table 1, all the indicators are significant at  $P < 0.05$ , the outer loadings range from 0.627 to 0.931, while the t-values

Figure 1: The structural equation model of jet fuel depots stock related performance

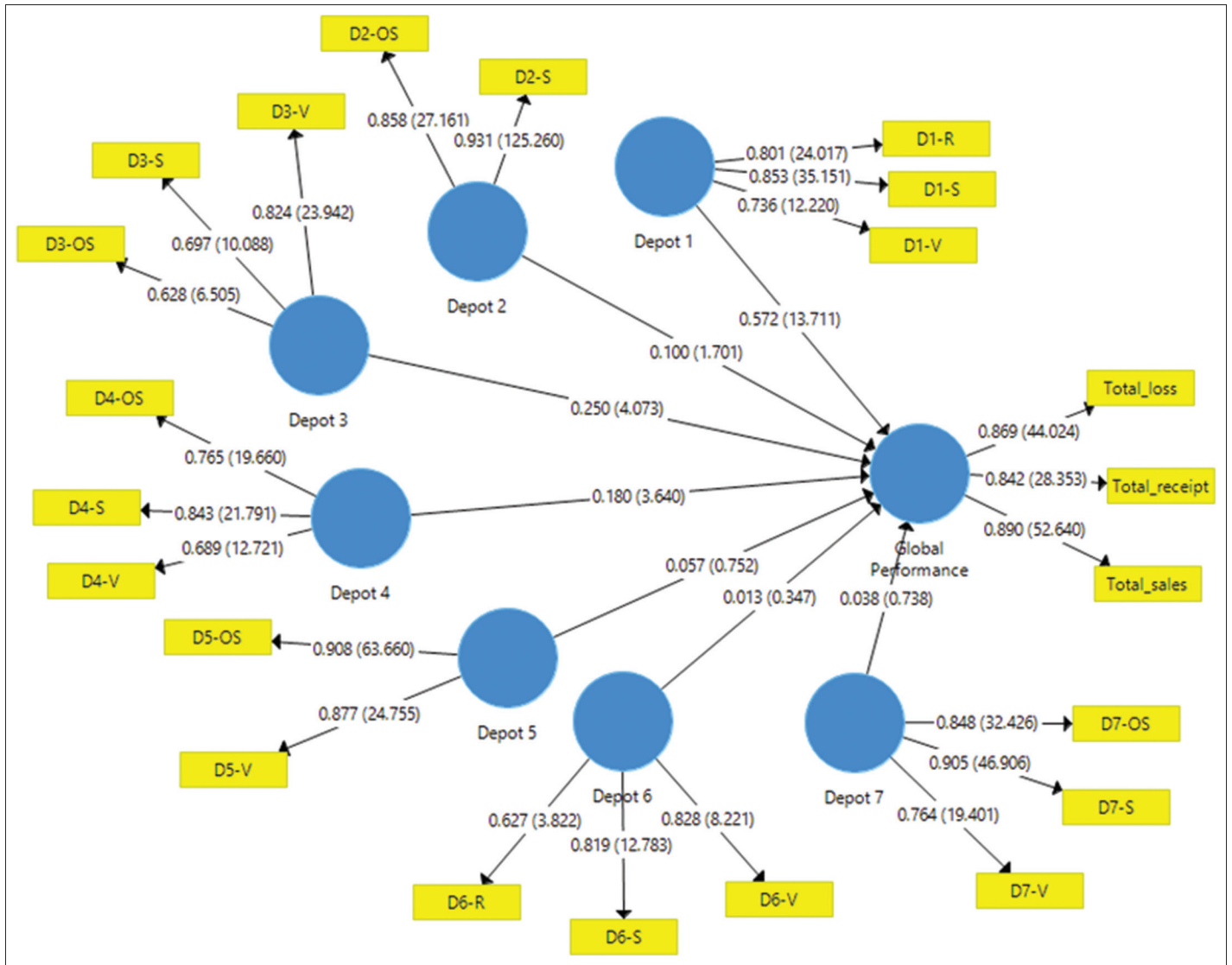


Table 1: Key statistics of the indicator parameters

	Sample mean	Standard deviation	Indicator loadings	T statistics	P values
D1-R ← Depot 1	0.803	0.033	0.801	24.017	0
D1-S ← Depot 1	0.855	0.024	0.853	35.151	0
D1-V ← Depot 1	0.745	0.06	0.736	12.22	0
D2-OS ← Depot 2	0.858	0.032	0.858	27.161	0
D2-S ← Depot 2	0.932	0.007	0.931	125.26	0
D3-OS ← Depot 3	0.632	0.097	0.628	6.505	0
D3-S ← Depot 3	0.688	0.069	0.697	10.088	0
D3-V ← Depot 3	0.825	0.034	0.824	23.942	0
D4-OS ← Depot 4	0.765	0.039	0.765	19.66	0
D4-S ← Depot 4	0.84	0.039	0.843	21.791	0
D4-V ← Depot 4	0.696	0.054	0.689	12.721	0
D5-OS ← Depot 5	0.911	0.014	0.908	63.66	0
D5-V ← Depot 5	0.879	0.035	0.877	24.755	0
D6-R ← Depot 6	0.601	0.164	0.627	3.822	0
D6-S ← Depot 6	0.826	0.064	0.819	12.783	0
D6-V ← Depot 6	0.827	0.101	0.828	8.221	0
D7-OS ← Depot 7	0.847	0.026	0.848	32.426	0
D7-S ← Depot 7	0.904	0.019	0.905	46.906	0
D7-V ← Depot 7	0.766	0.039	0.764	19.401	0
Total_loss ← Global performance	0.87	0.02	0.869	44.024	0
Total_receipt ← Global performance	0.843	0.03	0.842	28.353	0
Total_sales ← Global performance	0.89	0.017	0.89	52.64	0

**Table 2: Direct relationships for hypothesis testing**

Hypothesis	Relationship	Standard beta	Standard error	[t-value]*	P values	95% CL LL	95% CL UL
H <sub>1</sub>	Depot 1 → Global performance	0.573	0.042	13.711*	0	0.504	0.64
H <sub>2</sub>	Depot 2 → Global performance	0.097	0.059	1.701	0.045	0.001	0.193
H <sub>3</sub>	Depot 3 → Global performance	0.242	0.061	4.073*	0	0.14	0.341
H <sub>4</sub>	Depot 4 → Global performance	0.189	0.05	3.64*	0	0.107	0.27
H <sub>5</sub>	Depot 5 → Global performance	0.055	0.076	0.752	0.226	-0.067	0.183
H <sub>6</sub>	Depot 6 → Global performance	0.014	0.038	0.347	0.364	-0.047	0.078
H <sub>7</sub>	Depot 7 → Global performance	0.037	0.051p	0.738	0.23	-0.048	0.121

\*Significant at P<0.05. CL LL: Confidence limit lower limit, CL UL: Confidence limit upper limit

