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## Energy Distribution in Nigeria: Conceptualizing Frameworks for the Supply of White Petroleum Products in the Downstream Sector

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### **Abstract:**

*For the fact that Nigeria's refineries are more related to death or not working in full capacity, Nigeria's import dependency is not limited to non-oil commodities. Traditionally, Nigeria export crude oil and import refined petroleum products; therefore, the challenges of availability, sufficiency, and distribution of such products are often attributed to the downstream as well as the poor state of the country's refineries. Knowing that there are many players in the sector which include firstly the major importers and marketers whose reward comes in the form of subsidy payment by the government, and then the marketers who thereafter trade with a long list of middlemen or retailers, the question of who is responsible for the improper arrangements of petroleum products still is very arguable. Regarding movement and distribution of petroleum products in Nigeria, transportation has become a physical hindrance. Because of this system, petroleum products can be circulated to various regions from their origins. Almost 80% of petroleum gets circulated through roads. It has been observed a steady increased in the number of heavy vehicles which are used as a carrier. Poor condition of roads, disturbance among police, military, state revenue agency, and customs checkpoints also create problems in logistics. This study focuses to find factors which are responsible in the supply of white petroleum in the downstream segment of the Nigerian oil and Gas sector. It concludes that unless urgent and long-lasting measures are taken by the government and private sector, the performance of the sector will continue to dwindle with attendant multiplier effect on the economy.*

**Keywords:** Nigeria's Refineries, white petroleum, physical hindrance, customs checkpoints

### **1. Introduction**

Effective distribution of economic resources remains a serious challenge to both rich and poor nations. This implies that no matter the number of economic resources a country has, if it is not properly distributed, it will exclude some to some extent and perhaps favors others to a large extent, thereby introducing an imbalance, serious inequality or inequity that might be temporary or permanent (Hariston, 2018). It is perhaps needless to argue that although, Nigeria is an oil-rich country, and however, the availability of petroleum products always fluctuates from time to time. The popular paradox surrounding such state of affairs revolves around the questions of whether or not it is the upstream sector that is responsible or downstream sector. Knowing that the upstream sector deals with the extraction of crude oil from its sources and that the midstream sector is responsible for refining crude oil while the downstream sector deals with the distribution of refined petroleum products (gasoline, petrol, and kerosene); the problem of availability of such products in sufficient quantity may be as a result of poor distribution pattern. If that is the case, then the credit goes directly to the downstream sector.

According to the Department of Petroleum Resources (DPR) (Eboh, 2013) Nigeria is African largest oil-producing country and the fifth supplier to the United States as well as the sixth largest oil exporter, with a total of 173 oil blocks in operation. Nigeria is being identified among the 12 biggest oil producers in the Organization of Petroleum Exporting Countries, (OPEC), contributing about 1.535 million barrels per day (bpd) to the OPEC basket. Nigeria had recorded crude oil reserves of 37.5 billion barrels, natural gas reserves of 5.154 million cubic meters, securing eighth position in the world gas reserves and first in Africa (OPEC's Annual Statistical Bulletin, 2018). Yet unexpectedly the country depends on fuel importation to meet up domestic demands of petroleum products.

Since 1958 before Nigeria gotten its political and economic independence from British, since crude oil production and exportation started in Nigeria. It accounted for 7.1 percent of total exports in 1961, which was dominated at that time by cocoa, groundnut, rubber and palm oil, in that order. In 1965, oil constituted 13.5 percent of the nation's export earnings,

and by 1970, it had become the leading source of foreign exchange, accounting for 63.9 percent. By 1979, petroleum sales had completely overshadowed non-oil exports, as it then contributed about 95 percent of the country's export earnings. In 2012, oil and gas export accounted for almost 96 percent of export earnings. Also, in 2013, Nigeria budget is framed on a reference oil price of \$79 per barrel, providing a wide safety margin in case of price volatility (U.S Energy Information Administration (EIA), 2013). No wonder, Central Bank of Nigeria (CBN) reported in 2010 "that petroleum accounted for approximately 96 percent of the country's foreign exchange and 76 percent of the total government revenue" (CBN, 2010). As per Ogbonna and Ebimobowei, (2012), "total oil revenue generated into the federation account amounted to N34.2 trillion while non-oil revenue was N7.3 trillion, representing 82.36 percent and 17.64 percent respectively between 2000 and 2009.

