# FUEL SUBSIDY REFORMS AND SUPPLY CHAIN PERFORMANCE OF MARITIME TERMINAL OPERATIONS IN NIGERIA

**BY**

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**A DISSERTATION SUBMITTED TO THE DEPARTMENT OF MARITIME MANAGEMENT TECHNOLOGY, POST GRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF DOCTOR OF PHILOSOPHY (PhD) DEGREE IN MARITIME MANAGEMENT TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, OWERRI.**

**MARCH, 2024**

## CERTIFICATION

This is to certify that this thesis **"Fuel Subsidy Reforms and Supply Chain Performance of *Maritime Terminal Operations in Nigeria*"** *was carried out by* ***NDUBUISI, KENNETH*** **EZEBUNWA** (PGS/PhD/20144918308) in the Department of Maritime Management Technology, School of Management Technology, Federal University of Technology Owerri, for the award of Ph.D. Degree in Maritime Management Technology.

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# DEDICATION

This research is dedicated to God Almighty.

## ACKNOWLEDGEMENTS

My profound gratitude goes to my pillars of encouragement. First, To God Almighty through my Lord Jesus Christ, I Worship Thee.

To my astute supervisor and the Head of the Department of Maritime Management Technology, Dr. Obed B. Ndikom, May the Almighty God bless you, Sir. I remain eternally grateful to my other supervisors Dr. Ibeawuchi C. Nze, and Dr. T.C. Nwokedi. I am also grateful to Abu Momoh and CJ Nweke for assisting in the provision of marine terminal data and its analysis respectively. Thank you to Prof. Emeghara, and Prof. Onyemaechi, Thank you Dr. Donatus Onwuegbuchunam for helping me achieve "advanced PhD". To Prof K.U. Nnadi, Dean of the School of Logistics and Innovation Technology (SLIT), and the Associate Dean of SMAT Prof Okorocha for your, contributions and your unalloyed support. To Prof B. Asiegbu, the Post Graduate School Coordinator for your guidance, thoroughness, and scrutiny of this research process, God bless you, Sir.

To Prof B.O. Esonu, the Dean Post Graduate School, and the amiable Associate Dean PGS, Prof. C. Nweke, may the blessings of God remain your portion. I also thank my external examiner Prof Folasade O. Oderinde for the thorough scrutiny and objectivity of the dissertation. To my able PGS Schedule Officer, Mr. Anyanwu Ifeanyi Lazarus, God bless you, Sir.

I also thank you, my course mates, Dr. David Chikwendu, Dr. Lawrence Gbasibo, Dr. Okeke K. Okechukwu, Dr. Uche Martin Emenyeonu, Dr. Nwosu Emmanuel, Dr. Justice Mbachu, Nwoloziri E. Chinyeaka, and Hilary Effanga for your encouragements during this journey.

Finally, I thank my mum for her prayers and support towards answering "Mama Doctor",

to my wife, Dr. Juliet I. Kenn-Ndubuisi; my son Master KitChris Chukwunarurum Kenn-Ndubuisi, and my daughter Miss Kaylabecca Chimdirimnma Kenn-Ndubuisi for all the jest of "Advance PhD" and "daddy wey dey pamper, daddy wey dey ginger". I appreciate and love you all. God bless you.

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## ABSTRACT

The study investigated the fuel subsidy reforms and the supply chain performance of maritime terminal operations in Nigeria. The objectives of the study were among other things, to evaluate the effects of fuel subsidy reforms on the cargo throughput, bulk road vehicles calls, and ship calls handled at maritime terminals involved in the petroleum product import and distribution supply chain. The study also determined the coefficients of elasticity of cargo dues and ship dues payments of terminal operators as a result of variations in the pump price of petroleum products, daily swap import, number of approved supply vendors and annual subsidy payment occasioned by fuel subsidy reforms. Exploratory research design was used in which time series quantitative data on daily swap import, number of supply vendors approved, annual subsidy payment, pump price per liter, are sourced from secondary sources and used as proxies for fuel subsidy reforms while cargo throughput, ship call traffic, bulk road vehicles calls, cargo dues payments and ship dues payments of the terminal operators were obtained from the Nigeria port authority statistical reports and used as proxies for supply chain performance of the terminal operators in the handling of petroleum product transiting through it over the period. The methods of data envelopment analysis (DEA) and log linear multiple regression analysis were used to analyze the data obtained using statistical software. It was found that a 1% annual increase in pump price per liter will increase the throughput of petroleum product handled in the marine terminals by 0.12% while a 1% increase in daily swap import leads to a 0.653% decrease in cargo throughput handled in the terminals. In a similar manner, a percentage increase in number of supply vendors will lead to a 0.012% decrease in cargo throughput performance of the marine terminals while a percentage increase in annual subsidy payment will lead to a decline of 0.17% in cargo throughput performance of the terminal operators in the petroleum products supply chain. Furthermore, a 1% annual increase in pump price per liter will lead to a decline in ship dues paid by terminal operators by 1.196% per annum while a 1% increase in daily swap import leads to a 0.292% decrease in ship dues paid by marine terminal operators per annum. Similarly, a one percent increase in number of supply vendors will lead to a 0.453% decrease in ship dues paid by marine terminal operators involved in the distribution chain of petroleum products in Nigeria while a one percent increase in annual subsidy payment will lead to a decline of 0.232% in ship dues paid by terminal operators in the petroleum products supply chain. The equation depicting the effect of fuel subsidy reforms on cargo throughput handled at the terminals is: ***LogCARPUT* = 30.817 + *0.12LogPUPRI - 0.653LogDSI – 0.012LogNSV - 0.17LogASP.*** Similarly, the equation depicting the effect of fuel subsidy reforms on ship dues payments of the terminal operators is: ***LogSHDUES = 25.67 – 1.196LogPUPRI - 0.292LogDSI + 0.453LogNSV - 0.232LogASP*** among many other empirical relationships. The policy implications of the results were discussed and recommendations proffered on the basis of the research findings.



***Keywords: Fuel Subsidy Reforms, Marine Terminal Operations, Supply Chain Performance.***


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# CHAPTER ONE

# INTRODUCTION

## 1.7 Background Information

Nigeria is the largest crude oil producer in Africa, but the highest importer of refined petroleum products in Africa. Nigeria operates a unique and peculiar petroleum supply network subject to unmonitored fuel subsidy reforms and distortions. All these and more have left the supply and distribution of refined petroleum solely on the doorsteps of tanker vessels, liquid bulk terminal jetties and bulk road vehicles with their attendant challenges that have snowballed into perennial fuel scarcity and price hike in Nigeria.

Petroleum resources generate over 90 percent of the Nigerian foreign exchange earnings and approximately 80 percent of her government revenue. But these figures have refused to translate to better living standards for the citizenry. Nigeria at a time in history, paid more subsidy for imported refined petroleum than her export earnings for the same petroleum.

The undesirable effect of the unique supply and distribution network of refined petroleum in Nigeria coupled with the obsolete fuel subsidy reforms, has led to an expensive and expansive maritime supply chain to the end users.

The maritime supply chain of petroleum is now hinged on the engagement of Very Large Crude Carrier, Medium Range Vessel, Long Range vessels, Ship to ship Logistics systems, liquid bulk jetties and Bulk Road Vehicles for the supply and distribution of refined petroleum in Nigeria. This scenario is made worse due to the uneconomic functionality of the moribund refineries and the hemorrhaging pipelines, thereby overburdening the marine terminals or liquid bulk jetties, that remains the only major interface of marine and hinterland (offshore and onshore).

Ehinomen & Adeleke (2012) buttressed that NNPC under the Goodluck Jonathan's government bypassed pipelines, using tanker vessels to ship petroleum to the Warri and Port Harcourt refineries in 2011 and 2014 respectively due to pipeline vandalism. The bypass exercise cost the government an average of $7.52 per barrel to ship the domestic crude to the 2 refineries, given that the cost is against the government PPMC pipeline charge of about N0.30/liter (or roughly $0.03 per barrel) for moving the same product via pipeline to the refineries. These aggregated costs then culminate into refine petroleum product landing cost. This have impacted the supply chain of the petroleum distribution in Nigeria immensely.

According to (Ozili, 2021), the supposed optimum performance of the petroleum distribution network have been grossly limited in Nigeria basically through her numerous and interlinked economic policy uncertainty such as unexpected and sudden Central Bank intervention; change in government policy after elections; political interference in economic policy making; fall in global oil price; oil price shocks and uncertain government response; recession; unethical public policy and practices, stale inconsistent policy initiatives, inadequate decaying infrastructure, pipeline vandalism, product theft, product adulteration, environmental pollution, host community unrest, and the product supply network distortion.

In ameliorating the social, political and economic challenges of Nigeria, the government exacts full control over the petroleum industry by adopting segmented and unsustainable short-term approaches in managing the complex volatility of the petroleum distribution network and these unmonitored reforms have left the 6$^{th}$ largest producer of petroleum of the world, with perennial product scarcity challenge (Aminu & Olawore, 2014).

In the reports of Ogbuigwe, (2018) and Siddig, et. al. (2014), the Nigerian domestic consumption of PMS is approximately 35million litres daily and have increased geometrically to 66 million litres daily; the query remains how was the figure arrived at, given that, query is based on the backdrop that government agencies such as Nigerian Midstream and Downstream Petroleum Regulatory Agency (NMDPRA) and Nigerian Customs, has conflicting premium motor spirit (PMS) daily consumption figures?

The need to reengineer the supply chain performance for continuous improvement through effective system monitoring of the distribution of petroleum could have eliminated the discrepancies associated with the quantity supplied and distributed daily while also authenticating the figures for subsidy payments and national planning.

The importance of this reengineering cannot be overemphasized especially for the sake of accounting for the petroleum constantly freighted to foreign refineries by foreign tanker owners for refining and freighted back as refined petroleum which have also deprived Nigerian from the benefits associated with managing her own mineral resources. According to (Ibemere, 2023) of Legit, Nigeria Ship owners are requesting the government to revisit the Cabotage Act 2003 to help them compete with the foreign tanker owners in the shipment of PMS as they claimed that they lost $1.3 billion in 2 years to Nigeria. The need to also monitor and redesign the fuel subsidy reforms in line with the present infrastructural capabilities of Nigeria and its growing population is also very vital.

Therefore, the impact of fuel subsidy reforms on accountability and transparency indicators in the supply and distribution of petroleum product in Nigeria is actually domiciled in the supply chain performance of marine terminal operations at the marine terminals or liquid bulk jetties which is the nexus of the present petroleum distribution network in Nigeria. The performance of the privately and publicly managed marine terminals will also show their contributions in implementing fuel subsidy reforms to avert fuel scarcity over the period under review.

The perennial fuel scarcity and product price hike can be mitigated by the robust system reengineering of the infrastructure and also improve on system monitoring and continuous improvement of the marine terminal operations' supply chain performance as provided by the documentation of tanker vessels calls to terminals/ports, terminals-Bulk Road Vehicles interactions.

Furthermore, it is also expedient to empirically infer the contribution of Annual Subsidy Payment, Official Pump price, Daily Swap Import, and Number of Supply Vendors, on supply chain performance of marine terminal operations via monitoring of Cargo Throughput, Ships Gross Registered Tonnage (GRT), Ship Traffic, Bulk Road Vehicle (BRV) Traffic, Ship Dues, Cargo Dues, Berth Rent, Value Added Tax (VAT), as applied by NPA tariff/ billing department).

This thesis therefore tends to view the mitigation of the perennial fuel scarcity in Nigeria from the foundational theory prisms of the System theory, Contingency Theory, Institutional Theory, Goldratt's Theory of Constraints and Collaborative Governance approaches.

The analytical approach to this study is based on descriptive and inferential statistics. Correlation and regression test were used for the estimation of the relationship and significance of fuel subsidy reforms on the marine terminal operations in Nigeria. The application of the frontier estimation model-Stochastic Frontier Analysis (SFA) was used to estimate the extent of change between transient technical efficiency overall technical efficiency of the marine terminals, while Data Envelopmental Analysis (DEA) was used in the assessment of the relative performance of the marine terminal operations under the fuel subsidy regime period under study.

## 1.2 Problem Statement

Can perennial fuel scarcity and price hike ever be averted in Nigeria, given that Nigeria operates an unmonitored fuel subsidy reform; a distorted petroleum supply and distribution network that is dependent solely on tanker vessels, marine terminal-jetties and Bulk Road Vehicles for fuel supply and distribution?

The supply chain network saddled with the responsibility of supply and distribution of petrol in Nigeria is prone to huge delays, product losses due to displacement, corruption, high cost and other constraints. This structure has hampered the efficient supply and distribution of the refined petroleum in Nigeria which is reflected in the perennial fuel scarcity in Nigeria, coupled with the constant unexpected distortions on the global petroleum supply network which has exposed the system to numerous and dynamic uncertainties, for instance, COVID 19 pandemic, the ongoing Iranian oil industry sanctions, China-United States Trade War, and Ukraine- Russian war, etc. These constraints have consistently threatened the world economy through its effects on the maritime logistics network. Fuel scarcity, oil price fluctuation, high transportation cost, and high negative externality costs have also compelled the global economies to adjust, reengineer and realign their trade policies locally and internationally so as to effectively and efficiently manage their resource allocation and product distribution occasioned by the rapidly changing global petroleum distribution network.

Some governments resorted to introducing the fuel subsidy reforms with the aim of ameliorating the hardship caused by these distortions on the global petroleum distribution network and the maritime logistics network. The fuel subsidy reforms also introduced its own constraints or limitations, such as bureaucracy, corruption and over regulation of the petroleum industry. This also have led to the reengineering and redesigning of operations by the petroleum companies so as to be able to survive under these conditions (Chayita & Kaseke, 2021).

Table 1.1 shows the industry's rating of core reasons for fuel scarcity challenges in Nigeria.

**Table 1.1: Rating of Core Reasons for Fuel Scarcity in Nigeria.**

| Variables | Fuel Subsidy Reforms | SC Infrastructural Defects | Global Market Distortions |
|---|---|---|---|
| **Percentages** | 100 | 90 | 85 |

**Source**: Researcher's Pilot Survey (2022)

Nigeria introduced fuel subsidy reforms some 50 years ago around the 1970s, but corruption, lack of accountability, transparency and politics have ridiculed the reforms and are declared by most scholars as having outlived its relevance. In fact, the inability of the Nigerian government to provide the statutory Organization for Petroleum Exporting Countries (OPEC) quota of crude at a time, is a case in hand. As earlier mentioned, Nigeria at some point, had fuel subsidy payment exceeding the actual revenue generated from the export of the same petroleum. This gross mismanagement by the Nigerian government has led to massive borrowing from lender countries and organizations for infrastructural development.

In Nigeria, where subsidies have led to acute and frequent energy shortages, the populace and their representatives who are adversely affected are demanding to understand the scale and incidence of subsidies in order to address the problem (Kojima & Koplow, 2015).

The question on the lips of Nigerians still remains how efficient is the government-managed marine terminals performing in the execution of its fuel subsidy reform policies to averting perennial fuel scarcity and price hike, as against its competitor, the privately-managed marine terminals in Nigeria?

This study evaluated the impact of fuel subsidy reforms on the supply chain performance of marine terminal operations with Cargo Throughput, Ship GRT, Ship Traffic, BRV Traffic, and Port Charges such as Cargo Dues, Ship Dues, as performance indicators of interest. This study also appraised the relative performance of the government-managed marine terminal as against the privately -managed marine terminals in the implementation or execution of the fuel subsidy reforms of government.

## 1.3 Aim and objectives of study

The aim of the research is to evaluate the impact of fuel subsidy reforms on supply chain performance of marine terminal operations.

Other specific objectives include;

1. To assess the effect of fuel subsidy reforms on cargo throughput.
2. To appraise the effect of fuel subsidy reforms on ship gross registered tonnage.
3. To gauge the effect of fuel subsidy reforms on ship calls.
4. To investigate the effect of fuel subsidy reforms on bulk road vehicle calls.
5. To estimate the effect of fuel subsidy reforms on cargo dues.
6. To examine the effect of fuel subsidy reforms on ship dues.
7. To evaluate the extent of change between Transient Technical Efficiency and Overall Technical Efficiency of marine terminals.
8. To investigate the relative performance of the public and privately managed marine terminals, over the implementation of the fuel subsidy reforms

## 1.4 Research Questions

The study will endeavor to answer the following queries:

1. What is the effect of fuel subsidy reforms on cargo throughput?
2. What is the effect of fuel subsidy reforms on ship gross registered tonnage?
3. What is the effect of fuel subsidy reforms on ship calls?
4. What is the effect of fuel subsidy reforms on bulk road vehicle calls?
5. What is the effect of fuel subsidy reforms on cargo dues?
6. What is the effect of fuel subsidy reforms on ship dues?
7. What is the extent of change between Transient Technical Efficiency and Overall Technical Efficiency of marine terminals?
8. What is the relative performance of the marine terminals subject to the fuel subsidy reforms?

### 1.5 Research Hypotheses

From the above research questions, the following hypotheses were developed to enable for appropriate data collection and statistical analysis guidelines for the research.

1. Ho1: There is no significant effect of fuel subsidy reforms on Cargo Throughput.
2. Ho2: There is no significant effect of fuel subsidy reforms on Ships Gross Registered Tonnage (GRT).
3. Ho3: There is no significant effect of fuel subsidy reforms on Ship calls.
4. Ho4: There is no significant effect of fuel subsidy reforms on BRV calls.
5. Ho5: There is no significant effect of fuel subsidy reforms on Cargo Dues.
6. Ho6: There is no significant effect of fuel subsidy reforms on Ship Dues.
7. Ho7: There is no significant change between Transient Technical Efficiency and Overall Technical Efficiency of marine terminal.

### 1.6 Scope of the study

The research data were for the period of 2012 to 2021. The choice of the selected marine terminals-jetties was premised on the time the jetties commenced Premium Motor Spirit (PMS) cargo operations and have remained in the receipt of PMS till date.

The study period witnessed the transition of 2 democratically elected governments that, adapted 2 different fuel subsidy reform policies in the bid to solving the perennial fuel scarcity in Nigeria.

This research focuses on the evaluation of the impact of fuel subsidy reforms on supply chain performance on marine terminal operations in Nigeria, with special emphasis on 3 public and 3 private marine terminals located within the 3 NPA pilotage districts in the Niger Delta Region of Nigeria.

The refined petroleum product of interest is the Premium Motor Spirit (PMS)-petrol.

### 1.7 Justification of the Study

The need for the monitoring of the unmonitored fuel subsidy reforms implementation on supply chain performance of marine terminal operations cannot be overemphasized as this exposes reforms/policy impact on Cargo Throughput (product availability), Ship Calls, Ship Gross Registered Tonnage (vessel patronage), Bulk Road Vehicle (BRV patronage), Port Charges (port revenue), marine terminal operators spending etc.

It is also very vital to actually ascertain if the reforms /policies are addressing the perennial fuel scarcity challenges. The findings from the monitoring of the marine terminals will further disclose the performance vis -a- vis the efficient utilization of the resources employed in executing the fuel subsidy reforms. Therefore, the result will inform the policy makers on the next policy direction such as to increase maritime terminal resources capacity, or complete elimination of fuel subsidy policies as the panacea to solving the perennial fuel scarcity in Nigeria.

The study of the impact of these policies on the marine terminal operations will also indicate to government whether, there is the need to license more industrialists to invest in certain area of the supply chain to avert perennial fuel scarcity in Nigeria.

Maritime terminals of choice in this study were selected based on the fact that the jetties commenced PMS cargo operations on or before 2012 and have maintained cargo operations until date. The selected 3 publicly and 3 privately owned marine terminals are located within 3 out of 4 Nigerian Ports Pilotage districts in Nigeria, that services majority of the Nigerian hinterland in fuel supply and distribution. The marine terminal operators have outlived 2 governments with different fuel subsidy reform policies.

However, this study has empirically evaluated the effect and relationship between fuel subsidy reforms and the supply chain performance of marine terminal operations in Nigeria. Which means that the study has successfully shown the relationship between government policy decisions and how it impacted the supply chain performances of marine terminal operations in Nigeria. It has also exposed the contributions of the marine terminals in the implementation of the fuel subsidy reforms of government via the evaluation of the relative performance of the publicly and privately managed marine terminals over the period under review.

The monitoring of the impact of fuel subsidy reforms implementation, have assisted in the prevention of artificial product scarcity and service disruption as these can be spotted earlier before it becomes a bottleneck or constraint. Hence, product supply can be regular and uninterrupted at competitive prices, which will be beneficial to end users and government alike.

The constant devotion of material resources to the process of real-time data collection and analysis for the purposes of consistent monitoring of the reform outcomes, surely enabled great dividends through increased system transparency, accountability while also permitting informed decisions by policymakers for the public benefit.