varied from 3.822 to 125.26 thereby satisfying the minimum 1.96 t-value requirement for the indicators. The significance of each depot’s contribution to the global business performance is presented as tested hypothesis in Table 2. For the one-tailed t-test at 5% significance level, Hypothesis H<sub>1</sub>, H<sub>3</sub>, and H<sub>4</sub> have t-values that are >1.96 at P < 0.05 which confirms their significance and strong impact on the global business performance. In terms of the magnitude of the t-value, the order of depot contribution is as follows Depot 1, Depot 3, Depot 4, Depot 2, Depot 5, Depot 7, and Depot 6. The R square of the overall model is 0.902 as shown in Table 3, which implies that 90.2 per cent of the variation in the overall business performance is explained by the depots’ performance indicators.

From Figure 1, the path coefficient of the inner model can be observed, and it shows that Depot 1 with a path coefficient of 0.572 has the strongest effect on global performance, followed by Depot 3 with a path coefficient of 0.25, and next is Depot 4 with a path coefficient of 0.18. The remaining four depots have t-values that are below 1.96 and therefore their effect on global performance is considered weak.

The collinearity of the inner model was assessed to determine any potential issues. The result of the collinearity is presented in Table 4. The Variance Inflation Factor values ranged from 1.529 to 4.431, and these values are <5 indicating that there is no strong indication of multicollinearity (Choi and Chiu, 2017; Wong, 2013). The results of the discriminant validity check which establishes the Fornell-Larcker Criterion (Fornell and Larcker, 1981; Wong, 2013), is presented in Table 5. The AVE of the independent variables were assessed to determine the convergent validity, and as shown in Figure 2, all the AVE for the depot variables are all above the 0.5 threshold (Götz et al., 2010). The internal consistency of the model was evaluated using the CR (Hair et al., 2012) and as shown in Figure 3, the CR values are all above the 0.7 threshold value.