Although sufficient oil resources and unprecedented wealth, Nigeria depends on importation of petroleum products of which eighty-five (85) percent were imported from other countries (Ogbonna and Ebimobowei, 2012). Nigeria imports an estimated \$10 billion of fuel annually for domestic consumption. In 2012, Nigeria consumed 270,000 bbpd and in 2013, it imported vaguely more than 84,000 bbpd of petroleum products (U.S. Energy Information Administration (EIA), 2013). It imports fuel from distant countries like United States, United Kingdom, Venezuela, Canada, Brazil, Netherlands, and the Persian Gulf countries.

Nigeria is the largest producer of crude oil in Africa and the sixth largest among the OPEC members (OPEC, 2008). According to Azaiki and Shagari (2007), the petroleum sector, over the last four decades, has been playing a prevailing role and occupies a strategic position in the Nigerian economy. With proven reserves of roughly 23 billion barrels of crude oil, the country is the tenth oil-richest nation on planet earth (United State Energy Information Administration, 2007). Petroleum sector, in spite of various laudable attempt by the government to diversify the economy still accounts for about 90 percent of the country's foreign exchange, accounts for 80 % of government revenue, and contributes well over 20% to the country's Gross Domestic Product (GDP) (US EIA, 2012; World Bank, 2012; IMF, 2012). As per Iwayemi, Adenikinju, and Babatunde (2010), the demand for petroleum products in Nigeria has been on the rise since the early 1970s when oil was first discovered in commercial quantities. The role of major factor had been played by the growth of GDP per capita, which gave rise in the domestic demand of petroleum products. Increase in demand for energy and vehicles, fuel caused influx of foreign direct investment. Moreover, growing population had caused a huge demand for petroleum products in Nigeria.

## 2. Subject Significance

The Paper possesses both academic and practical significance. From practical perspective, it will benefit stakeholders in the petroleum industry to have better understanding of Nigerian situation as it is one of the largest exporter of crude oil to developed and developing nations of the world. For more than three decades therefore, crude oil has been the major source of energy, revenue and foreign exchange earnings for the Nigerian economy. Therefore, understanding the nature and dynamism inherent in the distribution of petroleum products in Nigeria will inform future policy making that may result to effective and efficient distribution in Nigeria. Therefore, it is worth mentioning to confirm the necessity of proper distribution such that operational cost can be minimized and all stakeholders can be benefitted. Distribution of PMS, AGO and DPK also determine the cost of petroleum. Therefore, the paper synthesizes alternative framework to curb the aforesaid problem.

The paper is timely and relevant because the need for a good distribution system for petroleum is required to cater the need of all stakeholders of this industry. This industry has importance in national economies especially that of developing nations in terms of revenue generation and source of foreign exchange earnings. The findings of this paper contributes to the understanding of supply chain management of petroleum products and recommends ways by which petroleum industry can improve its efficiency and efficacy in order to align with national as well as stakeholders' interest. Nigeria National Petroleum Corporation (NNPC), Major and independents marketers and other stakeholders of petroleum industry will be beneficial. As alternative distribution system can bring proper utilization of products and reduce complexities in the downstream sectors. This study will also create a future scope of research in this area. The work is expected to contribute to previous work on petroleum product distribution, which is relatively "strange" as the economy is now being set up on diversification route to reduce the level of overdependence on petroleum for foreign earnings as well as revenue as it affects other real sectors of the economy. The work also aims to provide useful information to stakeholders in the petroleum industry on how to synthesize alternative framework for the supply of white products in the downstream sector.

## 3. Concept and Reviews

### 3.1. The Petroleum Product

There is need to define the term product before dwelling on petroleum product. Product is a vital component of the promoting combine. Product both physical and intangible is needed to fulfill the need and satisfaction of consumers. It can be offered to marketplace for drawing attentions, attainment and utilization (Kotler and Armstrong, 1969).

Petroleum products include not only the naturally derived product, but also alternative, renewable and synthetic fuels and their blends (Army Techniques Publication, 2015). Moreover, these types of products can be useful for generation of power. After getting generated from crude petroleum, processing done by thermal cracking in the refineries, after which distribution done from pipeline to plants or loading depots.

### 3.1.1. Distribution

The term distribution has broad and varied conception in the world of economics and management depending on the context in which it is being used. It is the strategy of allocating products and services such that vital decisions can be taken regarding assorted and generally divergent objectives and methods.

According to Ilodigwe (2011), distribution consists of planning, implementing and finally controlling the flow, which are physical in nature, of goods, and related information. This aims to give profit of the customers.