Most importantly, the monitoring of the fuel subsidy reform implementation will aid further public trust and support for policy reforms, as transparency, effective communication and stakeholders' opinion are expressed in accountable domestic fuel price.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.0 Conceptual Framework

This study adopted mainly the concepts of fuel subsidy, fuel subsidy reforms, supply chain performance and marine terminal operations, other concepts included the concept of effectiveness and efficiency. These concepts were to expose the structure of the system under study and its peculiar relationship in the existential problems of the perennial fuel scarcity in Nigeria.

However, the desire by governments to ameliorate the fuel scarcity, have led to the consistent introduction of the fuel subsidy reforms without success. The understanding of the effects of fuel subsidy reforms on the marine terminal operations indicators was supposed to elicit remedial actions toward ameliorating the perennial fuel shortages and exorbitant price escalations of the product, but the unmonitored reforms have compounded the problems. Industry stakeholders have adjudged fuel subsidy as the major constraint in the achievements of regular fuel supply in Nigeria. This is due to lack of monitoring of the performance of the marine terminal operations indicators, subject to fuel subsidy reforms as expressed through the alteration of the official petrol pump prices (price control), control of quantity for crude swap-or imported domestic quantity for consumption, control of entrants of product supply vendors/traders, and the yearly subsidy budgetary allocation and payments. The industry stakeholders explained that subsidy in itself is not a problem, but corruption and mismanagement of the resources under the guise of subsidy is the crux of the problems.

This study is of the opinion that, the relationship that exists between fuel subsidy reforms and marine terminal operations is based on the perception that product availability can summarily be ascertained through the supply chain performance indicators as will be captured during the marine terminal operations at the jetties in the Nigerian context. The impact of the fuel subsidy reforms on the domestic consumption rates of petrol in Nigeria amongst other parameters, can be monitored, measured and evaluated through these marine terminals-jetties, given that these jetties provide most of the vital parameters on product supply and distribution such as ship calls, cargo throughputs at the tank farms, ships gross registered tonnage, BRV calls and other Port Charges (i.e. Ship Dues, Cargo Dues, etc). The marine terminal operations parameters used in this study are based on the indicators as captured in the Nigerian Ports Authority (NPA) Tariff for liquid bulk operations. Other indicators are those government policy reform parameters such as Annual Subsidy Payment, Official Petrol Price, Daily Swap Quantity, and Number of Swap Vendors as captured by Nigerian National Petroleum Company (NNPC), Nigerian Extractive Industries Transparency Initiative (NEITI), Central Bank of Nigeria (CBN) reports etc.

## 2.1 Concept of Fuel Subsidy

Kojima & Koplow (2015), defines "subsidy for fossil fuels as a deliberate policy action by the government that specifically targets fossil fuels, or electricity or heat generated from fossil fuels, and has one or more of the following effects:

A. Reducing the net cost of energy purchased.

B. Reducing the cost of production or delivery of fuels, electricity, or heat.

C. Increasing revenues retained by resource owners, or suppliers of fuel, electricity, or heat".

The definition of the word "subsidy" is said to be fragmented, highly aggregated and incoherent; Sometimes also termed broad, narrow, ethical, unethical, legal or illegal (UNCTAD 2015).

However, subsidies are supposedly a thoroughly thought-out policies which if not adequate will lead to erosion of the low-income earners in the country while also impacting negatively on the overall economy of the country (Kruger, 2023).

The word "subsidy" originated from the French and Latin meaning "help and aid". Its Latin word "regium donum" means "royal gift" or "royal charity". (www.vocabulary.com). It was first introduced in Ireland in the year 1690 by English King William III as a reward for the Presbyterian support, during his battle with former King James II. It was an annual or yearly grant paid to the needy of the nonconformist and the ministers of the Presbyterians, Baptist, independent ministers, widows to these ministers, etc. This subsidy was later discontinued in 1869 due to mistrust based on its political implication to the church (Crammer, et al., (2006)).

Hence, subsidies were referred to, as protectionist doctrine in the form of welfare packages designed to ameliorate or mitigate the inequality in the distribution of national income and wealth as inflicted by free market forces (Crammer, et al., (2006)).

Subsidy is an ancient practice engaged by many nations but at a globally high cost. The provision of subsidies by different governments are as a result of numerous reasons (World Bank, 2022). They are served as waivers, grants, concessions, and tax exemptions from government to certain demography of the population (Organisation for Economic Cooperation and Development (OECD) 2022).

Oxford Online Dictionary defined subsidy as "a sum of money granted from public funds to help an industry or business keep the price of a commodity or service low".

According to (Oyedeji, 2021), subsidy is a fraction of price meant to be paid by consumers, being paid instead by the government to alleviate the burden of the consumers. It is actually a deliberate policy of government by way of welfare stipends to reduce the economic disparities of a given society (World Trade Report (WTR), 2006)).

en.m.wikipedia.org explained subsidy as government incentive or government expenditure targeted towards individuals, household and businesses with the aim of stabilizing the economy. Subsidies ensure that individuals and households have access to essential goods and services while remaining viable. It also ensures that businesses enjoy the opportunity of surviving, staying competitive and being profitable.

It is a government intervention to reduce costs for both consumers and producers by financially supporting productions while also encouraging the consumption of such subsidized consumables by consumers (OECD 1998).

Some scholars have described government subsidy as a kind of government free financial transfer directly or indirectly to the subjects of microeconomic activities which enables firms to enjoy financial supports while also enjoying vintage position in a fiercely competitive domain which affects the direction of development and prospects of the firm (Meng (2021); Yang & Yang (2020); Xue & Gong (2019)).

According to (UNCTAD, 2012), subsidies are "financial contribution by a government or public institution or via government entrustment or direction of a private body (direct or potential direct transfer of funds; e.g., grant, loan, equity infusion, guarantee; government revenue foregone; provision of goods or services or purchase of goods; payments to a funding mechanism), or income or price support, which confers a benefit and is specific (to an enterprise or industry or group thereof, or limited to a designated geographical region)".

However. United Nations through its subsidiary United Nations Development Programme, (UNDP) advised that energy subsidies need to be defined precisely and also consistently assessed or evaluated for the purposes of effective monitoring of the implementation outcomes. They also observed that subsidy definition is also crafted based on the status of the country involved. For instance, the definition given by fuel exporting countries and that of fuel importing countries are slightly different. Hence, their evaluation and accessibility are also different.

According to the definition by Organisation for Economic Cooperation and Development (OECD), International Energy Agency (IEA), and International Monetary Fund (IMF), the existence of a subsidy is basically when fuels consumption taxes are lower than the taxes applied generally more on other goods and services. It is seen as when a particular fuel is officially sold lower than the accurate reference market price (UNDP).

For instance, IEA defined subsidy as the price-gap amount that exist between end user price and the reference price (landing cost/ international price). Inotherwords, subsidy = (reference price – End-user price) multiplied by units consumed (IEA 2010).

(McCulloch, Moerenhout, & Yang, 2015), defined fossil fuel subsidies as fuel consumption times the price gap between existing and efficient prices (including environmental costs).

According to Article XVI of General Agreement on Tariffs and Trade (GATT, 1994), "Subsidy is comprehensively explained as existing if:

A (1) there is a financial contribution by a government or any public body within the territory of a member (referred to in the agreement as "government"), i.e., were

i.) A government practice involves a direct transfer of funds (e.g. grants, loans, and equity infusion, potential direct transfers of funds or liabilities (loan guarantees);
ii.) Government revenue that is otherwise due is foregone or not collected (e.g., fiscal incentives such as tax credits);
iii.) A government provides goods and services other than general infrastructure or purchases goods;
iv.) A government makes payments to a funding mechanism or entrusts or directs a private body to carry out one or more of the type of functions illustrated in (i) to (iii) above which would

normally be vested in the government and the practice, in no real sense, differs from practices normally followed by government OR

A (2) there is any form of income or price support in the sense of Article XVI of GATT 1994; and

B. a benefit is thereby conferred" (Garsous, (2022); OECD Report).

The measurement of subsidy is a continuous process that involves adjustments while its implementation and effect tracking must also be consistent (Kojima & Koplow, 2015).

### 2.1.1 Reasons for Subsidies

According to Atansah, Khandan, Moss, Mukherjee, & Richmond (2017), the reasons for subsidy by government are numerous and could include, to financially reduce the bottlenecks or constraints concerning the consumers inability to purchase certain goods and services, such as health care, education, etc.

Subsidies could also be introduced by government to skew the production and consumption of certain goods and services to certain directions for desired purposes such as to encourage growth in certain sectors or industries. This is achieved by basically reducing the cost of production inputs for producers.

According to Schwartz & Clements, (1999), subsidies are applied to promote long term economic stability while also assisting the government in reacting to economic shocks occasioned by natural disasters, war, pandemics, and economic recessions. They are also good in mitigating against imperfect market conditions, when rational and competitive companies refuse to manufacture an optimal market outcome. The policy compels more industries entrants and the older firms to produce more positive externalities that will benefit the individuals that work in the companies, the company and the country at large.

Subsidies can encourage or discourage international or global interaction and integration through trade. It also affects the decisions concerning domestic resources allocation, expenditure productivity, and even income distribution (Schwartz & Clements, (1999)).

According to Kojima & Koplow (2015), the reasons for subsidies definition, identification and quantification are specific to the countries and the stakeholders involved. They claimed that some of the motives are driven by the costs, allocative efficiency, execution efficiency, and transparency of government spending programs.

### 2.1.2 Classification of Subsidies

The classification of subsidies is adjudged complex because government aids are executed in several ways, hence for the purposes of clarity and specification on how government monetary aid or interventions were made, categorization became necessary.

Scholars and stakeholders have given their different classifications of subsidies. (Guennette, 2023), classified subsidies as direct and indirect subsidies, while (Myer, 2008) adjudged subsidies as broad and narrow subsidies in one breath, and in another, included monetary and non-monetary subsidies. Bian, et. al., (2020) and (Timperley, 2021), categorized subsidies into production and consumption subsidies. Some other literatures included export subsidies, import subsidies, employment subsidies, tax subsidies and industry–specific subsidies amongst others earlier mentioned.

(I) **Direct Subsidies:** These are subsidies projected directly towards certain individuals, groups, firms, in the form of direct fund transfer, direct funding, direct tax giveaways or rebates, direct loans guarantee at favorable rates, price controls (Collins Dictionary of Economics, 2013). These are direct government expenditures in the form of tax incentives, soft loans, price support, provision of palliatives-provision of goods and services. They are governments' provision of resources such as land, water, petroleum to petroleum companies at prices below the market rates (Oil Change International 2021).

(II) **Indirect Subsidies:** These are subsidies targeted on certain activities of certain group in the form of price reduction as government support or rebate for such activities. These are government tax holiday to companies, they come as insurance, low interest loans, interest free loans, rent rebates, accelerated depreciation (Haley & Haley, 2013).

(III) **Production Subsidies:** These are government incentives to production or manufacturing firms to promote market price rebates, through donation of factors of production to encourage increased production of certain products (Myers & Kent, 2001). Production subsidies are economic tools applied mostly by developed countries. Its major challenge is the over production of the goods which in turn leads to obsolesce and high costs of storage. In the petroleum industry, production subsidies are also termed exploration subsidies. This is the government support given to petroleum companies for the purposes of exploration, development, extraction and transportation. They are expressed as national subsidies, state-owned investments and public finance funding for fossil fuel production (Oil Change International 2021). Production subsidies include, e**nterprise investment scheme subsidy** (which are government financial support given for the creation of new companies.), **Regional policy subsidy** (which are also government financial support for the development of certain regions of the country to minimize the under service of those areas) and **industry policy subsidy** (which also is government intervention to companies to encourage the companies in the provision of grossly demanded goods and services such as water, food, electricity, and education to the citizens within their operational domains.) (Oil Change International Report 2021).

(IV) **Consumption Subsidies:** These are government reduction of the prices of goods and services to encourage consumption of such goods and services (Myers,1998).
Consumption subsidy is mainly adopted in the developing countries to increase consumer spending which help countries in depression or recession to come out of such conditions. It is an instrument of leadership that directs the populace to a particular pattern of behavior, hence, the subsidies on education, health, electricity, food, water (Myers, 2001).
Consumption subsidy is basically a demand shift as the subsidies are given directly to the consumers.

(V) **Export Subsidies:** According to Collins Dictionary of Economics, "export subsidy is a form of production subsidy from government, given to manufacturers of export goods to assist the government in balance of payments" (Haley & Haley, 2013). Export subsidy have been criticized from different quarters as a conduit for over declaration of produced goods, and also exported product round tripping which defeats the purpose for the subsidy by not creating the real trade value (Adam, 2019). However, the Chinese government succeeded in altering trade patterns using the export subsidy method.

(VI) **Import Subsidies:** These are categories of government financial aids given to importers of specific goods for the purposes of consumption of such brand of imported goods to promote industrialization. Import subsidy could be executed through the reduction of shipping cost of specific goods which in turn leads to the reduction of the cost of the goods. It is also applied in creating bilateral relations using the principle of comparative advantage and balance of trade. However, it is sparingly used because of its adverse effect on the domestic production of the same goods. In fact, it often leads to a decrease in production of same product locally (Suranovic, 2018).

(VII) **Employment Subsidies:** These are government incentive to businesses and business owners to stimulate the creation of more jobs thereby reducing unemployment in the country. The financial aid is given to institutions to promote expert research and development in certain industries within the country for the purposes of averting freighting of foreign reserves to other countries. For instance, medical tourism. It is also an incentive that emboldens the employer-employee relationship, even when the employee is dormant and company is unproductive due to national economic crisis, he gets paid (Kim & Lee, 2019). The employment subsidy is a measure to stop job losses, preserve annual leave and retirement entitlements of workers even during downtime due to national crisis (International Labour Organisation (ILO) 2023).

(VIII) **Tax Subsidies:** Tax subsidies are strong, popular, and powerful tools of governments used to execute policy objectives such as job creation, economic growth and environmental sustainability. Tax subsidy is given by government to businesses to lessen their financial burdens and promote their productive capabilities. They come as tax breaks to groups of individuals or businesses in the bid to achieving certain outcomes without directly paying cash. It is a government strategy used to instigate business owners and consumers alike to a certain direction of production and consumption of the country. They come as education tax, health tax incentives, intellectual property tax incentives. Base Erosion and Profit Shifting (BEPS) – (this is a kind of tax subsidy that entails an individual or companies to move their profits to low tax jurisdictions for the purposes of reducing their general tax exposure or burden) etc. The tax subsidy is actually less transparent, difficult to monitor and implement as most nations are against it because of its propensity to fraud and abuse. It is also criticized as a subsidy that enlarges the inequality gap, as it is seen to benefit the wealthy and the large corporations. Tax breaks have actually led to the collapse of certain competitive industries and have encouraged monopoly in such market (www.indeed.com).

(IX) **Transport Subsidies:** Transport subsidy is one of the examples of industry-specific subsidies. It is the direct financing and operation of public transportation by government reduce road traffic congestion and air pollution arising from many cars on the road. The European Union and Chinese are presently operating on rail transport subsidies (European Union (EU) Technical Report 2007). It also includes the investments on roads and highways infrastructure from general revenue and not through road toll collection. It is observed that Germany's long haul buses enjoy the transport subsidy.

(X) **Housing Subsidies:** The housing subsidy is a government intervention fund to real estate companies to provide houses for the populace. It is also an instrument of government to support the construction industries in the bid to encourage home ownership. They are often expressed as assistance for down payments and interest rate through mortgages (Amadeo, 2018). The housing subsidy can also be expressed as tax holiday or import subsidy on the building materials to encourage home ownership.

(XI) **Energy Subsidies:** This is another type of industry-specific subsidy. Energy subsidy is often very huge, as the sector remains the major growth driver of most economies of the world (International Renewable Energy Agency (IRENA) report). According to (Timperley, 2021) in the work titled "Why Fossil Fuel Subsidies are so Hard to Kill" she posits that energy subsidies are government measures that is directed towards keeping prices of consumables below market price. Energy subsidies are government support to petroleum industry for purposes of fossil fuel exploration. It is also the government payments for energy consumption of its citizenry to stimulate small and medium scale enterprises. It is also a financial aid to encourage investment, research and development in renewable power generation companies. It is also government tax rebate to biofuel management companies and the funds support to nuclear operations companies. The fossil fuel subsidies enjoy about 70% of total energy subsidy payments, renewable power generation subsidies got 6%, biofuel got 6%, and 3% for nuclear (as cited by Jocelyn Timperley 2021). In fact, the global fossil fuel subsidies alone are estimated to be $1 trillion in 2022 (IEA Report 2023). Energy subsidies are executed as direct cash transfers to suppliers, consumers or related bodies. They can also be executed as indirect support through tax exemptions, rebates, price control, trade restriction, and limit on market access.

**(A) Fossil Fuel Subsidies:** Fossil fuel subsidies are actually the government support to the production and consumption of coal, petroleum oil and natural gas. According to Global Subsidy Initiative (GSI), fossil fuel subsidy is any action by government that lowers the cost of fossil fuel energy production, raises the price received by energy producers, or lowers the price paid by energy consumers (GSI Report 2021). It is also distinguished into implicit and explicit subsidies (International Institute for Sustainable Development (IISD) Report 2023; IMF 2023).

1. **Explicit fossil fuel subsidies:** They are governments' direct support to petroleum companies in petroleum, coal, and gas exploration and development. They are supports to producers in the form of accelerated depreciation of production machinery. In other words, they are capital cost allowances that come as tax incentives, grants, deductions, etc. given by government to production companies to reduce their costs of production during exploration (Lyman, 2023). It is said to have occurred, when regulated retail price of good is below international supply price of that good (IMF report 2023).

2. **Implicit fossil fuel subsidies:** They are under-charging of producers for environmental harm to a third party as a result of the producer's exploration and production exercise. It is also said to occur when retail price of goods fails to include external costs, inclusive of standard consumption tax (IMF 2023). The implicit subsidies are supposed environmental costs that, should have been borne fully by exploration companies, for the harmful externalities they discharge into the public space that causes adverse consequences, global warming, climate change, environmental pollution, death as a result of these (Lyman, 2023). The consumption taxes like value added tax, sales tax, carbon taxes are said to be undercharged and does not compensate enough for these harms. According to (Myer, 2008), they are classified under broad subsidies which are difficult to identify because they are less transparent and attributable.

### 2.1.3 Cost of Fossil Fuel Subsidies

The fiscal and social cost of fossil fuel subsidies are often very huge expenses made by governments from tax payers' funds and in most cases termed as undesirable. However, the explicit fossil fuel subsidies are bigger with developed economies than in developing economies. For instance, in 2014, the G20 governments commenced the funding of Oil and Gas companies with over $444 billion of public funds yearly, this was championed by USA and Russia for the purposes of exploration. According to IISD 2023 report, the G20 countries' explicit fossil fuel subsidies rose to $1 trillion in

2022. These massive funding by G20 governments were done through the Multilateral Development Banks (MDBs), bilateral financial institutions, for instance, the United States of America uses the World Bank, the Export-Import Bank, and Overseas Private Investment Corporations to finance fossil fuel companies for purposes of exploration. These spendings also include the cost of the deployment of military infrastructure and its maintenance to such exploration domains for purposes of securing their offshore investments.

However, these investments also come with huge social costs. The social costs are “unpaid” negative externality costs or implicit fossil fuel subsidies. The implicit fossil fuel subsidies are higher in developing economies because, most of the exploration investments done by the developed economies are within the domain of the developing economies, where these resources are natural and cheap. Compensations for the negative externalities caused by the exploration are meager or none existent. For instance, the French mining operations in Niger Republic is a case in hand. The US and UK Oil and Gas operations in Nigeria is another case that have left the country only with pollution and environmental degradation.

According to “The Malaysian Reserve”, IMF disclosed the result of their study on the implicit and explicit fossil fuel subsidies within 170 countries and the report showed that explicit fossil fuel subsidies for these countries rose from $500 billion in 2020 to $1.3 trillion in 2022 but their implicit fossil fuel subsidies which included the cost of impacts, environmental costs and failing of levying taxes on consumption, increased from $5trillion in 2020 to $7 trillion in 2022 (IMF, 2023).

These social costs associated with fossil fuel subsidies as disclosed in the above IMF report shows a huge increase of about $2 trillion. These costs from environmental externalities that brings about implicit fossil fuel subsidies remain detrimental to the general populace more than they benefit the general populace (Hope, et. al. 2015).

The high cost of these fossil fuel subsidies has led to a global call towards the phasing out of these fossil fuel subsidies. The delay of the global governments’ collective political will, coupled with governments’ struggle to recover from the economic recessions, COVID 19 pandemic, Russian invasion of Ukraine etc., have remained a major reason for the slow execution of the subsidies phase out process (IISD, 2022).