As revealed by the results of the model, the jet fuel marketer must pay adequate attention to those indicators with high factor loadings at each depot because they are important operational parameters that affect the overall stock and sale performance of the company. Also, Depot 2, Depot 5, Depot 7, and Depot 6 that have less effect on the global performance needs management attention towards identifying operational strategies that can help to boost corporate image at the concerned airports which will translate to sales, and also the stock holdings and management policies for those depots should be reviewed. Apart from anticipated sales, closely related to the issue of

**Table 3: R square of the dependent variable**

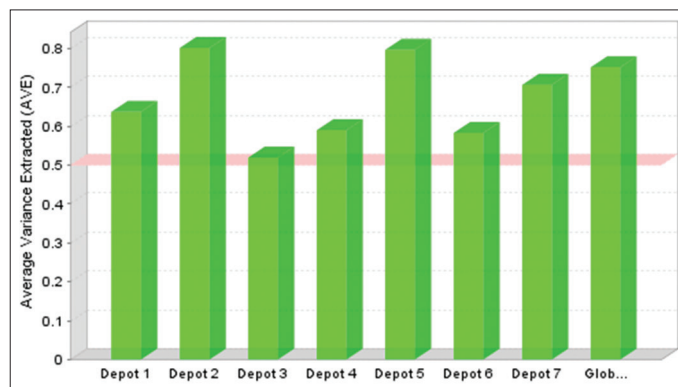
	R square
Global performance	0.902

**Table 4: Collinearity statistics - variance inflation factor**

	Global performance
Depot 1	1.591
Depot 2	4.431
Depot 3	1.668
Depot 4	2.373
Depot 5	3.751
Depot 6	1.529
Depot 7	2.113

VIF < 5 - Acceptable (No strong indication of multicollinearity)

**Figure 2: The average variance extracted values for the latent variables**



**Figure 3: The composite reliability of the implemented model**



stock management is transportation challenges, a comprehensive operational analysis must be deployed to identify logistic issues that are affecting product distribution and adequate control measures must be deployed.

**Table 5: Discriminant validity check using Fornell-Larcker criterion**

	Depot 1	Depot 2	Depot 3	Depot 4	Depot 5	Depot 6	Depot 7	Global performance
Depot 1	0.798							
Depot 2	0.592	0.895						
Depot 3	0.346	0.505	0.721					
Depot 4	0.356	0.692	0.556	0.768				
Depot 5	0.535	0.715	0.565	0.621	0.893			
Depot 6	0.338	0.544	0.378	0.419	0.57	0.764		
Depot 7	0.345	0.658	0.489	0.641	0.639	0.426	0.841	
Global performance	0.719	0.708	0.654	0.657	0.73	0.479	0.581	0.867

## 5. CONCLUSION

Jet fuel availability is extremely vital for interruption free, air transportation planning and management. The availability of jet fuel is a challenge in Nigeria causing flight cancellations and hike in air fares. Several contributory factors such as importation challenges, zero local production of jet fuel by Nigerian refineries, difficulty in accessing foreign exchange during the recession period, transportation challenges, alleged fuel hoarding and indiscriminate hike in jet fuel price by marketers, etc. have been attributed to be among the causal factors of jet fuel scarcity and high prices. In turn, jet fuel marketers have ascribed the high price of jet fuel to the operational realities of jet fuel business, citing high logistic costs, high taxes and fees, high cost of importation of jet fuel and spares, high cost of depot maintenance and so forth. Hence, it is vital for a jet fuel marketer to ensure operational efficiency and maximum productivity at each depot towards reducing the overall operational cost that may negatively affect the selling price of jet fuel.

In this study, the stock and sales data of seven airfield depots of a jet fuel marketer were analysed using PLS approach to SEM to identify the operational significance of each of the depots to the overall performance of the company measured via total sales, total product losses and total receipts. These reflective indicators have factor loadings 0.89, 0.869, 0.842 which confirms their suitability and impact as measures of global depot performance. The result identifies the depots that are contributing significantly to the overall stock and sales performance of the business, while those with less effect were also categorized based on their t-value. These analyses provide an opportunity and platform for fuel marketers to conduct science-based productivity analysis of their operations using relevant daily historical data towards identifying the important performance indicators per depot, and also for revealing their strong and weak operational locations which can be improved on through further operation and policy reviews.

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