From salesperson to end consumers all are being associated with this. For Kotler and Armstrong (2001), it is combinations of supply or physical distribution functions which are responsible for moving products from origin to end users. It lessens the number of transactions in the manufacturer-customer chain. It looks after the supply of products to fulfill the need of consumers (Egede and Ngwoke, 2013; Onahet *et al.*, 2004). After good reaches to the last stage, time, place and possession of distribution are there. To determine ultimate cost it is vital. According to, Vlad and Pavel (2015), from origin to final consumer, it can stimulate and motivate consumers and secure, distribute product services. Basically, by acting as a middle man between consumers and retailer-wholesaler, it helps to arrange and organize supply chain management system.

### 3.1.2. Petroleum Products Distribution

Distribution of petroleum products to ultimate consumers towards various locations is the main purpose (Adeleke, 2002). In Nigeria, pipelines and products marketing company (PPMC) is responsible for supplying, distributing and marketing (Anyadiegwu, 2015). Approximately four thousand (4,000) kilometers of pipelines are interconnected with twenty-one (21) highly dispersed depots.

As soon as petroleum leaves the refinery and goes to the consumers, one or more than one channel is started associated with this. For Brooks, Dallas, Kelly, and Sumeet, (2007), it consists of 2 elements: wholesale distribution (from product terminals to retail outlets) and retail distribution (to final consumers). PPMC is only looking after the wholesale supply, distribution and marketing of petroleum products in Nigeria. Figure 1 shows various channels of petroleum product distribution in Nigeria:

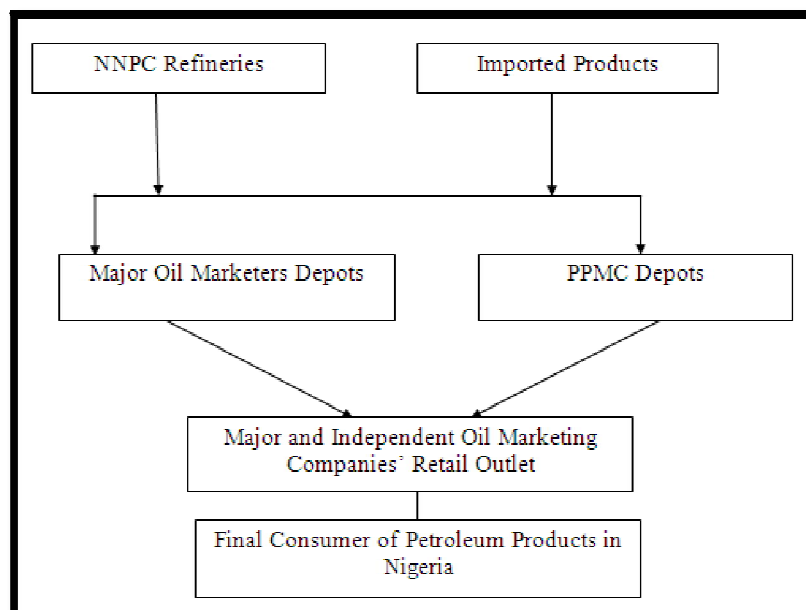


Figure 1: Flow Chart Channels of Petroleum Product Distribution in Nigeria

Figure 1: The physical flow of products: the retail route used by major and independent companies in Nigeria. Source: NNPC/PPMC Bulletin, 2010.

### 3.1.3. Petroleum Supply Chain

Petroleum supply is the management and execution of petroleum distribution from the supply point or original source to the customer, or end-user receipt, with emphasis on the continuous improvement of the efficiency of the supply chain. Petroleum supply involves the receipt, storage, distribution, quality assurance and surveillance, consumption, logistical planning and support of bulk petroleum (Army Techniques Publication, 2015).

Petroleum Supply Chain is a complex assortment of infrastructures and processes whose mainstream begins with the exploration of crude oil and finalizes with the delivery of petroleum products to consumers. The petroleum supply chain activities are sequential in nature and as such any failure is critical to the next phase and more so this implies huge working capital that is blocked in petroleum inventories (Fernandes, Barbosa-Póvoa, and Relvas, 2010).

### 3.1.4. Petroleum Industry

The rock oil business covers all processes of examination, extracting, sanitization, circulation rock oil product. Upstream, midstream and downstream are the three categories of this industry. Production and investigation are mainly

done by upstream. Storage is done at midstream and finally, transportation and marketing activities conducted at last stage. These stages cover commodities like crude oil, natural gas, natural gas liquids (NGLs, mainly propane, ethane and butane) and sulphur. According to Amponsah and Opei (2017), oil refineries, petrochemical plants, petroleum products distributors, retail outlets and natural gas distribution companies come under downstream.