The zeal for the continuation of fossil fuel subsidies is hinged on energy security for the governments, which in turn becomes more of political security for such economies (Brower, et. al. 2022).

Fossil fuel subsidies has remained a political tool for demanding votes from the citizenry and support from international governments (Martinez- Alvarez, et. al. 2022). As long as the developed economies still control the resources of the developing economies, the phasing out of fossil fuel subsidies will continue until a time the fossil fuel is less useful as an energy resource.

According to Brower, et. al. (2022), fossil fuel subsidies still remain the government's economic drain pipe for the diversion of public funds from essential uses in the disguise of securing energy for the future (IMF 2022). Coady, Flamini & Sears (2021), posit that fossil fuel subsidies are undesirable from the standpoint of equity because they encourage the economic inequality gap amongst the citizenry. It has reduced economic welfare and caused inflation. Adenikinju, (2009) and Ocheni, (2015), claimed that fuel subsidy reduces household income and also hurts the nation's economic growth. (Bazilia & Onyeji 2012) posit that fuel subsidies have discouraged competition among companies that enjoy subsidies.

Del Granada, Coady & Gillingham (2012) studies across 20 countries, spanning from Africa, Asia, Middle East to Latin America, from 2005 to 2009, have confirmed that universal subsidies have always favored the higher income earners more than it favored the less income earners who are actually the reason for subsidy implementation.

IEA Report (2023) titled "Fossil Fuel Consumption Subsidies 2022 Analysis" further confirms that higher fossil fuel prices affect the vulnerable poor demography the hardest while benefiting the rich demography. IMF Report of 2022, disclosed that global implicit subsidies, comprising locally generated air pollution, climate damages, large road transport externalities /road accident, and forgone consumption tax revenue, contributed 30%, 30%, 17%, and 5 % respectively to global fuel subsidies, while explicit subsidies contributed 18% to the total global fuel subsidies. The report further unveiled that explicit fossil fuel subsidies were mainly operational in Middle East & North Africa (MENA), Europe, Commonwealth of Independent States (CIS), and East Asia & Pacific (EAP). But East Asia and Pacific (EAP) were exposed to both implicit and explicit fossil fuel subsidies.

The global devastating social costs from fossil fuel subsidy prompted a global awareness and call by international community for the phasing out of "inefficient" fossil fuel subsidies in 2009 at Pittsburgh immediately after global financial crisis of 2008 (Mendiluce, 2023). The United States of America and their G20 counterparts made this call with a phase out timeline for 2025.

The Paris Agreement ratified by over 190 countries in 2015, announced their resolve to support the limiting of global warming to a maximum of 2 degrees Celsius or lower. In 2015, the international community reiterated their resolve to reducing the cost by signing of the 17 United Nations Sustainable Development Goals in Geneva.

In 2016 at Ise Shima Japan, G20 affirmed that the year 2025 will be the fossil fuel subsidies phase out year. But, COVID 19 pandemic have further disrupted the timeline, as governments strive to recover from the impact of the pandemic.

In conclusion, the external costs of subsidies are far higher than its investment benefits in exploration. (Hope, Gilding & Alvarez (2015). The political will to phasing out fuel subsidy is hampered by the need for cheaper energy.

### 2.1.4 Fuel Subsidy Reforms:

Considerably, fiscal approaches have led to fossil fuel subsidies reforms as exemplified in the studies of Sdralevicket et al., 2015; Coady et al., 2015; Ebeke & Nguoana 2015; Jakob et. al., 2015; Salehi–Isfahani et al 2015 (as cited by Omotosho, 2019); Kojima & Koplow (2015).

According to IISD 2010 report, subsidy reforms as exhibited by countries, are unique to countries and could be implemented accurately or wrongly. A lot of developed and developing countries have long engaged in fuel subsidy policy reforms, of which most of the countries have been tracked by International Energy Agency (IEA) and International Institute for Sustainable Development (IISD). The countries include Angola, Argentina, Algeria Azerbaijan, Bangladesh, Brazil, Canada, China, Chile, Egypt, France, Ghana, India, Indonesia, Iran, Iraq, Italy, Kazakhstan, Korea, Kuwait, Libya, Mexico, Nigeria, Pakistan, Qatar, Russia, Saudi Arabia, Senegal, Spain, Turkmenistan, United Arab Emirate, United States of America, Ukraine, Uzbekistan, Venezuela, and Vietnam.

Fuel subsidy reforms as practiced globally is difficult to compare because the countries variables of subsidy are not standardized (OECD 201) (Kojima & Koplow (2015)).

Fuel subsidy reforms are addressed with 2 main approaches namely the price-gap approach and the inventory approach (Kojima & Koplow (2015)). Although 6 other reform approaches have been suggested by IISD 2010 namely: Research; Reform objectives and parameters establishment; Frames of progress definition; Monitoring and Evaluation.

However, in all the approaches, the price gap methodology has always stood out. The price-gap approach has been used in the quantification of consumption subsidies (Coady et. al., 2010; Larsen & Shah 1992; Kosmo 1987). It is a methodology that compares the average end-user prices as paid by consumers with the reference prices that is equivalent to the absolute supply cost of the product. The difference which is the gap indicates that the said product is subsidized to the tune of the gap amount. Hence, the basic calculation of subsidy for a product is:

Subsidy = {(Absolute Supply Cost or reference Price minus Official Pump price or End-user Price) multiplied by Quantity Consumed}

However, product quality is also a factor in the determination of the reference prices. The IEA, government agencies report and international crude price reports provide data on reference price at different times and regions.

Some scholars have argued that reference price of petroleum should be based not only on quality but cost of production as a net exporter of petroleum.

The price-gap approach for net importers and net exporters of fuel could vary slightly as some could be explicit or implicit subsidies in application.

For net exporters, "reference prices were based on the export parity price: the price of a product at the nearest international hub, adjusted for quality differences, if necessary, **minus** the cost of freight and insurance back to the net exporter, **plus** the cost of internal distribution and marketing and any VAT. All calculations are carried out using local prices and the results are converted to US dollars at market exchange rates." (IEA Report)

Net exporters who subsidies the domestic consumption of fuel, could be termed as enjoying implicit subsidies when there is no budgetary effect on that consumption but, rather the consumption/payment is based on the local cost of production of the fuel. Therefore, it is adjudged as opportunity cost of pricing domestic fuel lower than the international market price. Meaning that other costs associated to the international market price which involves freight/ transportation costs is excluded.

For net importers, “reference prices are based on the import parity price: the price of a product at the nearest international hub, adjusted for quality differences, if necessary, **plus** the cost of freight and insurance to the net importer, plus the cost of internal distribution and marketing and any value-added tax (VAT). VAT was added to the reference price where the tax is levied on final energy sales, as a proxy for the tax on economic activities levied across an economy. Other taxes, including excise duties, are not included in the reference price” (IEA report).

For net importers, the price -gap approach of measuring subsidies is seen as explicit, when it is assigned a budgetary estimation and expenditures arising from the domestic subsidized sale of the imported fuel. Though the net importers could sometime be subject to operating as implicit subsidy. This is basically for countries that produces fuel domestically while also augments/supplements domestic fuel consumption by importing fuel e.g., Indonesia, USA etc. hence, their subsidy estimates capture both the direct expenditure and the opportunity costs in measuring subsidies. The assumed refined petroleum product transportation cost is dependent on the various country distances from the nearest hub. However, the average refined petroleum hinterland distribution and sales cost is assumed to be equal to the cost in United States of America. These average costs are reported in the industry reports.

Price-gap approach is actually a great methodology applied in estimating subsidies while also comparing subsidies across countries. However, it is limited in approach as it does not capture total subsidies such as research and development, production subsidies etc. which would have included economic impacts and efficiency.

Fundamental challenges to measuring fossil fuel subsidies should not be underestimated. Various methodologies are commonly used to assess the magnitude of energy subsidies. Benchmarking subsidies against the price of internationally traded fuels, which is the basis of the price-gap approach, is attractive because of its conceptual and technical simplicity. However, this approach may be complicated when there is no clear international benchmark or where significant adjustments are required to better determine a proxy for the value of specific fuels in local markets.

It is particularly important to adjust for freight costs and differences in energy density as well as Sulphur and ash content. As the price gap cannot be calculated, the subsidy cannot also be determined (UNDP).

### 2.1.5 Fuel Subsidy Reforms in Nigeria

During the Olusegun Obasanjo tenure as Head of State, he introduced the fuel subsidy regime through the Price Control Act of 1977 as a result of the international oil price shocks of 1973. This international oil price shock inspired the government toward cushioning the hardship as a result of the oil price increase. At this period though, there was no challenge of petrol scarcity, but there was the challenge of product price hike due to hike in international market price of petroleum.

However, this earlier challenge has metamorphosed into complex multiple challenges of product scarcity, product adulteration, product price hike, etc. leading to multiple regulations. In fact, according to (Ogbuigwe 2018), in his work titled "Refining in Nigeria; History, Challenges and Prospects", asserted that the petroleum supply chain in Nigeria is faced with the major challenge of continuous regulation of the downstream sector by the government.

In the petroleum rich developing economies like Nigeria, studies on fuel subsidy reforms are available as seen in the works of Adenikinju, 2009; Adeniyi et. al.,2011; Bazilia & Onyeji, 2012; Berument et. al., 2010; Coady et al., 2017; Krane & Monaldi, 2017; Umar & Umar, 2013 ; Omotosho, 2019) etc. due to the complex nature of the challenges facing the petroleum industry in Nigeria.

In the bid to solving the perennial fuel scarcity challenge, the government of Nigeria have continually altered the fuel subsidy reforms template (i.e., annual subsidy budgets, official petrol pump price, number of supply vendors, and daily swap imports) (PriceWaterCoopers PWC 2012).

These fuel subsidy reform mechanisms by government as administered and operated by Nigerian National Petroleum Corporation (NNPC) and other oil marketing companies still failed in the provision of constant and affordable refined petroleum product to Nigerians.

What is then fuel subsidy reforms?

Fuel subsidy reform, is the fiscal approaches that reduces the price of petroleum products below their supply cost (international market price) thereby making the petroleum more affordable to end users (Rentschler & Bazilian (2017), (IMF 2022).

The petroleum industry in Nigeria have undergone the listed fuel subsidy reforms:

1. Open System Import Account (OSIA)
2. Offshore Processing Agreement (OPA)
3. Refined Petroleum Exchange Agreement (RPEA)
4. Direct Sales Direct Purchase agreement (DSDP)

#### 2.1.5.1 Open System Import Account Policy reform:

The open system imports account policy commenced in 2008. This policy was a contractual agreement of importing refined petroleum products to meet domestic needs, where some fuel importers-traders delivered refined products (fuel) to Pipelines and Products Marketing Company (PPMC), a subsidiary of Nigerian National Petroleum Corporation (NNPC) in exchange for cash (PriceWaterCoopers (PWC) 2014).

This reform was introduced to support the NNPC in meeting the domestic need for refined petroleum product as the refineries had already started showing signs of unproductivity. Due to mismanagement in NNPC, with a debt overrun of over 3 billion dollars owed to fuel importers, coupled with the 80% decline in local refinery capacity, the open account import account policy was scrapped in 2010-2011.

#### 2.1.5.2 Offshore Processing Agreement (OPA) reform:

This is the agreement between NNPC and companies with the sole purpose of processing crude oil into specified refined petroleum products. NNPC allocates crude meant for the domestic consumption processing, to companies to be refined to augment domestic supply. The companies engaged by NNPC were mandated to have access to refinery facilities overseas and will be capable of processing the crude oil and delivering the related refined products to NNPC on Cost Insurance Freight (CIF) basis. In simple term, Under OPA, the contract holder, either a refiner or trading company, is supposed to lift a certain amount of crude oil, refine it abroad, and deliver the resulting products back to NNPC. The contracts laid out the expected product yields (i.e., the respective amounts of diesel, kerosene, gasoline, etc.) that the refinery will produce. The refining company can also pay cash to NNPC for any products that Nigeria does not need.

In 2008, as fuel shortages worsened and the government trying to checkmate the scarcity, decided to issue a tender for an Offshore Processing Agreement (OPA) and succeeded in engaging British Petroleum (BP) an affiliate Nigermed later in 2009. In 2010, PPMC signed another OPA with the Ivorian state-owned refining company Société Ivoirienne de Raffinage (SIR).

The OPA crude oil quantity was 30000 barrels per day for a valid period of three (3) months. The refined petroleum minimum cargo size of 20000MT is to be exchanged within 25 to 45 days period. The late exchange of the refined petroleum by the company attracts a surcharge of USD$5 per Metric tonne. (after 45days from date of Bill of Lading).

Subject to the OPA, the NNPC pays the companies for crude oil processing / refining at the fee of USD$2.50 per barrel of crude oil. (OPA agreement)

However, the contract holders for the OPA contracts did not change between 2010 and 2014, with the exception of Nigermed, whose OPA ended in 2010 (PWC,2014). In other words, the contract metamorphosed to being a medium to long term engagement. The OPA was mismanaged as the country was regularly short changed by the contract holders. Product quality, quantity, lead-time, and cost issues remained prevalent leading to perennial fuel scarcity due to delays in reconciliation of trade deals between NNPC and the refiners.

While OPA was in place, the government through NNPC engaged in another form of contractual agreement termed Refined Petroleum Exchange Agreement (RPEA)

**2.1.5.3 Refined Product Exchange Agreement (RPEA) reform:**

The demise of the Open Account Import Account policy and the operational inefficiencies observed while operating the Offshore Processing Agreement (OPA) led to the introduction of a new policy in 2011 termed the Refined Product Exchange Agreement (RPEA).

The RPEA contract is simply, the trade by barter kind of exchange whereby crude oil is exchanged for refined petroleum products, rather than sold for money. The crude oil for the swaps is from the NNPC's 445,000 barrel per day (Domestic Crude Allocation) which is the volume of crude oil that is available for trade.

RPEA entails PPMC delivering its allocated crude oil for the purposes of domestic utilization / consumption to Duke Oil/ company on the Free on Board (FOB) basis while exchanging in return, refined petroleum from Duke Oil/ company at the loadport in Nigeria. The company supposedly is a proven petroleum trading firm saddled with the responsibility of delivering the refined petroleum to PPMC at a designated ports in Nigeria on a Cost Insurance Freight (CIF) basis within 30days of crude oil delivery to the company. The trading company is mandated to deliver to PPMC the refined petroleum product of equal value of crude oil it received from PPMC.

In other words, under the RPEA, crude is allocated to a trader, and the trader is then responsible for importing specified refined petroleum products worth the same amount of money as the crude, minus certain agreed fees and expenses, the value of which the trader keeps.

RPEA is a renewable contract of a 12 months period with a crude oil allocation quantity of 90,000 barrels per day to the trading company. The trading company is expected to deliver a minimum of 27000MT and a maximum of 38000MT as part or full cargo quantity of refined petroleum products to be delivered by company which should be based on the value of crude oil delivered by PPMC.

By early 2011, the government represented by NNPC subsidiaries (Duke Oil and PPMC) had signed four (4) RPEAs with commodities traders, namely Talaveras, Aiteo, Ontario, and Trafigura, to trade in that capacity (PWC 2014)

In late 2014, PPMC did not renew its RPEA with commodities trader Trafigura Behee BV. Duke's contract was reduced to 30,000 barrels a day, and Duke Oil transferred the contract to AITEO. In other words, between 2010 and 2015, the commercial model for refined petroleum supply was premised on the ambiguous and controversial oil-for-product swaps and offshore processing agreements.

Until NNPC signed a new policy of Direct Sale of Crude Oil and Direct Purchase of Refined Products (DSDP) contracts, worth up to 330,000 barrels of oil per day (b/d), in 2016 as mandated by President Muhammad Buhari on assumption to office in 2015, the joint approach of OPA and RPEA were still operational.

#### 2.1.5.4 Direct Sale of Crude Oil and Direct Purchase of Products (DSDP) reform:

In 2016 Direct Sale of Crude Oil and Direct Purchase of Refined Products (DSDP) reform replaced the Offshore Processing Agreement (OPA) and the Refined Petroleum Exchange Agreement (RPEA) that provided the commercial template for previous oil-for-product swap deals in Nigeria.

However, the 2016 DSDP, was conceived to improve transparency along the supply chain, though structurally, the same with previous oil-for-product swap deals, except for clearer terms and tighter rules for timely accountability and trading transparency (PWC 2016).

This policy is subject to review within 3 months at most 24 months as the case may be. They were structured as short-term contracts with the consideration of international oil price fluctuations.

In a bid to ensuring the sustained supply of refined petroleum products in the country, the NNPC signed crude-oil swap deals with both local and international traders under DSDP reforms. The reform came into effect in June 2017 and were due to end after 12 months. However, the DSPS reform is still operational up until 2022 (Oyedeji, 2022).

The successful completion of the first agreement and its resultant impact on the refined products availability during the period led the NNPC to roll over swap contracts worth about $6 billion by six months until the end of 2018.

NNPC has awarded 15 consortia the right to lift Nigeria crude's oil under the Direct Sale, Direct Purchase (DSDP) Agreement, for a 12 months period, effective 1 October 2019. About 90% of the refined petroleum products consumed in Nigeria were imported, with the DSDP contracts accounting for approximately 70% of Nigeria's refined products supply (Alawiye, (2019)).

The fuel subsidy reforms by the Federal Government of Nigeria was accompanied by the changes in the official pump prices and also the budgetary allocations for fuel subsidy. Despite all these reforms, the challenges of the refined petroleum scarcity still persist and NNPC still remains the sole supplier of petrol for domestic consumption in Nigeria. The fuel subsidy reforms have never achieved its aim of consistent provision of affordable refined petroleum products to Nigerians (Oyedeji, 2021).

Ogbuigwe, (2018), also posit that fuel subsidy reforms have led to the scaring away of investors in the product supply chain system; it also has led to economically unprofitable refining; creation of inefficient markets; encouragement of rent seeking and smuggling; (product adulteration and economic sabotage) in Nigeria.

The main objectives for fuel subsidy reform in Nigeria is to lessen the financial burden or cost of goods for certain products for certain demography of the country (Oyedeji, 2021), while also protecting the low-income earners households and promoting domestic enterprise (Omotosho, 2019).

But this have not been effectively achieved because of sabotage and gross documented corruption by the stakeholders overseeing the product supply chain. E.g. the Malabu scandal amongst other corruption reports in the petroleum sector (Oyedeji, 2021).

However, the need to periodically evaluate the impact of these fuel subsidy reforms for the purposes of accountability and transparency along the supply chain will further prevent fuel scarcity and promote supply chains' continuous improvement.

This agrees with the position of IMF Report, (2008), titled "Fuel and Food Price Subsidy, Issues and Reform Options" where they suggested that evaluating fuel subsidy reform is vital to assess their impact on the efficiency of resource allocation, resource distribution, fiscal burden and their spillover.

The resource allocation and distribution index make the supply chain performance measurement a very vital component of making the fuel subsidy reform empirically assessable; while also encouraging continuous improvements in product supply (IMF 2008).

The frantic attempt to having a universally accepted understanding of the terms and methods of subsidies calculation will promote a healthy comparison of countries and sectors subsidies, which can lead to price benchmarking while also evaluating policies on subsidies and their impacts (Kojima & Koplow, 2015).

For instance, PPPRA Subsidy Cost Build Up Template has variables such as: FOB Rotterdam Barge, Freight Rate Cost of petrol plus freight (offshore Nigeria), Lightering Expenses, Insurance Cost, NPA Cost, NIMASA Cost, Jetty Throughput Charges, Storage Charge, Financing/Cost of Fund, Landing Cost, Wholesale Margin, other Distribution Margins include Transporters Allowance (NTA), Retailer Margin, Dealer Margin, Bridging Fund, Marine Transport Average (MTA), PPPRA Admin Charge (PPPRA Report, 2020). This template is also adopted by the Ghanaian government for the management of the country's subsidy regimes though with a little alteration.