### 3.2. Downstream Sector

The operation of petroleum industry by sector is majorly divided into three, most especially with regard to petroleum supply chain. They are the upstream, midstream and downstream sectors. These sectors are also referred to major areas of petroleum supply chain management (Fernandes, Barbosa-Póvoa, and Relvas 2010). Selection and design conducted at upstream and the downstream sector focuses on refinery process design and scheduling and the design and planning of petroleum supply chain networks (Fernandes, Relvas, Alem, and Barbosa-Póvoa, 2016).

Generally, Midstream operations are considered a part of the downstream sector. In a nut shell, the upstream sector is concerned with exploration and production while downstream sector is concerned with refining, marketing and servicing. Important activities come under upstream are

- Examination and production;
- Crude oil carrying and storage space;
- Geodetic survey;
- Geological activities;
- Drilling operations;
- Seismic data acquisition; and
- Civic works such as site surveys and preparation of drilling locations.

Thus, activities in the downstream sector include:

- Crude oil and gas conversion into refined and petrochemical product;
- Gas treatment; and
- Transportation and distribution of refined products.

### 3.3. White Product

There are two basic types of manufacturing plants that are used in the oil industry to produce crude oil; refineries and lube plants. Refineries produce light or white products; example of white products is gasoline, diesel oil, kerosene, aviation fuel, etc which are shipped in large quantity to tank terminals, distribution centers or to industrial customers. Also, refineries produce heavy or black products, example of such products are base stock for lubes and residual oil which are shipped in bulk to industrial customers and lube plants. Lube plants produce lube oils, greases, and waxes, which are shipped in bulk or packaged to distribution centers or industrial customers. Refined white products are shipped in large quantities from refineries to tank terminals and industrial customers by a variety of modes (ship, barge, pipeline, rails). White products are usually distributed from tank terminals to retail outlets or gas stations and industrial customers by tanker trucks. There exists a variety of operations in this segment of the distribution chain. The characteristics of a specific operation are affected by the competitive environment, demand density, company policies, laws and regulations, and numerous other factors (Ronen, 1995).

## 4. Empirical Evidence from Nigeria

Examining distribution constraints of petroleum products by road transport using Pipeline and Products Marketing Company (PPMC) in Kaduna was studied by Obasanjo and Nwankwo (2014). The study set out to examine the on road distribution of petroleum products from PPMC Kaduna. Data from both primary as well as secondary have been used. Based on structure data collection tool and random sampling methods data have been collected. K-W test results that mechanical problems, short-fall and delay in off-loading are the major problems. The correlation matrix of the trucking problem shows that variables were inter-related. The interconnectivity between the volume of petroleum products and number of trucks used has been revealed by the student t-test at 5% level of confidence. The PMS and number of trucks used gives a t-test value of 1.447,  $p < 0.222$ , equally DPK-number of trucks shows a t-test value of 1.751,  $p < 0.155$  and AGO-number of trucks provides a t-test value of 1.833,  $p < 0.141$ , at 4 degrees of freedom and at 95% confidence interval respectively. Use of advanced technology has been advised along with more proper driver training education for effective distribution logistics. Automated framework, on the basis of Knowledge-based collaborative engineering in the pipe networks for both upstream and downstream petroleum industry are really required (Sheremetov, Batyrshin, Chi and Rosas, 2008).

How a stress analysis engineers can able to spot certain pipe arrangement, weight, thermal and pressure stress at safe operation levels also have been suggested.

Using Chi – square, Egede and Ngwoke (2013) assessed the impact of cost of distribution on the pump price of petroleum products in the south – eastern Nigeria. The study administered questionnaires where 1200 petroleum marketers were sampled across the 5 states of south east. Moreover, the study identified pipelines as best and economic means of petroleum products towards various regions. The prices, shipping freight, rents, salaries, allowances, spare parts, electricity, bank charges, and premiums from government officials are basically customary costs. The study ended with the distribution cost, the price of petroleum product increases at retail outlets, which further resulted in long queuing and shortage which can encourage black market transactions. For both upstream and downstream petroleum industry, a

knowledge-based collaborative engineering of pipe networks had been recommended by Sheremetov, Batyrshin, Chi & Rosas (2008). It can be adopted for flexibility analysis in the upstream and downstream petroleum industry. Stress analysis had been conducted by Multi-Agent System, with weight, thermal and pressure stress at protected operation levels as inputs. SATD-AFE application has been used here. Stress and flexibility analysis have been tested in actual engineering project scenarios. Experimental results permitted to enhance the precision of the developed methods achieving a perfect match with the expert classifications. Hydrocarbon liquids had been made responsible for failures in pipelines by Ambituuni *et al.* (2015).

Theft/sabotage, a major cause of failure to pipelines, has caused 35% per km-year damage well above failure rates reported on other pipeline systems around the world. Depending on the region in Nigeria, losses occur in pipeline range from 4% to 38% per km-yr. On an average, the operator of the pipeline system considered loses about \$US100 million/year due to these failures. It does not include the costs associated with payment of compensation, fines, environmental clean-ups, litigation, etc. The paper suggested improving pipeline safety systems to lessen these fatalities and costs.

Effect of human resource management (HRM) on planning and implementation of marketing strategies of petroleum products has been highlighted by Alaba and Agbalajobi (2014b). 486 staffs out of 852 personnel received training. Whereas, 316 staffs received managerial courses. 782 empty positions were being recognized in the company, which was divided into 505 for project labour forces and 95 were from technical departments. The main problem was in poor supply, distribution and performance. For Akure, Nigeria, transportation challenges for distributing petroleum products had been highlighted by Adenigbo, Balogun, Olisa and Arigbede (2017) using GPS and Questionnaire on the basis of 126 samples from retailing points on Ilesa to Akure to Owo expressway. For analysis GIS and descriptive analysis has been used. A total of forty-two stations were being covered from Ibule to Shasha market in Akure with an average of 372 metres between two different stations. The factors causing hindrance were bad roads, irresponsible driving, tanker leakages, equipped robbery, serious traffic congestion, delays at loading port, perfunctory problems, accident and fire outbreak, harassment from enforcement agencies and high cost of fuelling vehicle. Supply and distribution systems of petroleum had been further reviewed by Akpoghme and Badejo (2006) in Nigeria. Network and connectivity problem had been found as a major problem. Disrupt, destruction, banditry and improper maintenance was the main causes. The problem between imported products and landed costs had created problems for the federal government and independent marketers. Risk management framework of petroleum products has been identified by Fernandes, Barbosa-Póvoa, and Relvas (2010). For distributing petroleum product, main identified products are drilling rigs, pipelines, petroleum depots, oil tankers, refineries, offshore platforms, and transport equipment. It had been revealed that for both micro and macroeconomic level, petroleum supply chain is a very risk prone and high-impactful industry. For supply chain risk management (SCRM) framework it provides methodologies. Kazemi and Szmerekovsky (2015), developed a deterministic mixed integer linear programming model for downstream petroleum supply chain network for optimal distribution in terms of locations, capacities, volume etc. Find out optimal cost and optimum configuration was main purpose of this model. This model has achieved a trade-off to minimize impact of demand and costs with set of constraints for capacity growth.

3-node structure model had been used by Chinedu (2017) to solve supply and distribution problem of fuel in Nigeria. Liquid fuel supply and distribution problem had been solved by this study to find policy reform areas in the sector. Sleaze, improper preservation of existing refineries, signpost and distraction of imported petroleum products and militant activities are the main factors for shortage of fuels in Nigeria. Optimization of a multi-period Supply, Transformation and Distribution (STD) scheduling problem under uncertainty for product demand, spot supply cost and spot selling price had been done by Escudero, Quintana and Salmeron (1999) using 2-stage scenario analysis by partial recourse approach. Effect of petroleum products supply and domestic prices on distribution done at domestic level, had been assessed by Auwal and Jerry (2012) using Vector Auto-regression (VAR) model and Ordinary Least Square (OLS) estimation for monthly data ranging from 2005 to 2010. This study found that the imported quantity is the key mean of supply.

To find the impact of gas injection and swap, a study had been conducted by Farahani and Rahmani (2017) on the petroleum supply chains. A mixed integer linear programming (MILP) model had been adopted to maximize the net present value (NPV) of a crude oil network. By including production planning, facility location-allocation, and distribution planning, it had been found that gas injection into oil reservoirs is one of the most essential factors. This outcome helped to yield long-term profits. Innovative method of source and reservoir rock pyrolysis had been used by Beti, Thul, Ring, McLennan and Levey (2018) to unearth new incremental S1 method for a range of rock types and API gravities. It found a straight line correlation between refractive index (RI) and oil-density.

## 5. Conclusions

Nigeria's bequest in oil has not been converted to a positive economic performance. Rather, mono-cultural status has created an unstable situation for past decades and international oil markets are becoming risk prone. Huge dependency on crude oil market of Nigeria is creating continuous structural difficulties for economy. From 1980 this negative trends has started still continuing. Reform initiatives need to be taken on immediate requirement basis to stop this economic down fall. Diversification is required immediately. For concentration are required from the end of policymakers to enhance the agricultural and solid mineral sectors. Proper projections of dynamics of energy distribution are highly recommended for economic performance. More utilization of distribution systems is also required.

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