### 2.1.6 Fuel Subsidy Reforms of some Countries

The Iranian government advertised its reform program as a redistribution scheme that would help the poorest households instead of threatening to simply phase out or eliminate subsidies, as with botched reform attempts in the past. January 5, 2010, the Iranian parliament passed the Targeted Subsidies Reform Act which was their government plan to phase in reform pricing and redistribution over the course of a five-year period, and the revenue from price increases was estimated to be US$20 billion in the first year of reform. The policy was to adjust fuel prices to 90 percent of the FOB Persian Gulf level and help equilibrate Iran's pricing to its neighbors' rates and diminish black market incentives.
Another key to Iran's reform policy was the government's ability to ensure cash transfers were distributed to households before prices increased. At about US$45 per household, the transfers were considered generous enough to mitigate any economic shocks. The Iranian banking system also played a critical role in the reform policy rollout as banks collectively opened an estimated 16 million new accounts to enable all eligible households to access their transfers. Additionally, the banking sector upgraded its infrastructure and payment systems to guarantee seamless access to accounts as reform pricing took effect. Finally, banks expanded the ATM network to include many rural regions which did not previously have ATM access
Siddig et. al., (2014) tested the effect of fuel subsidy reforms on fiscal planning of countries. The studies disclosed that, fuel subsidies distort fiscal planning of countries. The study further revealed that, the fuel subsidy reduction, led to increased GDP and reduced household income of the countries.
In 2018, China made a profound move to enforce fuel subsidy reforms by legislating against any local and /or international companies capable of causing high pollution and carbon emission within her domain. This move by China have redefined the phasing out of only "inefficient" fossil fuel subsidy and the complete redesigning of the policy to properly carter for the poorest in the demography (George & Urpelainen, (2021)).

In 2021 at Glasgow, the group of 7 advanced economies-G7 (made up of Canada, France, Germany, Italy, Japan, UK, USA, European Union) and the group of 20 countries bonded by global challenges - G20 governments which comprises of European Union, African Union, Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, Saudi Arabia, South Africa, South Korea, Turkey, the UK, and the USA) during the 26$^{th}$ Conference of the Parties to the

United Nations Framework Convention on Climate Change termed (COP 26 summit) reiterated their firm commitment in the phasing out agenda of fossil fuel subsidies, in which 20 countries pledged to desist from financing fossil fuel projects abroad through their international finance corridors. In the same summit also, 157 countries pledged to accelerate the process of fossil fuel phase out.

The same commitment was repeated at the COP 27 of 2022, with a caveat that financing of petroleum project can only be based on a firm promise that it has to be in consonance with the terms and conditions that externalities will be within the 1.5 degrees Celsius warm limit, which is in tandem with the Paris Agreement (OECD 2022).

Global Subsidies Initiatives (GSI) exposed global threads by countries in compliance to the phasing out of fossil fuel subsidies in their domains. For instance, 53 countries embarked on fuel consumer reforms through increased taxes on fossil fuel while 34 countries reformed their consumption subsidies, 14 countries increased their fossil fuel taxation, while 7 countries adopted both techniques.

According to IMF Report 2022, the study disclosed that the fuel price reforms through reduction in fossil fuel subsidies, elicited a steady reduction in the projected global carbon dioxide emission. Meaning that fuel price without subsidies will drastically eliminate Co2 emissions. This discovery has led countries to the adoption of fuel price and tax reforms for a systemic phasing out of negative externalities.

Jones, (2023), posits that the G7 governments can implement the phasing out of fuel subsidies through decarbonization of their electricity system to 2035, stoppage of petroleum development financing, stoppage of international public finance for fossil fuel projects. But in the event that energy development must be financed which is only during desperate times, then it has to be under strict restriction and only for the purposes of alleviating the hardship of the poorest of the poor (IISD Report).

IMF advised that, if subsidies must be sustained in any country, then the fuel subsidy reforms must be redesigned to accommodate mainly the less income earners within a safety net measure (IMF 2021).

There are challenges existing in the subsidy reforms template as practiced by some countries which have led to strong economic inefficiency and fiscal argument basically on the application of standard consumption tax rates to energy products. For instance, Indonesia and Chile apply standard VAT rates to all fuel products; Iran applies a 1 percent VAT premium on kerosene and gas oil, but a 4 percent premium on Mazut used for power generation; France imposes a reduced VAT of 5.5 percent on electricity and natural gas, compared to the standard 20 percent) and Ghana introduced a special petroleum tax, equal to the standard VAT rate, in 2014.

Local energy prices may also vary widely, between Indonesia and Ghana, due to weak infrastructure, poor distribution channels and low population densities. (UNDP) (WBG (2017); Government of Iran (2008); EU Commission (2020); KPMG (2020)).

In Chile for instance, the metro fare was modestly increased due to cost of inputs and this affected the urban working poor adversely. However, the bus fares were increased by 10 pesos while metro fare at peak hour was increased to 30 pesos and at off peak hours fares are reduced by 30 pesos. The provision of an alternative transportation has also helped in ameliorating the choice and finance challenge of the working urban poor of Chile as the government further invested in new fleet of electric buses as alternative transport mode while also encouraging cleaner environment devoid of air pollution and incessant congestion.

According to Kojima 2015, the fuel subsidy reform applied by a net importer of fuel like South Africa is exemplified by the Department of Energy, which they claim that its reference price is realistic, and of market-driven costs of importing large portion of liquid fuel requirements (www.energy.gov.za/files/petroleum_frame.html). Hence, in South Africa, Basic Fuel Price is equal to Free on Board (FOB)+ Freight + Demurrage + Insurance + Ocean Loss + Cargo Dues(wharfage) + Coastal Storage + Stock Financing + Inland Transport Costs + wholesale margin + Retail Profit Margin + government taxes and charges. This is also similar to the model adopted by the Nigerian government.

FOB represents a combination of Mediterranean, Singapore, and Arab Gulf FOB prices which is dependent on the fuel type, price adjusted for gasoline octane number using linear interpolation freight.

The freight rate is subjected to a monthly assessment termed Average Freight Rate Assessment which is a function of the risks and supply and demand of ships transporting refined petroleum product internationally. Freight rate as published by London Tanker Broker Panel on the 1st January yearly. Demurrage is a rate published by the World Scale Association Limited, it has a total demurrage time limited to 3 days. Insurance is 0.15 percent of the FOB value and freight. Ocean loss is 0.3 percent based on the sum of the FOB+ Freight+ Insurance values.

Wharfage is the tariff by the South African National Ports Authority. Coastal Storage is the cost of providing storage and handling facilities at coastal terminals.

Stock financing is the cost based on the landing cost of refined petroleum products + stockholding of 25days + the ruling prime interest rate less 2 percent.

The reference price template as explained above is always subject to time queries, which is the time between observed FOB price and the time of effecting the official selling prices. These variables culminate at the marine terminals during marine terminal operations.

### 2.1.7 Supply chain Concept

What is supply chain?

Supply chain is explained based on its various structures, which is dependent on the type of products, activities and facilities that are involved before the end product is achieved. However, supply chain facilities in every structure comprises basically of suppliers, manufacturers, distributors, wholesaler, retailers and final consumers.

Supply Chain is a network between a company and its suppliers to produce and distribute a specific product to the final buyer. (www.investopedia.com).

Lutkevich (2021), explicitly defined supply chain as the network of all the individuals, organizations, resources, activities and technology involved in the creation and sale of a product.

George & Pillai (2018), defined supply chain as a network of members connected together by flows of inventory, funds and information with the objective to reduce overall system costs.

Lambert, et. al., (1998), defined supply chain as the alignment of firms saddled with manufacturing, supplying, transporting, warehousing, wholesaling, retailing to bringing products or services to market for the final consumer.

Considerably, Kozlenkova et al., (2015) and Nagurney, (2006) defined supply chain as suppliers' efforts to deliver goods or services to consumers by engaging activities, resources and technology, from organizations and people.

Steven (1989), elaborately defined supply chain as "a connected series of activities which is concerned with planning, coordinating, and controlling materials, parts, and finished goods from supplier to customer. It is concerned with two distinct flows of material and information through the organization"

Hugos (2011), simply defined supply chain as the stages involved in fulfilling a consumer's request directly or indirectly.

According to Christopher, (2012) and Asgari et. al., (2016), they defined supply chain as a set of firms connected via different activities and processes with the objective of creating value along the pipeline in the form of products and services with the objective of satisfying the desired expectations of their customers.

Maun et. al., (2021) agreed with Christopher, (2012) and Asgari et. al., (2016) that, supply chain is a series of value-adding activities existing between raw material supply companies and demand for end products (as cited by Karl et al., 2018).

Aitken et. al., (2005) and Naylor et. al., (1999) definition of supply chain, further revealed terminologies suitable for the concept of interest in this study. Aitken et. al., (2005), defined supply chain as the network of connected and interdependent organizations that work together to enable the flow of products into markets whereas pipeline is defined as the specific operational mechanism and procedures that are employed to service specific product/ market contexts.

Naylor et. al., (1999), defined supply chain as a system whose constituent parts include material suppliers, production facilities, distributive services and customers linked together through a feed forward flow of materials and feedback flow of information.

According to Beamon (1999), Supply chain is defined as a network of facilities and distribution options that performs the functions of procurements of raw materials, and these materials are transformed into intermediate and /or finished goods, and the finished goods are then distributed to the final consumers.

Micheal (2003), defined supply chain as an integrative process whereby raw materials are transformed or processed into finished products, then delivered to distributors, retailer and to the final consumers.

Christopher (1998), further and more specifically included also the terminologies of interest in this study also by the mention of upstream and downstream flows. He defined supply chain as the connection of companies or network of organizations involved in both upstream and downstream flows, in different processes, and activities to deliver products and services to the ultimate customer.

Mentzer et. al., (2001) also agreed with Christopher's definition of Supply chain as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer"

The above definitions show that petroleum sector's supply chain synchronizes perfectly into the supply chain concept. In fact, Alhosani, et. al., (2023) concurred that the petroleum industry is involved in a global supply chain that offers a classic model for implementing supply chain management techniques.

#### 2.1.7.1 Petroleum Supply Chain

What is Petroleum Supply Chain?

According to Tripathi, et. al., (2018), they described petroleum supply chain as comprising activities, which are geographically dispersed for exploration, procurement, transformation, storage, and distribution with transportation network linking facilities from one products flow to end customer through distribution channels.

According to Baiye (2020), the petroleum supply chain is a sequence of activities that source, transform and deliver petroleum products to end consumers.

Petroleum Supply Chain is a complex integrative processes of crude oil operation/purchase, crude transportation to refineries, refining operations, refined product purchase, refined product transportation, and distribution of refined product to final consumers.

The petroleum supply chain can be operated and owned by an owner/ government (as a vertically integrated owned system) (Fernandes et al., (2010), Pillai et al., (2010)) such as in Saudi Arabia, Nigeria etc. or it can also be owned and operated by different echelon owners of the petroleum supply chain (as a horizontally integrated owned system).

The petroleum supply chain is a complex system that comprises of 3 major integrative systems or sub-supply chains, namely upstream supply chain, midstream supply chain, and the downstream supply chain which is the main area of interest in this research.

The upstream supply chain processes include exploration, forecasting, production, and logistics management of delivering crude oil from remotely located oil wells to refineries. The downstream supply chain commences from the refinery, where the crude oil is processed into the crude oil derivatives/ consumable products PMS, AGO, LPG, Naphtha, bitumen, condensates, petrochemical etc. The downstream supply chain also involves the process of forecasting, production, and the logistics management of delivering the refined products /crude oil derivatives to customers around the globe (Husain et. al., 2006).

The downstream supply chain is the phase that interacts most with the final consumers who are expected to benefit from the completeness of the measurable or quantifiable value chain transfer by way of competitive price, excellent quality, improved quantity, constant availability, etc

#### 2.1.7.2. Supply Chain Performance

The actualization of supply chain management is from the concept of Supply Chain performance. According to George & Pillai (2018), the aim of supply chain is to maximize overall profitability (output) and it is calculated as the variance between Generated revenue from customers and total cost incurred across all stages of the supply chain. The more the supply chain profitability, the more successful the supply chain. Supply chain success is measured in terms of supply chain profitability and not in terms of just an echelon's profit. Hence, the success of any supply chain is dependent on supply chain strategy and the competitive strategy. Supply chain performance is the extended supply chain's activities geared towards meeting end customers' requirements which include product availability, on-time delivery in a responsive manner (Hausman, 2004).

Considerably, Supply chain strategy determines supply chain efficiency and responsiveness while its competitive strategy simply is the set of customers' needs that they seek to satisfy through the goods or services rendered. For a successful supply chain, the echelons need to understand their goal while also understanding their respective uncertainties and capabilities in relations to efficiency and responsiveness. The shift in global market competitiveness is now not between companies but between supply chains (Christopher, 2005).

Therefore, the success of supply chain performance is based on coordination, collaboration, information sharing mechanism along the chain for purposes of value creation (in a nutshell, information sharing details should include suppliers' capacity, customers demand, inventory levels of other echelons and inventory policies). It is also vital to note that other factors that affects supply chain performance include environmental factors or operating conditions and supply chain decision parameters or internal factors (George & Pillai, 2018).

Therefore, the concept that is responsible for monitoring and ensuring that there is continuous improvement in the process of supply chain management is termed Supply chain performance. Supply chain management can only remain efficient when the supply chain network is subject to monitoring and measurement for the purposes of continuous improvement to establishing the supply chain performance.

The importance of supply chain management therefore lies in the performance measurement endeavors of the system.

Trisnawati & Pujawan (2021), defined supply chain performance as "a measurement system that provides a formal definition of supply chain performance models based on mutually accepted steps, measurement methods that determine the procedures, responsibilities and accountability of supply chain players and the regulation of measurement systems by supply chain players" (Eccles & Pyburn 1992, Holmberg, 2000). For instance, in the works of (Hausman, 2002), companies' management are concerned about competitions hence, the skill to outsmart competition and competitors is by synergizing with consumers and suppliers alike who are outside the internal environment to achieve the satisfaction of the end users. Hence, system performance is no more on individual company performance but supply chain performance. The activities of product availability, and on time delivery, is now tied to group activities of collaboration across individual company boundaries for a win-win result for all participants in the supply chain.

Supply chain performance therefore is borne out of the alliance of companies across different boundaries involved in the transformation of raw materials through different components and activities to finished products for the benefits of the end user which entails functions like, procurement, exploration, refining, distribution, warehousing, marketing, sales and research and development, who are encouraged to add measurable value to the system and end users.

#### 2.1.7.3 Supply Chain Performance Measurement

Supply chain performance measurement (SCPM) has evolved over the years, as a very strong concept in the study of supply chain management. SCPM have undergone several processes and refinement over the years, since its introduction by scholars due to its numerous importance and justifications in today's world (Ferdoush, et. al., (2018)).

According to Kumar et al., (2020), Supply chain performance measurement (SCPM) supports holistic approach to decision making process, whereby top-level management eagerly strive to understanding the bottom-line impacts of their decisions while also monitoring the performance measurement parameters as reflected from finance, procurement, manufacturing, warehouse, distribution, customer services in the organization.

Furthermore, Gunasekaran et al. (2004) emphasized that, supply chain performance measures should be balanced on both financial and non-financial prisms and should be classified at the strategic, tactical and operational management levels.

Though, Sillanpaa, (2011) claimed that, there are no metrics for total supply chain performance measurement because metrics are developed separately for each case and industry.
Gunasekaran et al. (2001) posits that, supply chain management needs an effective performance measurement and the lack of it, is a major bottleneck in the achievement of efficient supply chain management (Lai et al. 2002).

Therefore, supply chain performance measurement, is a management tool that emphasizes on measurability of supply chain networks or supply chain web performance to achieving transparency on the conduits or channels for the purposes of monitoring continuous improvements of the system (Stefanovic, (2014)).

Holmberg, (2000) and Eccles & Pyburn (1992) defined Supply Chain Performance Measurement as a system that, provides a formal definition of supply chain performance model based on mutually agreed goals, metrics and measurement methods that specify procedures, responsibilities and accountability of supply chain participants and the regulation of the system by them. In achieving the effective supply chain performance measurement, all participants on the supply chain should agree on an effective performance measurement system which will be effectively communicated to stakeholders and participants in the supply chain for enhanced transparency in the whole supply chain (Simatupang & Sridharan, (2002)).

In furtherance to the assertions, of Simatupang & Sridharan, (2002); Holmberg (2000); and Eccles & Pyburn (1992), Hussain et al., (2019) summarized them by asserting that performance measurement parameters or metrics should be universally accepted in comprehensiveness, acceptability and steadiness as earlier mentioned.

Chan et al. (2006) further supports Simatupang & Sridharan, (2002) position that, the need for supply chain management to support continuous improvements and decision making (or policy reforms) gave rise to the need for an appropriate performance measurement system. Nedaa et al., (2012) stated earlier that, measurement is vital because, it affects directly the behavior that impacts supply chain performance. Researchers have also explained that, accurate performance measurement is beneficial and impactful to businesses for accurate and easy policy formulation, policy implementation, firms' strategic control, staff motivation and also in firms' culture retention. Hence, SCPM provides the means for firms to have access to confirming its supply chain improvement or degradation.

The monitoring of supply chain performance is achieved using qualitative and quantitative performance indicators.

The importance of Supply chain performance measurement is therefore critical to systems for the following purposes:

1. to achieve competitive advantage in their supply chain (Gunasekaran et al., 2004; Agrell & Hatami-Marbini, 2013)
2. to know how effective their operations is (daily cargo handled) which shows their capacity to meet customers' requirements (Neely et al. 2005; Parker, 2000; Gunasekaran et al., 2004)
3. to ascertain how efficient is their operations (what quantity of resources such as employees, equipment, surface area, cost etc. deployed in executing daily cargo handled). It shows how economical an organization utilizes its resources to meet customer's requirement.
4. to check and compare the pre-performance against post-performance of the organisation for continuous improvement on customer patronage and satisfaction while aiding the process of decision making (Parker, 2000).
5. to assess the rate of progress made towards achieving set targets or organizational goals (Parker, 2000; Gunasekaran et al., 2004; Bai & Sarkis, 2012).
6. to assess the increase in employee's motivation (Kaplan & Norton, 1992; Neely, 2005; Groen, Wouters & Wilderom, 2012).
7. to also benchmark their performance with their competitors.
8. to encourage continuous improvement in supply chain network through policy initiatives, policy implementation and policy target monitoring.
9. to expose the discrepancies existing between planning (Target/policy) and implementation (Actual/revenue), which leads to organizations taking corrective actions (Tripathi et al., 2018).

#### 2.1.7.4 Performance Measurement

What is performance measurement? Bititci et al., 1997; Melnyk et al., (2014), defined performance measurement as simple as the tool that gathers information of the performance of an organization.

Neely et al., (1995); (Neely, Gregory, & Platts, 2005) detailed performance measurement as the process of quantifying the efficiency (how a firm's resources is utilized economically to achieving a predetermined level of customer satisfaction) and effectiveness (the extent to which customer's requirements are met) of a given task or action (Nedaa et al., 2012).

Hellingrath (2008) agrees with the above definition as he also defined performance measurement as the measurement system used in the evaluation of effectiveness and efficiency of organizational structures, processes and resources of an entire supply chain.

Chan (2003), further elaborated more in his definition of performance measurement as an aim to improve customers' fulfillment requirement and achieve organizations' strategic goals through the provision of valuable information.

Bhagwat & Sharma (2007) agree with Chan (2003) as they also explained performance measurement as a tool that, exposes the need for operational improvements and ultimately gives feedback on operations which are tailored towards firm's objectives, firm's strategic decisions and customer satisfaction.

Rose, (1995) definition of performance measurement also concurs with the above assertions as she defines performance measurement as the process of evaluating performance in relation to defined objective, with a pathway to improvement.

The "defined objective" in Rose's definition could also include government objective (such as fuel subsidy reforms) which impacts the petroleum supply chain objectives of customers' satisfaction or product availability, for instance in places like Nigeria, Venezuela etc.

Abu-Suleiman et. al., (2004), summarized the importance of performance measurement system as follows:

a. Performance measurement drives organizational actions in 2 ways by asserting that:
    i. Monitored performance measurements enjoy high visibility within an organization and people strive to achieve high performance while using the measures as benchmark subject to being surpassed.
    ii. Identification of areas that need improvement spurs on corrective actions by management in such area.
b. Performance measurement provides the basis for evaluation alternative while setting decision criteria. The performance measurement system relevance is based on its target of optimizing its performance across multiple strategic, tactical and operational objectives.
c. Performance measurement should have a closed loop control structure such as feedback system which will provide necessary feedback information to communicate progress, diagnose problems, and identify opportunities for improvement while also testing the effect of different strategies in the system.

Notwithstanding the claims of Sillanpaa (2011), as mentioned earlier, Nedaa et. al., (2012), exposed that, some researchers (Beamon, 1999; Keebler, 2001; Gunasekaran et. al., 2004; Tangen, 2004; Ramaa et. al., 2009; Akyuz & Erkan, 2010; Kurien & Qureshi, 2011)) have studied the selection of the accurate performance metrics for supply chain systems and they are of the opinion that an effective SCPM system should be characterized by:

1. Inclusiveness: Covers all aspects and processes of a supply chain
2. Universality: Allows for comparison under different operating conditions
3. Measurability: Output is quantitative and can be measured
4. Consistency: Metrics are compatible with supply chain goals (as cited by Nedaa et al., 2012).

Several researchers such as (Lai et. al., 2002; Beamon, 1999; Keebler, 2001; Gunasekaran et. al., 2004; Parker, 2000; Lapide, 2000; Chan & Qi, 2003; Chan, 2003; Simchi-Levi et. al., 2002; Basu, 2001; Beamon & Ware, 1998; Bourne et. al., 2000; Bourne et. al., 2002; Dasgupta , 2003; De Toni &Tonchia, 2001; Gunasekara et. al., 2005; Gunasekaran & Kobu, 2007; Harrison & New, 2002; Kaplan & Norton, 2006; Kennerley & Neely, 2002; Kennerley & Neely, 2003; Kim, 2006; Kleijnen & Smits, 2003; Koh et. al., 2007; Landeghem & Persoons, 2001; Li et. al.,2005; Li et. al., 2007; Lummus et. al., 2003; Maskell, 1992; Martinez & Kennerley, 2005; Melynk et. al., 2004; Najmi et. al., 2005; Petroni &

Panciroli, 2002; Ren, 2008; Sahay, 2006; Shepherd & Gunter, 2006; Stewart, 1995; Suwignjo et. al., 2000; Talluri & Sarkis , 2002; Tian et. al., 2003 ; Vereecke & Muylle , 2006; Zhaofang et. al., 2006; Venkata,, 2007; Öztaysi & Uçal,, 2009; Agami et. al., 2011; Cirtita & Glaser-Segura, 2012; Tan et. al., 2011; Hall & Saygin, 2012; Agarwal & Shanka, 2005; Sarode et. al., 2009) concurred that, performance measures have to be measurable, non-conflicting and clearly defined across the supply chain along with many other characteristics (as cited by Nedaa et. al., 2012.)

The effective and efficient management of any supply chain to achieving continuous improvement should be through the close implementation and monitoring of the metrics of performance in the system.

According to Sink & Turtle, (1989), "anything that is measurable is manageable". Neely, (1998); Neely & Andy (2005) buttressed the above assertion by asserting also that, a claim of the knowledge of a system, is when you can measure and express such system in numbers, otherwise your knowledge of such system is limited and unsatisfactory.

Measuring performances of a system could be approached both qualitatively and or quantitatively in their planning, sourcing, making, delivering, timing, costing, quality, flexibility, and operationally or in combination of approaches.

According to Hussain et al. (2019), the performance measurement parameters should concur to standard features like comprehensiveness, universal acceptability, and steadiness with the capacity to adopt to other measuring tools (Ferdouch, & Habib, 2022).

The performance measurement of systems is of different characteristics, and dependent on the type of system that is evaluated. For a petroleum sector supply chain, systems like upstream, midstream and downstream are evaluated separately or totally as the need arises. The performance measurement of the marine terminal operations consists of both financial and non-financial metrics.

The performance measurement of systems is so vital in exposing and disclosing the health of the units of the systems, the state of the different systems in relation to each other and also how to improve or mitigate the units or systems in relation to each other (Matondang & Sitompul 2019).

According to Chan, (2003), performance measurement is a process of quantifying the effectiveness and efficiency of an action. The comparison of performance measurements on systems help to discover and identify a good supply chain.

Performance measurement is qualitative when there are no direct numerical measurement (.e.g product quality, customers satisfaction, supply chain vulnerability, supply chain resilience, supply chain vulnerability etc.). Performance measurement is quantitative when it can be numerically described. The quantitative performance measurement includes fill rates, costs, inventory levels, resource utilization (Beamon, (1999); Chan & Chan, (2005); Longo & Mirabelli,(2008)).

It is observed from literature that Chopra, et. al., (2010) and Pillai, et. al., (2013) used Supply Chain Fill Rate and Bullwhip effect (BWE) as one of the supply chain performance metrics. Pillai & Elluri (2013) used order variance ratio, total cost of the supply chain (TCSC) and bullwhip slope (BwSl) as performance metrics for supply chain. Other scholars such as Bayraktar, Lenny, Koh, Gunasekaran, Sari, & Tatoglu, (2008) used order variance and Bullwhip Effect (BWE) as supply chain metrics. Dominguez, et. al., (2014), applied inventory variance and zero replenishment phenomenon. Salvatore et. al., (2010) used risk of shortage while Pamulety & Pillai, (2011) used Total Cost of the Supply Chain (TCSC).

1. Supply Chain Fill Rate: This is the percentage of orders a company can fulfill without running out of stock. It is an indicator of order management, fulfillment efficiency and a company's ability to meet consumers or customers demand with their inventory level. It is service level metric of a company for a product without stockout or lost sales (Chopra, et. al., (2010)). Supply chain fill rate or customer service level is actually the average fill rates of all the retailers in a supply chain which is dependent on the companies' inventory policies (Pamulety, et. al., (2017); Pamulety & Pillai, (2011))
2. Bullwhip effect: According to Pillai, et. al., (2014), it is a fluctuation of demand resulting to an increased volatility along the system from the retailer up to the manufacturer resulting to inefficiency and disorganization along the supply chain. An increase in demand eliciting a corresponding demand on other echelons in the supply chain. It is can be controlled and reduced but not totally eliminated.
3. Bullwhip Slope: According to Dominguez et. al., (2014), Bullwhip Slope is an entire supply chain measure that shows the presence of bullwhip effect. Its rating in higher value of the slope means faster fluctuation of the bullwhip effect through the supply chain. While a lower value translates to smooth fluctuation or propagation.

4. Risk of shortage: this is simply the possibility that something may not be available or inadequate for supply. It is actually the echelons risk of shortage of goods or services to its customers. According to Sezen & Kitapci, (2007). It is calculated by counting the number of stockout and dividing it by the total number of periods for which demand arises.
5. Zero Replenishment phenomenon: This is defined as the time by which an echelon member does not place an order.

(a) Inventory variance. This performance indicator quantifies the fluctuations in actual inventory in every period. Increase in inventory variance will lead to higher handling costs of good higher storage costs.

(b) Total cost of the supply chain (TCSC): it is a cost associated with the inventory management which includes inventory holding costs, shortage costs, ordering costs, and transportation costs which is varied due to inventory policies in use. TCSC is equivalent to the sum of the inventory holding costs, shortages costs, ordering costs, and transportation costs for whole members in all stages of a supply chain.

Performance measurement systems tends to provide information for monitoring, control, evaluation, and feedback functions for operations management (Trisnawati & Pujawan (2021))

According to (Rakhman, 2006) performance measurement provides these privileges:

- Performance measurement directly or indirectly control the performance of systems,
- It keeps systems on- course towards achieving set goal(s),
- Performance measurement improves system performance,
- Faulty performance measurement approach diminishes supply chain or system performance,
- Performance measurement findings lead to (re)direction of the supply chain/system.

According to (Hausman, 2002), all supply chain is expected to have at least one performance measure on each of the 3 mentioned critical dimensions. Some of the major supply chain wide metrics that contribute in the global monitoring of supply chain performance are captured in three (3) key dimensions of service, assets and speed.

- **Service Metrics:** Service metrics refer to the ability to anticipate, capture, and fulfill consumers demand with personalized products and on time delivery. This exercise is geared towards mitigating against incurring out-of-stock cost or scarcity cost or late delivery cost.

- **Asset Metrics:** Asset metrics relate to cash, inventory or things with commercial value. In any supply chain, the most vital asset is the inventory throughout the supply chain. From raw material- petroleum to Work-In-Progress- refinery and finished goods-petrol. The inventory metrics are represented in monetary value and time supply (inventory turns). Turns is cost of goods sold divided by inventory value. This relates to inventory flows- product flow, in other words cargo throughput. The comparison of time supply or inventory turns and monetary value ($) are commendable at certain conditions. The monetary value accounts for tied up funds in inventory-working capital. As regards marine terminal operations, ship dues, cargo dues, berth rent, etc. are also metrics associated with inventory as captured in the UNCTAD port pricing reports and NPA tariff reports. UNCTAD (2021) disclosed key performance indicators to also include, port calls, ship size, greenhouse gas emission, liner ship connectivity, port cargo handling performance (UNCTAD 2022).
- **Speed Metrics:** Speed is time-related metric. They are capable of tracking velocity of execution while tracking responsiveness and flexibility. The speed metric is synonymous to lead time which is one of the major benefits of an efficient supply chain.

  It is often measured by supply chain cycle time, which is the total time spent to fulfil a new order when upstream, midstream and downstream echelons are on zero inventory.

According to Hausman (2002), supply chain cycle time is measured as a summation of all the longest constraints or bottlenecks of all the lead-times at each stage of inventory movement in the supply chain. An example of speed metric in shipping or marine terminal operations is berth occupancy, ship turnaround time, cargo throughput, vessel laytime etc. The reduction in the time spent by inventory in the supply chain system, translates to very significant improvement in the responsiveness to the end users.

Given that petroleum sector is mainly global in outlook and also the mainstay of some economies like Nigeria, the interests in this sector is massive which have led to pressure from the citizenry, government, host community, fellow operators and support systems on the supply chain network. It is so crucial that any distortions on the inputs, or processing, will affect the outputs and outcomes with feedbacks like scarcity, price hike, civil unrest, etc.

Distortion could arise from the fluctuation in international oil prices, pandemic, war, government policies, infrastructural decay, distortions in sea trades etc. which will immensely hinder free flow of the value chain in the supply chain. These possibilities have subjected marine terminal operations into intense competitive operation. The increase in government control via over regulation of the industry have also led the marine terminal operators to strive for increased and consistent drive for process efficiency. The process efficiency is also enforced due to constant fluctuations arising from external and internal environments that makes contingency planning a statutory standard in the sector for firms to remain in business.

The supply chain for petrol as presently operated in Nigeria has lengthy lead times and costly transactional supply chain costs. This is so because, importation of petrol is solely handled by NNPC who then schedule off-takers most times with NNPC chartered vessels. Though off-takers can charter shuttle vessels to load from NNPC mother vessels when NNPC is short of daughter vessels. This transshipment exercise also causes delays in product delivery to the final consumers. The distortion of the "First Come First Serve" loading schedule by government due to national interest and security concerns contributes to delays in product supply to certain end users. This practice has always hampered improvement in supply chain responsiveness or flexibility in satisfying the final consumers. As a result of these conditions, there is need for an effective new entrant of suppliers, synchronization, monitoring, measuring and sustenance of the flow of finished products to the final consumer to avert product scarcity. This can be achieved through the effective integration and performance monitoring of the input, processing, and output echelons to identify and prevent hitches while promoting seamless flow of refine petroleum products, money, and information through the marine terminal hub. Hence the adoption of the supply chain performance measurement approaches.

In marine terminal operations, there are key performance indicators which are the same as the seaport performance indicators except for the emphasis on product type and unit of measurement. For instance, liquid bulk units are in cubic meter or metric tons or barrels. The Nigerian maritime operation is mainly managed by Nigerian Ports Authority (NPA) while the terminal/tank farm operation is managed by depot owners. The performance indicators are cargo throughput, ship call, cargo dues, ship dues, etc.

According to (Tongzon,1995), the determinants of throughput or cargo size for instance, are geographical location, frequency of vessel call, port charges, economic activity, and terminal efficiency.

a. The geographical location of the marine terminal, seaport, or jetty has an impact on the cargo size. The characteristics of the geographical location of the jetty or seaport such as transshipment ports operates differently in capacity from an isolated small economy. The location also determines the kind of cargo generation or receipt. A port or jetty location that enjoys tax free and free trade zones can also encourage increase in cargo size.

b. The frequent call of vessels to the port or jetty also determines cargo size, because it also serves as signal of attraction to importers and exporters for such port services. ((Bird 1988, Slack 1985) as cited by Tongzon 1995). According to Meyrick & DÉste 1989), 3 categories of factors that determines cargo size are route factors, costs factors, service factors. The route factors include frequency, capacity (Port Approach channel draft), convenience directness, flexibility and transit time which is a function of the distance from fairway buoy to the berth. The cost factors include freight rate and other costs. Service factors include delays, reliability and urgency, avoidance of damage, loss and theft, fast response to problems, cooperation between shippers and carriers, documentation and tracking capacity Wilson et. al., 1986 (as cited by Tongzon, 1995).

c. Port Charges are also an important factor that affects the cargo size or throughput because shippers are always concerned about indirect costs and direct costs associated with delays, loss of market shares, loss of market confidence and opportunity forgone due to inefficient service delivery.

d. Economic activity is another vital factor that drives cargo size in port or marine terminal domains. The demand for port service is said to be a derived demand, hence, the level of demand for a countries port service in a global scale is a function of the economic activities' relationship exposed to with other countries.

e. Terminal efficiency is another very vital factor to cargo throughput. The speed and convenience to which terminals attend to shippers and carriers using automation, integrated top class equipment in cargo handling which reflects the labour and productivity level of the port or jetty remains a key determinant to cargo throughput (Tongzon,1995).

For this research the output variables or performance metrics are as cited from some reviewed literatures on seaport efficiency studies that applied Data Envelopmental Analysis and Stochastic Frontier Analysis for performance estimations. Such variables include Cargo throughput, Ship Calls / Traffic, Bulk Road Vehicle Calls/ Traffic, Ship dues, Cargo dues, Berth rent, Ship Gross registered tonnage, Value Added Tax (VAT), Others variables are Jetty draft, Shore tank Storage capacity, port approach channel draft, Berth to FWB distance, ShipLengthOverAll, etc.

The data for the variables used in this study were gotten from the Nigeria Ports Authority Tariff reports and the Nigerian Shipping Agents billings to terminal owner, vessel charterers, and cargo owners for the husbanding of tanker vessels in the Niger Delta region of Nigeria.

#### 2.1.7.5 Evolution of Supply Chain Performance Measurement

In the 18th and 19th centuries, only generic financial quantitative accounting metrics were used in the form of cost/yard, cost/metric tonne etc.

In the 20th century, a systematic financial indicator, the "Dupont System Scale" was birthed by Dupont Company in 1903 to assess the performance of different units hence the development of widely used performance indicator the "Return on Investment" (ROI) (Parker 2000).

The uncertainties caused by the Second World War globally, made companies to assess performance measurement from an integrated mixed approach of both financial and non-financial prisms which combine variables such as cost per metric tonne with customer satisfaction. This mixed approach was developed and introduced as "Balanced Scorecard" by Kaplan and Norton (1992) for evaluating non-financial indicators while also monitoring system performance. As cited by Nedaa et. al., (2012), it was a great fit but could not be used in measuring supply chain performance in isolation (Kurien & Qureshi, 2011; Lapide, 2000).

In recent times, the drive for information sharing aided by integrated telecommunication and online framework have improved the measurement process on different supply chain systems.

However, according to Nedaa et. al., (2012), financial indicators are not enough tools to be applied in the measurement of supply chain performance basically, because of the underlisted reasons:

1. Financial indicators are historical, short termed and internally oriented.
2. Financial indicators do not capture strategic indicators that, are non-financial such as customer satisfaction and perception,
3. Financial indicators indirectly do not reflect operational effectiveness and efficiency of systems.

The inadequacies of only financial indicators in measuring performance have given rise to more approaches by scholars such as (Ramaa et al., (2009); Akyuz & Erkan, (2010); Kurien & Qureshi, (2011); Estampe & Lamouri, (2011); Lauras et al., (2011)) in the performance measurement of supply chain, as will be discussed below.

Nedaa et al., (2012) revealed that, these scholars and more, divided supply chain performance measurement (SCPM) into 2 broad systems of financial and non-financial SCPM. The financial was further divided into 2 sub-segments while the non-financial were divided into 9 sub-segments.

#### 2.1.7.5.1 Financial Performance Measurement Systems

The Financial Performance Measurement System (FPMS) are of 2 methods namely Activity Based Costing (ABC) and Economic Value Added (EVA) accounting methods which focused on financial indicators for measuring supply chain performance.

**Activity Based Costing (ABC):** Kaplan and Burns in 1987 developed the ABC approach in the bid to synchronize financial measurement to operational performance. The approach was for better cost and productivity assessment of the supply chain process by disaggregating activities into cost drivers or individual tasks in estimation of costs or time resources needed for each task. ABC approach limitations were basically its strict reliance on financial metrics (Kaplan & Burns,1987).

**Economic Value Added (EVA): (**Stern et al., 1995) in 1995 developed the EVA approach to improve on the traditional accounting methods of short-term financial results limitations to a long-term financial result for shareholders value. The EVA approach declares that increase in shareholder's value is a function of the increase in company's earnings above its cost of capital. EVA approach in a nutshell estimates the company's return on capital or economic value addition but had a limitation in indicating operating supply chain performance indicators but solely financial indicators.

#### 2.1.7.5.2 Non-Financial Performance Measurement Systems

The Non-Financial Performance Measurement System (FPMS) are of 8 methods mainly focused on non-financial indicators for measuring supply chain performance.

**Supply Chain Balanced Scorecard (SCBS)**

Abu-Suleiman et al., (2004) adjudged SCBC as a powerful tool that provides manager a comprehensive view of the organizations' performance. Kaplan and Norton in 1992 developed the balanced scorecard (SCBC) as a performance management model that, assist managers in accessing and assessing with ease the operational and financial measures of their strategies in the organization. Kaplan and Norton introduced the following 4 major perspectives: Financial, Customer, Internal Business Processes, and Innovation, and Learning perspectives as the variables of interest to measure and monitor during strategy implementation in the organization. The Balanced Scorecard's limitations are that, it is a static, top to bottom and non-interactive approach (Lobman et al. 2004) and though extensively applied in the field but lacks implementation methodology as conceptual frameworks. However, according to Kottala & Herbert, (2019) SCBC model is plagued with multiple constraints. According to Taghipour et al, (2015), SCBC is not applicable to small organizations and it lacks the ability to advance or advise the best measure in tackling cause and effect relationships in an organization. It lacks the ability to compare internally and externally with other business performance while also lacking in proffer appropriate direction for businesses (Kurien & Qureshi 2018).

Hussain et al. (2019) claimed that, SCBC overlooked vital external factors such as government regulations, risks, uncertainties, sustainability, collaborations, continuous improvement, environment, buyer-seller collaboration, social factors, supplier network, strategic factors, employee motivation, employee engagement, team building, agility factor, resilient factor, then future business opportunities.

**Supply Chain Operations Reference Model (SCOR):**

According to Phan et. al., (2019), SCOR model was developed by the Supply Chain Council (SCC) in 1996 with a common process-oriented language of (plan, source, make and deliver) for the enhancement of business supply chain effectiveness with a process-related approach of (designate, measure and estimate) the supply chain configuration and management.

Nedaa et al., (2012) described SCOR as a model that, is adjudged "the only integrated cross functional framework that links performance measurement, best practices and software requirements to a detailed business process model". According to (Stephens, 2001; Huang et al., 2004; Lockamy & McCormack, 2004) they all claimed that, SCOR model is a tool for the enhancement of business efficiency while regulating the supply chain performance measurement through monitoring inter linked financial statements with a common integrative language of Plan, Source, Make, Deliver and Return.

SCOR Model have 12 performance matrices for the evaluation of system performance which could be based on Reliability, Responsibility, Responsiveness, Flexibility, Cost and Asset.

However, SCOR has been criticized as a robust and exhaustive model that will require a well-defined, dedicated infrastructure, managerial resources with continuous business process reengineering to synchronize the business with best practices.  According to Shokoryar et al. (2020), SCOR model is rigid that, it lacks the ability to handle global supply chain, subject to market uncertainty as the model is deficient in accommodating business sustainability, information technology related visibility, business risks, training and development, firms intra and inter functionality integration, capacity building etc.

**Dimension Based Measurement Systems (DBMS):**

Beamon, (1999) disclosed that, there are 3 types of measures that are vital in the supply chain performance measurement system and they are individually expressing the overall performance measurement of supply chain system though their individual result affect one another. These measures are; Resources (manufacturing cost, inventory cost, return on investment (ROI)), Output (Total sales, on-time delivery, fill rate) and Flexibility (volume changes, new product introduction).

According to Ramaa et. al., (2009) the DBMS concept supports the measurement of any supply chain based on dimension such as those mentioned above. (i.e. Resource, Output and Flexibility).
Hausman, (2003), identified Service (ability to fulfil clients demand), Assets (things of financial value such as inventory, cash,), and Speed (velocity or responsiveness time related metrics) as another set of dimensions suitable for the performance measurement of a supply chain. However, DBMS is a simple, implementable executive model, but lack the properties of showcasing supply chain internal performance function.

**Interface Based Measurement Systems (IBMS):**

Lambert & Poblen (2001), introduced and proposed IBMS framework which links the performance of each supply chain echelon or stage within the supply chain. These performance linkages from point of origin to point of consumption is for the maximization of the shareholders' value as well as that of each echelon in the supply chain system. According to Ramaa et al., (2009), IBMS framework is theoretically good but its applicability in business is subject to complete transparency in information sharing amongst all echelons in the supply chain which seems to be a difficult task.

**Perspective Based Measurement System (PBMS):**

Otto & Kotzah (2003), developed PBMS framework with the mindset of assessing all perspectives possible for supply chain performance measurement, hence the provision of 6 metrics for each of the 6 perspectives in supply chain performance measurement. The 6 identified perspectives are; System

Dynamics Perspective, Operations Research Perspective, Logistics Perspective, Marketing Perspective, Organization Perspective and Strategy Perspective.

For instance, the Logistics Scorecard (Lapide, 2000) is a Logistics Perspective of PBMS with metrics like Logistics Financial Performance Measures (expenses and return on assets); Logistics Productivity Measures (orders shipped per hour); Logistics Quality Measures (shipment damage) and Logistics Cycle time Measures (order entry time).

However, PBMS is prone to a tradeoff existing amongst one perspective measurement over other perspective measurements.

**Hierarchical Based Measurement Systems (HBMS):**

Gunasekaran et al. (2004) developed the HBMS with the objective of allocating financial or non-financial measures according to official hierarchy or organogram in a system, hence, they classified these measures as strategic, tactical or operational to fast-track appropriate decisions by the appropriate management team/level (Ramaa et al. 2009). The classification and integration of the HBMS framework is all encompassing, as all strata of the team participates; though the framework is subject to partners conflicts along the supply chain.

**Function Based Measurement Systems (FBMS):**

Christopher, (2005) developed FBMS as an easily implementable framework that, connects all applicable supply chain performance measures in different linkages of the supply chain (Ramaa et al. 2009). However, FBMS views supply chain functions individually and in isolation from an overall strategy. Hence, it lacks the top-level synergized influence on the total supply chain which makes it dangerous for the total supply chain network.

**Efficiency Based Measurement Systems (EBMS):**

The EBMS is a Data Envelopmental Analysis (DEA) efficiency-based framework which has been subject to so many modifications. However, Charnes, Cooper and Barnes have been credited as the initiators and developers of the efficiency framework due to their pioneer work of DEA. EBMS are supply chain performance measurement systems with focal interest on systems efficiency (Ramaa et al., 2009; Chan & Qi, 2003; Chan, 2003; Charan, et al., 2007; Sharma & Bhagwa, 2007; Chen &

Paulraj, 2004). Wong & Wong (2007) as cited by Nedaa et al., (2012) developed several approaches with case studies in assessing the internal supply chain performance efficiency of systems.

The efficiency existing between 2 supply chain members were studied by Chen et al. (2006). They proposed a function that identifies inefficiencies amongst the supply chain members.

An improved new DEA based approach from the conventional DEA model with in built intermediate measures for measuring supply chain efficiency was also developed by Liang et al. (2006). In 2007, Berrah & Cliville (2007) developed a model that, was conventionally incomparable by aggregating the primary performance model with the overall performance of a supply chain using Choquet Integral Operator for the synchronization. EBMS framework analyses supply chain performance measures relatively to the supply chain members in the overall supply chain which could sometimes be misleading to evaluators.

**Generic Performance Measurement Systems (GPMS):**

According to (Tangen, 2004; Kurien & Qureshi 2011) some generic performance measurement models have been developed as early as in the 80s which are not supply chain related. The models such as Nash Equilibrium proposed by John Nash is a solution concept from the game's theory. Nedaa et al. (2012) affirms that, Nash equilibrium exists when 2 or more players are assumed to know the equilibrium strategies of the each other, and no player has something to gain by unilaterally changing their strategy.

**Performance Prism:**

Performance prism is a comprehensive model with the ability to view different stakeholders more than other frameworks like the traditional performance measurement framework. It is a conceptual framework that queries the firms' strategic foundation before recommendation and deployment of measures while also accommodating the earlier neglected employees, partners, suppliers, agents, etc. as new stakeholders.

Neely et al. (2001) proposed that performance prism is a performance measurement framework that based its performance measurement on 5 distinct and linked perspectives of stakeholder satisfaction, strategies, processes, capacities and stakeholder contributions.

However, according to Tangen (2004); Kurien & Qureshi, (2011), the performance prism framework lacked the guidance on how to identify and select the performance measures.

In conclusion, supply chain performance measurement has undergone through series of reformations and scrutiny and EBPM is one of the proven classic model suitable for the analysis of the petroleum industry because it is global and systemic in application and outlook.

#### 2.1.7.6 Supply Chain Management

Supply chain management as a management concept have evolved from the year 2000, as a combination of previous concepts from the 19th century such as Just in Time (JIT), Total Quality Control (TQC), Total Quality Management (TQM), Lean Thinking, Time Based Management (TBM), Activity Based Management (ABM) and Business Process Reengineering (BPR) (Laamanen &Tinnila 2002).

In the works of Cooper et al (1997) and Lambert et al (1998), Global Supply Chain Forum gave a generally acceptable definition of supply chain management as "the integration of key business processes from end user through original suppliers that provides products, services and information that add value for customers and other stakeholders".

According to Crimi & Ralph (2002), Supply chain management as introduced first by Oliver and Meyer in 1982, emphasized that it is an integrative process or management approach or methodology or collaboration of physical network of companies involved in supplies, manufacturing, warehousing and retailing so that raw materials can be transformed to finished goods and distributed to the final consumers at right time, right quantity and right location hence reducing costs while meeting customer satisfactions that includes product availability(Crimi, & Ralph, (2002)).

According to Simchi-Levi et. al. (2004), they defined supply chain management as a set of approaches used to efficiently integrate suppliers, manufacturers, warehouses and stores so that merchandise is produced and distributed at the right quantities to the right location and at the right time in order to minimize system wide costs while satisfying service level requirements.

Christopher, (1998) posited that, supply chain management is the management of upstream and downstream business relationships amongst suppliers and customers with the aim of producing large customer value with smaller total costs for the whole supply chain.

Dubey, & Samar Ali, (2013) defined Supply Chain Management as the management of upstream and downstream associations with vendors and customers to provide better customer value by optimizing the supply chain.

Supply chain management in a nutshell, is the coordination of different echelons in a value creation process, for the benefit of all stakeholders, with the objective to continually improve the performance of all echelons as a system.

The success of any supply chain is hinged on the efficient and continuous performance measurement and monitoring of the network - that is supply chain management. Likewise, the success of any marine terminal operations is dependent on the continuous improvement of its operation through consistent monitoring, measurement of its performance indicator and quick adaptation to the effects of policy summersaults.

### 2.1.8 Concept of Marine Terminal Operations

According to Aguero-Tobar, Gonzalez-Araya, & Gonzalez-Ramirez (2023), port operations is classified into maritime operations, terminal operations, and connectivity or land.

Maritime operations are defined as the processes involved from vessel arrival to the dock until the end of its cargo transference. The maritime operation incurs the bulk of transportation cost in the whole petroleum supply chain as practiced in Nigeria.

Terminal operation overlaps with the marine operations in receiving the cargo from the vessel into the tank farm. While connectivity or hinterland operations correspond to the processes linked with the cargo door-to- door delivery or distribution to the fuel stations, outside the tank farm (Bierwirth & Meisel, 2010; Murty et al., 2005).

Lawinsider.com explained marine terminal as a public or private commercial wharf located in the navigable water of the state used or intended to be used as a port or facility for the storing, handling, transporting or transferring of goods to and from a vessel.

Some other definitions explained marine terminal as a point of transfer for cargo loading and unloading as it is transferred from ship to rail and trucks (www.cdc.gov).

Guide Container Terminal (2023), defined marine terminal as the space that enables the shipment of cargo by end consumers while acting as a vital distribution node.

According to Seaport Chapter Draft (2015), terminal operations is dependent on other sectors such as road, rail corridors as well as power generation and distribution.

Terminal in other words is the structure that connects maritime transport (i.e. ship) to other modes of transportation such as truck, train and barges, they act as gateways between a country and another.

However, according to 46CFR § 520.1(0)(13), the marine terminal operator is one that provides wharfage, dock, warehouse or other terminal facilities to ocean common carrier moving cargo in the ocean- borne, foreign commerce of the United States of America. Marine terminal operators include public port authorities who own and maintain docks and other port infrastructure and private terminal operators that lease terminals from a public port authority and operate the leased terminal as a private business.

Therefore, marine terminal operations is the management of cargo, dock, ship activities or processes relating to transshipment, warehousing, maintenance, pollution prevention, contingency planning, emergency responsiveness and safety, procedural writing, regulatory compliance etc

This is the management and operation of marine terminals. It can be operated by states and their political subdivisions, railroads, common carriers and warehousemen (www.fmc.gov; www.ecfr.gov; www.lloydmaritime.com)

Marine terminal operation is basically the interactions between the marine and hinterland leagues in cargo/passenger transfer operations. It can also be termed as an intermodal or multimodal transshipment operations between marine and land cargo/passenger transfer operations (Rodrigue et al. 2013). Marine terminal operations comprise of the container terminal operations; liquid bulk/oil terminal operations; passenger terminal operations; dry bulk terminal operations; offshore rig/ equipment supply terminal operations; Roro terminal operations, etc. conveying cargo that may be volatile, flammable, and expensive in nature (Denizhan & Gormez, (2018).

Van Duijn (2009), further defined the primary function of the terminal to be a place that connects different modalities together, to provide a buffer for (temporary) storage and to change product flow size and behavior.

The comparison of the functions of liquid bulk terminal to other marine terminals, shows little or no difference, except for cargo type which also affects handling equipment types and style of operations as earlier mentioned. In other words, liquid bulk terminal is that marine terminal that specializes majorly on petroleum products (CCDOTT, 2000). For liquid bulk terminals like fuel terminals, the need for extra caution in cargo operations is inevitable to avoid leakages since the cargo is volatile and flammable in nature. This terminal operation is subject to the international, regional and local rules and regulations guiding such cargo operation. Hence, the port management tariff in accordance to the United Nations and World Bank standards remains applicable, given that the cargo in question- energy, petroleum is one of the engines of survival of the world economy.

In the definition by oiltanking.com, oil terminal referred to as tank farm, oil installation or oil depot is an industrial facility for the storage of oil, petroleum, petrochemical and refined petroleum products and from which the stored products are transported to other storage facilities that service the end users.

The petroleum industry plays a vital role in the general socio-economic development of the world and supposedly with special benefits for the countries that are endowed with such natural resources like Nigeria. Despite the immense economic benefits associated with the development of the petroleum industry and its allied companies along its supply chain, the industry is subject to huge governmental controls while also contributing to huge degradation of the environment through its negative externalities principally from its operations. This have attracted international attention, as it is ascribed as the major source of climate change.

The seaport is the nexus that functions as the platform within the global supply chain and the global production network. They are dynamically reactive to global trade patterns, consumer preferences, policy distortion etc (Nottenboom, et. al., (2023). It is the main intermodal hub accommodating the marine terminal operations which includes liquid bulk operations, depot/ terminal operations, and connectivity operations amongst other modes of transportation. It is a specialized hub that is saddled with the responsibility of receiving crude oil and refined petroleum products. It consists of jetty, used for berthing of tanker vessels laden with liquid bulk cargo. It is a specialized liquid bulk intermodal interface linked with 2 to 3 modes of transportation for the transshipment of petroleum products. The liquid bulk marine terminal-jetty is connected with pipelines for product transfer between tanker vessels and terminal storage tanks. These terminals comprise of storage tanks linking the jetty through pipeline. It is installed with pump house, cargo control room, safety appliances, gantry loading bays, metering appliances, Bulk Road Vehicles parking area, tanker rail wagons tracks, barges mooring area, and all the modes of transportation are also accessible to approach loading points for product transshipments in different quantities.

The marine terminals are designed based on international and statutory safety, security and operational standards of the petroleum industry, to be able to fulfill quality and efficient deliveries on the market demands for the refined petroleum products.

Liquid bulk or Oil terminal operation entails four (4) salient operations which require efficient use of inputs to produce outputs. The activities under the oil terminal operations are:

- Vessel and Berth Activities which entails the management of berth or jetty limitations such as draft, jetty length overall, quay length, port channel approach draft and width, berth availability, tidal restrictions. Hence, the Marine Oil Terminal are linked to jetties with deep-water draft for easy berthing or mooring of tanker vessels (Oram & Baker, 1971) as cited by Ng Siew Ming & Muhammad Zaly Shah (2008)).;
- Ship's Cargo Discharge Activities comprise of the use of sizable hoses with ships pumps to discharge cargo through a distance between ship and the storage tanks. The jetty is designed based on the size of the tanker vessel expected to be calling at the jetty. With this in mind, it means that jetty length, jetty draft, port/jetty channel approach and tank farm storage capacity are very vital determinants. It is also pertinent to state that the performance and efficiency of each terminal will depend on speed of transferring petroleum product through the pipeline, measured and monitored as berth occupancy/ utilization or rate of cargo throughput. The product transfer rate is a function of the vessel pumping capacity, distance between jetty and receiving terminal, and the diameter of the pipeline used for the product transfer (Ng Siew Ming & Muhammad Zaly Shah (2008)). The marine terminal performance and efficiency could be assessed as the faster the vessel turnaround time at the jetty, the more the vessel calls/ voyages within a specific time and also the lesser the berthing costs at such jetty. In other words, the faster the evacuation of the stored products at the tank farm through BRV calls, the more the vessel calls within a specific period;
- Storage of the Liquid Bulk Cargo Activities includes the use of tank farms or depots as a temporary cargo holding place for BRVs or Rails to access their cargo in smaller capacities. These storages are often built near to the jetty which could also double as blending plant, near

oil refineries, jetty or coastal waterfront locations designed as an intermodal or multimodal interface for the distribution purposes to the fuel stations (Rahmanian, Agar, Bin Dainure, & Mujtaba, (2018)). Most of the storage tanks are also interconnected by valved pipelines for ease of product inter-tank transfers. Some of the storage tanks are designed with fixed or internal floating roofs or external floating roof tanks (engineersedge.com). The fixed roof tanks are designed with a vapor space above the product, which serves as a breather for the tanks during product receipt or product evacuated. The floating roof tanks are used for the storage of refined petroleum products or products with high volatility to avert product loss due to evaporation. The internal fixed tanks are those normally used in the storage of Bitumen, these classes of tanks are internally installed with heating coils that use hot water, steam to keep product warm, while increasing product viscosity to allow for easy transferability of products by pumping. Liquified petroleum gas (propane, and butane) storage tanks are installed with Horton spheres to mitigate evaporation.

- Hinterland Cargo Distribution and Intermodal Cargo Transfer Activities involve the distribution of liquid bulk through BRVs, rails, pipeline to the final consumers at fuel stations, industrial parks, etc. The oil terminal is installed with connecting pipelines from the jetty to the storage tanks at the tank farm, equipped with ship loading and unloading gears to enable cargo transfer into BRVs, rails, barges etc.

However, the efficiency in evacuation process of the liquid bulk at the depot/ terminal is not only dependent on the above 4 mentioned activities (CCDoTT, (2000) as cited by Madueke,(2013)), but also dependent on the safe evacuation of the volatile refined petroleum product, hence the whole terminal system from the tanker vessel through the storage facility to the BRVs, have safety equipment and protocol exercised (Standard Operating Procedure) for safe cargo operation along the supply chain. This promotes cargo throughput, increase vessel patronage, BRV patronage, tank farm patronage, port / jetty patronage, fuel stations and final consumers' patronage.

In a nutshell, the main function of a terminal is to tranship and handle cargo or freight through an intermodal interface, albeit separated cargo and transport mode (Rodrigue et al., 2013). According to Ng Siew Ming & Muhammad Zaly Shah (2008) there is limited available literature on liquid bulk terminal industry operations and performance as most ports of the world is mainly interested in the container operations.

However, seaport operation is the same as marine terminal operations for liquid bulk because the parameters for measurement are in many ways the same. The efficiency of seaports is also a function of the seaport pricing structure, jetty capacity and cargo handling capacity at the terminal (Ng Siew Ming & Muhammad Zaly Shah (2008)). The improvement in seaport performance or efficiency will mean an increase in cargo throughput while also achieving reduced terminal costs to promote healthy competition. It is worthy of note that the petroleum terminal efficiency is vital in vessel, inland waterways and road transport fuel bunkering for industrial and domestic use (Long, 2007 as cited by Ng Siew Ming |& Muhammad Zaly Shah (2008)).

For the purposes of this study, the marine terminal operations of interest are those of liquid bulk terminals operating in the Niger Delta region of Nigeria. Six dispersedly located terminals were evaluated in relation to the impact of fuel subsidy reforms on their operational supply chain performance. The terminals under study were those built and managed by government -NNPC, and oil marketing companies in Nigeria.

However, in Nigeria, the NNPC and the major marketers (Conoil, Mobil, Oando, MRS, AP, etc.) were the pioneer liquid bulk terminal builders, while the independent marine terminals were the recent entrants into the supply chain. The independent marine terminals came into existence as a result of the inability of the government refineries to balance the increment in the demand of petroleum product supply and its distribution into the hinterland. This led to the licensing of the independent private marine terminals to import and also commence cargo operation in their terminals under the petrol subsidy funding.

The vessel husbandry of the marine terminal operation is handled by the Nigerian Ports Authority (NPA)who attend to the vessels and their cargoes. In handling these responsibilities, pilots are assigned, vessels are assisted to berth and sail, cargoes are unloaded and or loaded all at a fee and in accordance to internationally best practices and procedures, with the full compliance to the payment of its corresponding statutory charges which comprises of pilotage charges, towage charges, cargo dues, ship dues, berth rent, environmental protection levy, fire coverage, insurance, value added tax (VAT), etc. as captured in the NPA Yearbook 2023 and UNCTAD port pricing article 1975.

The cargo dispensing operations from vessels to and from the tank farms to the BRVs is supervised by the government compliance agencies and other third party logistics providers such as

(NMDPRA), NNPC, Cargo inspectors, Cargo and depot owners, insurance companies. This exercise entails the joint monitoring, measuring and certification of the quantity and quality of fuel based on international best practices on safety, product quality and quantity parameter guidelines. The successful completion of this exercise guarantees the release of the tanker vessel to NPA for sailing purposes.

At the sailing of the tanker vessel from the jetty, the depot's commencement of hinterland product distribution through bulk road vehicles (BRVs) etc. to final consumers becomes the priority. This is basically to be able to get ready for another cargo receipt or vessel call.

As earlier pointed out, the marine oil terminal is managed in accordance to local, national, regional, international codes and standards with its legal and statutory requirements as certified in the design, construction, operation and maintenance guidelines of marine terminal operations. The relevant international standards for marine terminal operations are as follows:

1. Design Code for Aboveground Atmospheric Storage Tanks, American Petroleum Institute, API 650;
2. Overfill Protection for Storage Tanks in Petroleum Facilities, American Petroleum Institute, API Recommended Practice 2350, 4$^{th}$ Edition;
3. Process Safety Management of Highly Hazardous Chemicals Standard, 29 CFR 1910.119, Occupational Safety and Health Administration (OSHA, 1992 February);
4. OECD Guidance Concerning Chemical Safety in Port Areas (OCDE/GD (96)39), Organisation for Economic Cooperation and Development (OECD, 1996);
5. Design, Construction, Operation, Maintenance, And Inspection of Terminal and Tank Facilities, American Petroleum Institute, API STD 2610;
6. Guidance For Oil Terminal Operators, International Maritime Organization (IMO)International Ship and Port Facility Security (ISPS)Code (2003);
7. Functional Safety-Safety Instrumented Systems for The Process Industry Sector, International Society of Automation (2004 September);
8. Environmental, Health and Safety Guidelines for Crude Oil and Petroleum Product Terminals, World Bank Group (2007 April);
9. Safety Guidelines and Good Practices for Pipelines, ECE/CP.TEIA/2006/11, United Nations Economic Commission for Europe (2008 December);

10. Tank Inspection, Repairs, Alteration, And Reconstruction, American Petroleum Institute, API Standard 653, 4th Edition, April 2009;
11. Tank Farm Guidelines for The Chemical Industry, Basle Chemical Industry (BCI, 2009);
12. Prevention of Tank Bottom Leakage- A Guide for the Design and Repair of Foundations and Bottom of Vertical, Cylindrical, Steel Storage Tanks. Engineering, Equipment Material Users Association. (EEMUA 2011);
13. Safety Guidelines and Good Industry Practices for Oil Terminals, United Nations Economic Commission for Europe (ECE), 2013.

Pertinently marine terminal operation entails basically these step-by-step processes:

- Vessel berth at jetty
- Government authority to issue clearance/ Free Practique
- ISPS/ Ship/shore checklist and naval clearance
- Cargo quality and quantity inspection before discharge
- Off specification - Quality test analysis- On specification
- Loading arm/ hose connection/ lining up piping system
- Commenced vessel pumping operations
- Tank/ cargo inspection
- (Beyond tolerance) - Quantity and nomination- (Within tolerance)
- Completed vessel pumping operation
- Ship/shore tank inspection
- Final ship/shore documentation
- Vessel unmooring and sailing
- Product in terminal/storage tank
- BRV arrives terminal for loading
- Document entry, ATL
- BRV at Gantry position
- Metering and loading gantry arm connection
- Loading valve opened and loading of BRV commences
- Observe and measure

- End loading BRV.
- Pick up loading arm
- BRV moves for tank reullaging
- BRV leaves terminal gate for fuel station.

The marine terminal operation is actually a process that overlaps with jetty operations and depot/terminal operations. Hence, a delay in jetty operations, translate to a delay in depot operations and also a delay in product delivery to the end consumers. The delays transmit costs such as product scarcity cost, vessel demurrage cost, jetty logistics charges, fuel stations out-of-stock costs, cost of fuel price hike, cost of idling of BRVs, etc. The delays in the supply chain could also be due to faulty or downtime of fuel dispensing equipment, low product demand due to high product price, product glut or bad roads hindering speed of returning BRVs. All these delays culminate into reduction in cargo throughput, vessel traffic, etc. These supply chain challenges are major in marine terminal operations because they hinder regular cargo traffic flows. It also could lead to diversion of patronage to other competing supply chain networks.

Efficient supply chain networks are prone to more patronage by ships, cargo importers, BRV owners and fuel station owners which also guarantees cargo availability along the chain. The efficiency of these supply chain networks could also translate to increased or expansive improved investments in marine terminal equipment, larger automated storage tanks, jetty upgrades to be able to accommodate bigger vessels and also provisions for multimodal opportunities for faster evacuation of products (Merk & Dang, 2012). Therefore, for the purposes of continuous improvement in the marine terminal operations to averting product scarcity, the petroleum industry deserve the monitoring of the marine terminal operations' key performance indicators.

### 2.1.9. Effects of Fuel Subsidy Reforms on Supply Chain Performance of Marine Terminal Operations.

Ojo (2023) in his article titled "The Impacts of Fuel Subsidy Removal on the Midstream Supply Chain in Nigeria" claim that there are far reaching effects of fuel subsidy reforms on the midstream and downstream supply chain in Nigeria, which include changes in the cost of goods due to the changes in cost of transportation. The associated foreign exchange factor for machineries spare parts and also international free market price of bunkers for powering the supply chain echelons which include these transportation modes in the midstream and downstream sectors is also impacted.

In other words, a fuel subsidy policy that reduces subsidy payment for fuel (i.e. high fuel cost) will lead to an increase in the cost of transportation modes and their maintenance as utilized in the midstream and downstream supply chain such as tanker vessels, pipelines, refineries, Bulk Road Vehicles, Storage tanks, jetties, etc.

Ojo (2023) also mentioned that fuel subsidy reforms impact on the volatility of demand for goods as a result of the changes in the market dynamics caused by subsidy variables adjustments. The fuel subsidy reforms impact the consumption or production of certain goods and services either directly or indirectly. The increase in the subsidy amount of fuel, leads to the increase in the cost of goods subject to transportation cost, production cost, storage cost etc. The increase in the consumption of fuel translates to the increase in the consumption of leisure-travels, holidaying, recreation, etc. by the end uses.

The demand for midstream and downstream infrastructure utilization will also increase as a result of increase in fuel consumption occasioned by fuel subsidy reforms. In other words, the removal or reduction in the fuel subsidy amount, will subject midstream and downstream supply chain activities to reengineering and remodeling of their operations to just- in- time approach due to the effect of the volatile fluctuations of the international market price of petroleum. Hence, demand forecast along the supply chain will now be based on real time- short term and not long-term planning. For instance, the jetty cum tank farm operations of oil marketing companies will be subject to stiffer competitions while some will be left to decay due to low patronage or they are forced to merge with those that have more businesses.

The tanker vessel coastal services will be expensive due to high cost of bunker and low traffic, as many vessel owners would have to deploy their vessels to regions of high demand. Limited patronage for coastal tanker vessels will be due to low demand for the consumption of petroleum product occasioned by high cost of the fuel, goods, leisure, holidaying and low overall living standards. The demand volatility cascades down the supply chain and because these echelons overlap and interface, the need to prevent bullwhip effect while struggling to optimize their infrastructure capabilities along the value chain becomes sacrosanct.

Fuel subsidy reforms also have a way of disrupting demand and supply of goods and services. As this happens the midstream and downstream supply chain activities also get disrupted. The disruption could be in the form of shortages in the supply and distribution networks of the supply chain given that there is a change in the attitude of consumers which will also instigate a readjustment by the service providers in the supply chain. The reaction of the marine terminal operators as a result of fuel subsidy reforms challenges is often geared towards reengineering of their operations through contingency planning which might include remodelling of her business models, pricing adjustments, operational integration and alignments, etc. to ensure infrastructure optimization while promoting seamless flow of products to the end users. (Ojo, 2023).

Optimization of Infrastructure **-** Fuel subsidy reforms also affect the utilization of marine terminal operations' supply chain infrastructure because of the change in the market dynamics of fuel and its multiplier effects on the supply chain. Hence, the adjustment of the facilities' infrastructural and operational capacity has to be in tandem with the realities posed by the fuel subsidy reforms.

The adjustment starts with the reallocation of resources within the marine terminals, while also investing and upgrading the facilities' infrastructure to accommodate the adjustments in the shift in demand for their services and for the purpose of efficient service delivery to end users.

Considerably, the human resources anchoring the marine terminal operations will be adjusted, expertise will be adjusted, storage tank utilization will be amended, BRVs sizes and traffic will also be tweaked. These actions will be to curtail wastages and promote efficiency in product supply to end users. (Ojo 2023).

The fuel subsidy reform policy could also affect the marine terminal operation in the stakeholder's investment drive and decisions. Such as divestments in the area of horizontal ownership or operations of the midstream and downstream sectors of the oil and gas industry. For instance, when the fuel subsidy reforms encourage increase in consumption of good and services, stakeholders could invest more in the supply chain echelons, like tanker vessel ownerships and management, BRV ownership and management, fuel station ownership and management while also expanding their marine terminals. They also could invest in modular refineries while acquiring and owning their own oil wells. This boom could snowball into competitive and efficient running of the total supply chain of petroleum through the introduction of information and communication technology in the management of the network as practiced by Aramco of Saudi Arabia.

If the fuel subsidy reforms are detrimental to the consumption of fuel, then there will be a deliberate drive towards alternative energy source and divestment to cheaper sources of fuel which also will translate to cheaper means of transportation. The need for robust sponsorship in research and development for the invention or reinvention of alternative to fuel power will be intensified. This will encourage an overall system reengineering and continuous improvement of the maritime terminal operations.

Fuel subsidy reforms also affects the costs and fares for transportation of which the port and marine terminals are part of the system (Adeniran, (2018). He also posited that, fuel is a major factor amongst other factors that affect or influence the cost of transportation in Nigeria which also translates to the cost of goods and services. The reform factor of government on fuel consumption through fuel subsidy policies, is also a veritable factor that could impact transport economic system's performance.

The execution of the fuel subsidy reforms was for the purposes of providing consistent fuel to the low income earners in all nooks and crannies of Nigeria. This policy has strategically made the port a key custodian of the distribution process of petrol in Nigeria because they oversee the husbandry of all vessels calling into Nigerian ports while also generating revenue through port charges to government from this exercise.

According to Adeniran & Yusuf (2016) the port is one of the important elements in transportation system amongst other elements such as infrastructure, vehicles, terminals and operations, the marine terminals/ports as a node of interest in the execution of the distribution of the subsidized fuel in this study cannot be over emphasized (Adeniran 2018).

Jean, Claude & Brian (2006), explained that transportation costs are monetary measures of both fixed and variable costs of the transport provider spent in the provisions of transportation services to a person or organization. They went further to explain transportation rate as the price paid by the transport user for the transportation services rendered to such individual or firm. This is actually the price paid for the conveyance of passenger and or goods to an agreed destination at a particular time. These rates are actually influenced by transportation cost as influenced by location/geography, type of product conveyed, economies of scale or carrying capacity of the craft in use, fuel for equipment or transport modes, infrastructure conditions, trade imbalance and government policy.

Adeniran (2018), studied the effect of fuel subsidy on transport costs and transport rates in Nigeria, and he posited that fuel subsidy reduces the overall transport rate and cost of transportation to longer distances. He also claimed that the overall cost of transportation will be minimal when economies of scale of the carrying unit is utilized in the conveyance of goods. This is very true for transportation modes that operate with subsidized petrol as its vehicular bunker while also embarking on a long haul.

He further asserts that the operational efficiency of the terminals or hubs and other transportation infrastructure such as road networks, have direct impact on transport cost.

The efficiency of the terminals translates to reduced supply chain delays or lead time and also supply chain costs. The overall transportation system efficiency in the supply and distribution of petrol subject to fuel subsidy reforms, will further improve the patronage of the system as the operational cost will be competitively minimal. This will in turn impact positively on the general standard of living of the citizenry as wastages will be reduced to the barest minimum, while system reengineering for purposes of system continuous improvement will remain sustained.

The sustainability of the fuel subsidy reforms is driven by the volatile soaring international market prices of petroleum amongst other factors such as the world energy crisis which have burdened countries all the world without the exception of countries like Nigeria, Venezuela, Ukraine, Uzbekistan, etc. who are oil producing countries (IEA, 2014).

The poor implementation and management of fuel subsidy policy reforms have made Nigeria economy to suffer from the Dutch Disease and Resource Curse syndromes over the years. This is so obvious as the country is still grappling with poor infrastructure exemplified in the comatose or moribund status of her 3 refineries amongst other infrastructural decays. The discovery and the management of petroleum resource, have brought more crisis to the Nigerian citizenry which is epitomized in the regular host community unrests, vandalism, environmental pollution, oil theft and national economic sabotage. The revenue accruable from sale of petroleum that was supposed to be used for infrastructural development and economic diversification were ferried away through the process of subsidy management and petroleum product swap importation. The reckless mismanagement of the petroleum resources by corrupt governments has been so monumentally abysmal to say the least. The fuel subsidy policy reforms have caused the misallocation of the scarce resources and also served as an instrument of endemic corruption in the country. The fuel subsidy policy reform in Nigeria is synonymous to price distortions, revenue losses and under investment in petroleum supply chain network infrastructure, leading to the perennial fuel scarcity in Nigeria. It has also sidelined and eroded private sector competitiveness in the supply chain (IMF, 2013).

#### 2.1.9.1 Concepts and Metrics of Effectiveness and Efficiency of Marine Terminal Operation

The study on economic performance measurement is premised on the concepts of productivity and efficiency. Concept of productivity is defined as the ratio of volume measure of output to the volume measure of input used, while the concept of efficiency as a relative concept is a benchmark concept that compares performance in relation to other like organizations or systems (OECD 2001).

In reviewing literature on economic performance analysis of systems like terminals and ports, stochastic frontier analysis (SFA) is often applied. According to Oum, et. al., (1992), they claimed that in transport studies, the two major reasons for studies on economic performance are basically" gross measures of productivity and shift measures of technical change".

Effectiveness in management means completing and supplementing work effectively, it means achieving outputs or goals using the least available inputs resources. Effectiveness is actually achieving much outputs or huge returns with very minimal resources or inputs. Effectiveness also means achievement of huge outputs in the best possible way under the absence of material, financial and informational resources, reduction in the input or resources (Al-Barzanji & Al-Hawasi 2014). Therefore, a great organization will always strive to achieve both efficiency and effectiveness.

According to Omar (2023), there are two directions regarding the relationship between the effectiveness and efficiency concepts. Firstly, is that effectiveness can be achieved without efficiency and efficiency can also be achieved without effectiveness. Effectiveness and efficiency can also be in the same direction at the same time. Another possibility is that of efficiency cannot be achieved without effectiveness at the same time. This buttresses the definition presented by Draker for both effectiveness and efficiency, whereby effectiveness (doing the right things) first is achieved before efficiency (doing the right things well) is achieved (Ahmed Abdul Razzak Al-Sayed Omar (2023)).

Efficiency is explained to be the ability to produce an intended result in the manner that results in the least wastage of time, effort and resources while effectiveness is the ability to produce a better result, one that delivers more value or achieves a better outcome.

#### 2.1.9.1.1 The Concept of Effectiveness

Effectiveness has been defined as the ability of a firm to achieve profit, and the ability of firms to increase their number of customers. It is also the degree of satisfaction of these customers.

Some scholars also defined effectiveness as achieving satisfaction of working individuals. Some also explained effectiveness as the ability of an organization to provide things that have value to society.

However, the definition of the concept of effectiveness by Peter Drucker remains more germane, as he defined effectiveness as doing the right things. It is the measurement of the ability of the firm to achieve the objectives and aims that were set in advance.

The concept of effectiveness is defined as the ability of a firm to achieve its set goals and missions (Roghanian et. al., (2012))

According to Roghanian, et. al., (2012), Peter F. Drucker mentioned 5 requirements to achieving organizational effectiveness and they are time management, decision making, promote organizational structure, prioritization, results orientation. Some other scholars explained that the concept of effectiveness is a continuous process that collaborates the firms to the surrounding environment.

According to Mohammed, (2015), Dervitsiotis defined the concept of effectiveness of a firm as the value created for the beneficiaries by the business concerns. In other words, effectiveness is concerned mainly with the firm's output, which is a function of how management deals with beneficiaries, customer satisfaction with the service or product, coupled with community involvement in plans and developmental programs.

Scholars have also explained effectiveness as showing the ability of the worker or employee to deal urgently with surrounding challenges. It is also the measure that estimates the extent to which the goals and plans set by the firms are achieved.

More debates and arguments by scholars on the relationship between efficiency and effectiveness has been ongoing. Santiago Simpas, and Ramon Garcia were of the opinion that effectiveness can be achieved without efficiency and vice versa. In contrast to Simpas and Garcia observations, Peter F. Drucker argued that effectiveness cannot be achieved without efficiency, without effectiveness there is no efficiency. However, Druckers explanation is more succinct as it describes effectiveness as simply doing the right thing, while efficiency is doing the right thing well (Mohammed, 2015).

The regular reforms by policy decision makers in Nigeria as a result of the challenges of perennial fuel scarcity amongst other challenges is seen by the researcher as an application of the concept of effectiveness in trying to fix the challenges of fuel scarcity. The actions of the policy makers in successive governments to avert the scarcity challenge have remained a daunting task. The drive for effectiveness and efficiency by government using the available resources such as those used in maritime terminal operations, should also be in alignment with the goals of the fuel subsidy reforms by government. This collaboration will bring about an effective and an efficient policy direction towards ameliorating fuel scarcity challenge in Nigeria. Hence, there should be compatibility between the desired goals (reforms) and the available resources (Kharkhash, 2015) as cited by Ahmed Abdul Razzak Al-Sayed Omar (2023)

**2.1.9.1.2 Concept of Efficiency**

The principle of efficiency states that an action achieves the most benefits when marginal benefits from the allocation of resources equals marginal social cost with the goal of producing desired products at the lowest possible cost, eliminating misused resources (www.investopedia.com).

The UNESCO definition of efficiency is an ability to perform well or achieve a result without wasted resources, effort, time or money using the smallest quantity of resources possible (Analytic Quality Glossary).

According to Houston (1979), efficiency is the ability to produce expected outcomes or changes. However, Fisher (1972) explained that efficiency has economic, engineering and organizational concepts which is based on the ratio of inputs against outputs in production (Palmer &Torgerson (1999)).

According to (Omar, 2023) efficiency in management simply means doing the right work, achieving the right goal, achieving good results for the system.

The concept of institutional efficiency represents the rational criterion in the use of available financial, material and human resources and information. Institutions that aim at growth and development must ensure the continuity of the material, human and informational flow, in order to achieve its goals effectively and continuously, especially since the reality in contemporary environments is characterized by the scarcity and limitations of available resources, which makes institutions constantly suffering from the difficulty of obtaining those mentioned resources of the qualities and quantities necessary to achieve their goals. Institutions must also not exaggerate in achieving goals with the lack of sufficient necessary resources; This exposes it to severe failure, as it is necessary to achieve compatibility between the desired goals and the available resources (Kharkhash, 2015) as cited by Ahmed Abdul Razzak Al-Sayed Omar (2023).

The efficiency concept is relevant across all sectors of human endeavors. Efficiency could be at individual level, collective level, human resources management level and institutional level. Considerably, efficiency entails the integration of efficient individuals to efficient team through to institutional/ organizational efficiency (Bouyahyawi & Bin Ahmed, 2016).

Efficiency is goal oriented and expressed as a dynamic process with its constituent element interacting with each other on instruction. Efficiency is not an abstract, it is visible, observed and only by the analysis of the result from the application of means and activities of components/ elements activities in the system/ organization that it can be felt.

According to Palmer &Torgerson (1999), however, there are 3 major concepts of efficiency namely; technical, productive and allocative efficiencies. Efficiency measures the utilization of resources with the aim of getting the best value of money or outcome. In other words, efficiency is concerned with the relationship between resource inputs and either intermediate outputs or outcomes.

While, Wang et. al., (2005) explains that efficiency comprises of technical efficiency, scale efficiency and allocative efficiency. Technical efficiency is defined as the relative production between the observed output and the best possible output. Scale efficiency is defined as the relative scale between the observed firm size and the optimal firm size. Allocative efficiency is a measure of the benefit or utility derived from a proposed or actual choice in the distribution or apportionment of resources

According to Palmer & Torgerson (1999), some evaluations of performance have actually used intermediate outputs as a measure of effectiveness which is said to have led to suboptimal recommendations. In economic efficiency, maximization of outcome from allocated resources is ideal, but inefficiency exists when resources reallocation could be producing increased outcome.

**Technical efficiency** is concerned with the physical relation between (inputs) resources and outcome. In this case, technically efficient position is achieved at the maximum possible improvement in outcome as obtained from a set of resource inputs. Hence, an intervention is technically inefficient if the same or greater outcome could be produced with less of one type of the input resources. Technical efficiency also refers to the ratio of actual output to potential output of the spending unit.

**Productive efficiency** refers to the maximization of outcome for a given cost. In other words, it is the minimization of cost for a given outcome. The use of different combination of inputs as alternative interventions, the choice between the interventions is based on the relative costs of the different inputs/ resources. Productive efficiency encourages the evaluation of the relative value of money of interventions with direct comparable outcomes. It is incapable of addressing the effect of reallocation of resources at a larger level.

**Allocative efficiency** considers the productive efficiency, which is the input used to produce outcome, but also the efficiency in the distribution of the outcome amongst the community/organization. It is rooted in welfare economics that strives on opportunity costs. Therefore, allocative efficiency is achieved when resources are allocated so as to maximize the welfare of the community or organization. It is acclaimed that allocative and productive efficiencies are static concepts being concerned with how much can be produced from a given stock of resources at a certain point in time (Dalamore, 2014).

The technical efficiency tackles the issue of using given resources to maximum benefit or advantage. While productive efficiency chooses different combinations of resources to achieve maximum benefit for a given cost. Allocative efficiency concentrates on achieving the correct or right mixture of resources to maximize the outcome for the organization, community, institutions, society. Allocative efficiency is more of global or community-based interest. Pertinently, if the system is subject to limited resources, the productive efficiency concept will eliminate as" inefficient" some technically efficient resource input combinations, while the concept of allocative efficiency will eliminate some productively efficient resource allocations.

For instance, Seaport Efficiency according to Pallis & Rodrigue (2002) port efficiency is a multi-dimensional concept that refers to operational performance, particularly to maximize produced outputs or the production of a given output with limited possible resources.

The operational performance measurement of a system focuses on the productivity and relates to the physical quantities of the items, levels of effort expended, the scale or scope of the activities and efficiency in transforming these resources into some products or services. Traditionally, Berth occupancy, revenue per ton of cargo, capital equipment expenditure per ton of cargo, turnaround time and the number of gangs employed to facilitate cargo operations were the port performance indicators but over time, other vital indicators have been added. For maritime operations, maritime access efficiency is a major component of port performance which include, average anchorage time caused by lack of berthing slots to accommodate specific ship size, draft of channel /jetty/tidal fluctuation, distance from berth to anchorage, terminal productivity issues, etc. The average ship turnaround time is also a vital indicator which represents the time spent at berth servicing the ship, sometimes referred to as dwell time. The traditional indicators used in measuring terminal operations efficiency includes average yard dwelling time. (This time includes, inbound, outbound/ transshipment time).

The hinterland operations of picking cargo from the terminals are also a critical performance indicator to the overall performance of the supply chain. This is reflected in the average truck turnaround time, sometimes represented as truck traffic over a period of time/ BRV Traffic. This indicator is subject to bottlenecks which involves document processing for truck, security and safety screening protocols for these trucks. It is pertinent to mention that the performance of the terminal unloading equipment is also an indicator and an important component of the terminal's performance.

However, the transport operations beyond the terminal are often not considered a port performance indicator, though their inefficiency grossly affect the marine terminal operations. The issues of traffic congestions due to bad road, accidents, affects the supply chain performance of marine terminal operations (Notteboom, et. al., 2022).

Efficiency measurement in marine terminal operations is a continuum that start from the marine leg through terminal operations to the hinterland leg. It is an integrated system of measurement. Other port efficiency measurement indicators include financials which are benchmarked against other ports, terminals (Pallis & Rodrigue (2002)). The marine terminal is strategic for market capturing and socioeconomic contribution.

For instance, the financial performance of the port entities such as marine terminals operators and the performance of the governance model are also considered as essential in assessing port efficiency and performance. Ports and terminals operation performance and efficiency also considers its connectivity performance which reflects capacity, costs, congestion. The connectivity performance is driven by the significance of the importance of integrating ports/ terminals into other global supply chains which could lead to waivers in documentation process to encourage reduction in the overall supply chain leadtime. This fit is achieved when the tariff of the respective ports is competitive and while also some port enjoys a comparative advantage over its competitors.

Port efficiency concept is multidimensional, as it covers operational performance, connectivity performance, environmental performance, governance performance, safety, security and occupational health performance, market capturing and socio-economic contributions. According to Pallis & Rodrigue (2002), the port performance measurement also includes the port environmental performance, safety, security and occupational health performances. The efficiency of a port is systemic, integrative and a continuum that includes maritime operations, terminal operations and hinterland operations as earlier mentioned. This simply means that port efficiency is integrated and interrelated because an inefficiency recorded on an echelon renders the whole system inefficient.

Efficiency is a relative concept, i.e. the performance of an economic unit must be compared with a standard (Forsund & Hjalmarsson, 1974), and it is thus used to characterize the utilization of resources. Therefore, two outputs are required: the production structure of the container port/terminal industry and the efficiency index of individual ports/terminals in the industry.

Efficiency in marine terminal operations is simply " doing things right". In the words of Peter Drucker, the right things are both important to the customer and also influences decision making. The mismanagement of the right things (resources) leads to customers' dissatisfaction which is ineffectiveness or not "doing the right things". Synergy needs of organizations led them to being supply chain partners for the sake of sustaining system effectiveness and competitive advantage.

In this study, the researcher strives to empirically explain how the fuel subsidy reforms impact the maritime terminal operations community or seaport users, by way of patronage of tanker vessels, tank farm/ terminal, BRVs, etc. This is the reason for the choice of variables or indicator adopted for this study which cuts across all the vital indicators along the supply chain. E.g. cargo throughput, vessel traffic, BRV traffic, environmental protection levy, fire coverage (safety), etc. the researcher also wants to statistically expose the relative efficiencies of the marine terminals over the years under review.

**Estimation methods of efficiency**

In the estimation of systems productivity and efficiency, regression estimation methods, index number, corrected original least squares (COLS), Data Envelopmental Analysis (DEA), and Stochastic Frontier Analysis (SFA) traditionally suffices.

**The Index Number Model:** The index number model, constructs input and output aggregates by index formula and provides a productivity indicator. Index number is an economic data figure reflecting price and quantity compared with a standard or base value, which its base is often equals 100 and the base number is expressed as 100 times the ratio to the base value (www.wikipedia.com).

Index numbers are devices used for measuring changes in the magnitude of a group of related variables, over a given period of time.

Index number is primarily used to simplify complex or complicated comparisons. Countries apply index numbers to modify public polies such as adjusting government benefits for inflation. (www.investopedia.com). Index in economics, is a statistical measure of change in a representative group of individual data points derived from sources such as company performance, price, productivity, etc. Index number could be price index numbers, value index numbers and quantity index numbers.

The merits of index number approach include its ease of calculation. But its limitation includes chances of error as the index numbers are presented as a result of deliberated samples, it is hard to make international comparison of items between developed and underdeveloped countries, the difficulty of disentangling technical changes from the effect of scale economies and input substitution. Total Factor Productivity (TFP) is the most widely used measure in the index number approach.

**Data Envelopmental Analysis (DEA):** Data Envelopmental Analysis (DEA) is a mathematical programming approach to estimate productive efficiency. Its degree of efficiency or inefficiency is based on the distance between the production frontier and the observation. The approach maps out a production function based on inputs and outputs. The DEA approach is very sensitive to outliners; it doesn't consider measurement errors and statistical noise; hence it cannot be used to test the statistical significance of the efficiency index for a particular observation. But it doesn't consider a priori structural assumption on the production process. According to Agüero-Tobar, et. al., (2022), presented a classification of port variables used in data envelopment analysis as variables' classification supporting the selection of maritime operation variables for the efficiency analysis.

**Original Least Square (OLS) Estimation Method:** Original Least Square (OLS) Estimation Method is a regression method that fits an 'average line calculated by the production function' through the data. This frontier represents the production technique of the considered industry and indicates information such as the degree of returns to scale of the industry and the individual firms in the industry. Frontier represents the 'best possible practice' in the industry or sample studied. Once the frontier is estimated, efficiency then can be evaluated against the frontier.

The strength of all the statistical/ econometric methods including OLS is that they are consistent with the underlying economic theory that offers a potential explanation for cost or production structures. It also separates between different variables' roles which affects output; it also has standard statistical tests to assist the analysis.

The weakness of the OLS is due to its traditional assumptions in regression method, which means that it assumes that economic agents are rational and efficient at any time, which is not always true which already an inbuilt inaccuracy.

**Corrected Original Least Square COLS:** Corrected Original Least Square COLS is a parametric approach to evaluating productive efficiency. It is also classified as a regression method but different from OLS estimation method. The COLS also uses the OLS estimation approach of average line which cuts through the observation, which is later shifted as corrected line to enclose all the data. The corrected line is the representation of the efficiency frontier. This method enables the estimation of the individual decision-making unit to be measured against the frontier.

The strengths of the COLS approach are as follows; (1.) It discloses production technique information. (2.) It also separates roles of the different variables as they affect outputs as manifested by all parametric methods. (3.) the average line adjustment via corrected line to the frontier helps in estimating relative efficiency.

The limitation of the COLS approach is that it operates based on prior assumption or specification or arbitrary specification of the production function. This is common with parametric methods. According to (Greene, 1993), COLS are not capable of measuring statistical noise or error. COLS is also sensitive to outliers since the “best” performer on the outline serves as the benchmark on which the average line needs to be shifted or corrected to achieve the frontier.

**Stochastic Frontier Analysis (SFA):** Stochastic Frontier Analysis (SFA) is a parametric and stochastic approach to estimating production efficiency. It calculates the inefficiency of economic units based on distribution assumptions, meaning that different individual decision-making units can have different inefficiencies. In estimating production efficiency using SFA, there exists 2 random terms of statistical noise and inefficiency which is accommodated by SFA. Its estimation approach is different from COLS ad DEA because it does not adjust to frontier.

The strength of SFA is that it discloses information about the production techniques while also distinguishing different variables roles as they affect output. It also accommodates statistical noise which makes it possible for the evaluation of certain assumptions and hypotheses. SFA allows for flexibility in specification of production technology (functional form). SFA also allows for the modelling of environmental or exogenous variables. However, SFA weaknesses are the need to impose priori structure when constructing a frontier functional form; there is need for the imposition of the assumption concerning the distribution of inefficiency to be able to eliminate the error.

Considerably, Index number approach is applied basically for the measurement of the effect or impact of technology changes while other approaches namely OLS, COLS, DEA and SFA are mainly considered for gross measures of productivity.

Stochastic Frontier Analysis’ statistical and parametric econometric attributes are effective for the analysis of industry structures and the frontier attributes that are designed for benchmarking the relative efficiency of industrial ports/ terminals There are two primary ways to identify the frontier, namely mathematical programming – later developed as the DEA approach, and regression analysis – later developed as the SFA approach.

SFA is a statistical modelling method for efficiency and benchmarking analyses. The SFA method identifies the frontier through a regression method with a composed error term. The composed error term was first proposed by Aigner, Lovell & Schmidt (1977) and Meeusen &Van den Broeck (1977).

Aigner & Chu (1968), Seitz (1970 and 1971), Timmer (1971), Carlsson (1972), Forsund & Hjalmarrsson (1974 and 1979) developed the mathematical programming method that led to this outstanding framework which brought DEA to becoming a popular method for empirical studies.

However, port efficiency, effectiveness and resilience are the 3 components of port performance. Port performance measurement is dependent on operational efficiency measures which is evident in practice and in academia (Brooks, & Cullinane (2010); Pallis, et. al., (2010) and Agüero-Tobar, et. al., (2022)). There is availability of operational efficiency data on ports vis -a-viz marine terminal operations and there are also researches that measure efficiency of ports or marine terminal operations using Data Envelopmental Analysis DEA and Stochastic Frontier Analysis SFA models (Jeh (2022); Lim, &Lee (2020); Brooks, et. al., (2011); Agüero-Tobar, et. al., (2022); Radukic, et. al., (2023)) for Nigerian seaport efficiency evaluation, extensive studies have been conducted using these models (Onwuegbuchunam et al (2020); Ogochukwu & Kayode (2021); Nze, (2021); Ndubuisi & Nwoloziri (2020); Okeudo (2015); Nwanosike, et al., (2012)).

The study on **economic performance measurement** is premised on the concepts of productivity and efficiency. Concept of productivity is defined as the ratio of volume measure of output to the volume measure of input used, while the concept of efficiency as a relative concept, which is a benchmark concept that compares performance in relation to other like organizations or systems (OECD 2001). Efficiency is a relative concept, which has to compare the performance of an economic unit with a standard unit (Forsund & Hjalmarsson, 1974). It is thus used to characterize the utilization of resources. Therefore, two outputs are required: the production structure of the container port/terminal industry and the efficiency index of individual ports/terminals in the industry. Efficiency comprises of technical efficiency, scale efficiency and allocative efficiency. Technical efficiency is defined as the relative production between the observed output and the best possible output. Scale efficiency is defined as the relative scale between the observed firm size and the optical firm size. Allocative efficiency is a measure of the benefit or utility derived from a proposed or actual choice in the distribution or apportionment of resources (Wang et. al., 2005).

The assessment of marine terminal operations is seen from the prism of the port users who consider the inputs of different systems stakeholders (vessel owners, tank farm owners, BRV owners, fuel station owners etc.) in achieving their ultimate goal of efficient and effective service delivery. The keen interest of marine terminal operators is to satisfy the needs of its customers through services which will lead to enhanced patronage of such marine terminal operator. However, marine terminal operators that desires to continuously improve is advised to adapt the Germanischer Lloyd "container terminal quality indicator" process as introduced in 2008 presently applied in container terminals, which is a quality standard process which is based on customers' assessments (Martilla, & James, (1977)). It is an Importance – Performance Analysis made popular by Martilla, & James (1997) which is used in the assessment of service quality and customer satisfaction.

Port performance components of efficiency and effectiveness provides feedbacks to policy makers on reasons for reengineering the marine terminal operational structures to achieving the economic desires of the consumers and the system stakeholders. The monitoring of performance indicators represented by efficiency and effectiveness in port systems have led to large scale stakeholders' interest, thereby leading to extra infrastructural investments in the supply chain system (tank farm investments, indigenous tanker vessel ownerships, BRV investment etc.), these fits are achieved basically because of the continuous monitoring and improvement of the performance of the supply chain elicited by the complains from the end users.

In reviewing literature on economic performance analysis of systems like terminals and ports, stochastic frontier analysis (SFA) is often applied. According to Oum, Tretheway & Waters (1992), they claimed that in transport studies, the two major reasons for studies on economic performance are basically" gross measures of productivity and shift measures of technical change".

In summarizing the approaches for analyzing economic performances, Index number approach is applied basically for the measurement of the effect or impact of technology changes while other approaches namely OLS, COLS, DEA and SFA are mainly considered for measures of performance and productivity in this study.

**Marine Terminal Operations Metrics**

Ports are synonymous to marine terminals. The marine terminal efficiency, effectiveness and resilience are contributory to the 3 components of port performance. Port performance measurement is dependent on operational efficiency measures which is evident in practice and in academia. (Brooks, & Cullinane (2010); Pallis et. al., (2010)). There is availability of operational efficiency data on ports vis -a-viz marine terminal operations and there are also researches that measure efficiency of ports or marine terminal operations using Data Envelopmental Analysis (DEA) and Stochastic Frontier Analysis (SFA) models. In fact, Nze & Ejem, (2020); Ndubuisi & Nwoloziri, (2020); Okeudo, (2013); Emeghara, (1992); Barros, (2012); Barros & Athanassiou, (2004); Bauren et. al., (2018); Bichou,(2013); Cullinane et. al., (2005); Roll & Hayuth,(1993); Tongzon, (2001); Wanke et. al., (2011); Jeh, (2022); Lim & Lee, (2020); Brooks et. al., (2011); Radukic et. al., (2023) are some examples.

In most of the reviewed literature the classification of port variables used in Data Envelopmental Analysis (DEA) supports the variables' classification for the selection of maritime terminal operations variables for efficiency analysis (Agüero-Tobar et. al., (2022)). Other variables included in the port performance variables such as market capture performance indicators as disclosed by Nottenboom et. al., (2022). They are maritime traffic per market which include amongst others total tonnage (metric tons), - total liquid bulk (tons), vessel calls/ size (GRT) per type of vessel-Tanker and other liquid bulk carriers. Maritime traffic is defined as the vessels throughput per type of cargo handled by ports movements served in a given period (annum/ quarter/ month). It is a worldwide performance measurement indicator. Throughput of liquid bulk cargo is reported in tons. While, vessel traffic is the number of different sizes and types of seagoing vessels carrying different types of cargo or/and passengers) calling at the port in a given period of time. Vessel call size is the average or maximum size of the seagoing vessel calling at the port. This indicator is characterized by LOA and gross registered tonnage of vessel. These indicators and the monitoring of their characteristics sends signal to port management and policy makers on the capabilities of such ports.

The assessment of marine terminal operations is seen from the prism of the port users who consider the inputs of different systems stakeholders (vessel owners, tank farm owners, BRV owners, fuel station owners etc.) in achieving their ultimate goal of efficient and effective service delivery. The keen interest of marine terminal operators is to satisfy the needs of its customers through services which will lead to enhanced patronage of such marine terminal operator.

Therefore, the port performance components of efficiency and effectiveness provides feedbacks to policy makers also on reasons for reengineering the marine terminal operational structures to achieving the economic desires of the consumers and the system stakeholders.

The monitoring of performance indicators influenced by the concepts of efficiency and effectiveness in port systems have led to large scale stakeholders' interest, thereby leading to extra infrastructural investments in the supply chain system (tank farm investments, modular refinery investments, indigenous tanker vessel ownerships, marginal oil field investments, BRV investments etc.), these fits are achieved basically because of the continuous monitoring and improvement of the performance of the supply chain elicited by the complains from the end users. However, as earlier mentioned, marine terminal operators that desires to continuously improve is advised to also adapt the Germanischer Lloyd "container terminal quality indicator" process as introduced in 2008 presently applied in container terminals, which is a quality standard process which is based on customers' assessments (Martilla, & James (1997)). It is an Importance – Performance Analysis made popular by Martilla & James (1997), which is used in the assessment of service quality and customer satisfaction.

**Fuel Subsidy Reform Metrics**

Researches on Fuel subsidy reforms is vast and have covered different class of countries and have also adapted different approaches to fuel subsidy reforms. This peculiarity of countries has also led to unique and common grounds in variable application to achieving the objectives of the countries' subsidy reforms.

In the study conducted by Omotosho, (2019), he mentioned official pump price control by government in relation to the expected open market price- reference price as key variables in fuel subsidy reforms in Nigeria.

Nwachukwu & Chike (2011), also buttressed this point by asserting that government control of petroleum pricing stands as a variable for fuel reforms.

Globally, as disclosed in the reviewed literature on fuel subsidies using price gap approach, reference price, consumed quantity and end users' price- Official pump price have always remained regular variables in executing subsidy reforms in the petroleum industry (Coady et al. (2010); Larsen & Shah (1992); Kosmo (1987)).

Hence, the basic calculation of subsidy using the price gap approach is: Subsidy = {(Absolute Supply Cost or reference Price minus Official Pump price or End-user Price) multiplied by Quantity Consumed}. The reference price is actually the international oil price.

In a research work by Ochuonu, (2013), he disclosed that petroleum consumption quantity, domestic pump price, amount spent on petroleum subsidy payments and GDP were important variables in the computation of fuel subsidies in Nigeria.

Akinyemi et. al., (2015), examined the impact of Fuel Subsidy Reforms on environmental quality in Nigeria, using 2 step cointegration procedure techniques (the Johansen and the Engle-Granger). The study estimated 3 scenarios of subsidy payment, case of effective subsidy and a case of no subsidy payments. The study disclosed that case scenario one of subsidy payment and case scenario three of no subsidy payments do not significantly influence environmental quality. In other words, the study claim that subsidy payment does not enhance quantity of fuel consumption in Nigeria. The research in testing its hypotheses on impact of fuel subsidy on environment, applied the model specification that included variables such as emissions from liquid fuel consumption which is proxied for measurement for environmental damage.

OECD have also carried out numerous researches on countries that had embarked on fuel subsidy reforms, and the key variables monitored and evaluated in the research, especially in her report on Ukraine were variables such as budgetary allocation and transfers, government revenue foregone (or tax expenditure- tax breaks)induced transfers in the form of cross subsidies- regulated price for the poor households, residential consumers, or below market tariffs and risk transfers to government- financial supports to government energy sector-renewable or alternative energy sources, taxation, and energy pricing (Petkova et. al., (2023); OECD (2023).

In the application of price gap approach in estimating consumption subsidies, net importers, "reference prices are based on the import parity price: the price of a product at the nearest international hub, adjusted for quality differences, if necessary, plus the cost of freight and insurance to the net importer, plus the cost of internal distribution and marketing and any value-added tax (VAT). VAT was added to the reference price where the tax is levied on final energy sales, as a proxy for the tax on economic activities levied across an economy. Other taxes, including excise duties, are not included in the reference price." For example, the standard variables in calculating the landing cost of subsidized petrol in Nigeria as reported by PPPRA in 2020, consists of FOB Rotterdam Barge, Freight Rate = Cost of petrol plus freight (offshore Nigeria), Lightering Expenses, Insurance Cost, NPA Cost, NIMASA Cost, Jetty Throughput Charges, Storage Charge, Financing/Cost of Fund, Landing Cost at terminal, Wholesale Margin and the Distribution Margin components which are Transporters Allowance (NTA), Retailer Margin, Dealer margin, Bridging Fund, Marine Transport Average (MTA), NMDPRA Administrative Charge (PPPRA report 2020).

In Indonesia subsidy was shifted to aviation fuel quantity consumption in 1999, which was targeted at the wealthier households and later in 2019 government subsidized coal by putting a price cap to protect the finances of the Indonesian government-owned power distribution company. The pricing formula introduced earlier by the then Indonesian government was abandoned in 2003 but rejuvenated in 2015 with a three-monthly pricing review. The reform of 2015 was as a result of the low international oil price which also was expected to bring about savings in the countries budgetary allocation due to cheap fuel leading to infrastructural development. This also buttresses the point that international price, quantity and budgetary allocation for subsidy are variables for fuel subsidy reforms. In Indonesia, the size of subsidy remains an indicator of the financial health of Pertamina, the national energy company.

Another example is in the fuel subsidy reforms as indulged by France, who were levying the rural and semi urban working poor under the guise of carbon tax- excise tax in 2014. It was kind of mandatory as there were no alternative mode of transportation available for this class of commuters. This tax approach adversely affected the fuel price in France in 2015. Though budgetary allocation of about EUR 10 billion in 2018 was made with a monthly EUR 100 for workers with minimum wage. This also shows that fuel price and subsidy budgets are variables in addressing fuel subsidy reforms.

Iran's subsidy reforms in 2019 led to pressure on the standard of living of the middle class and lower-class citizens of Iran, due to the sudden price increase on fuel price. The poor documentation of the fuel quantity consumed led to failure of the subsidy implementation, which in turn led to cash management problems as epitomized by belated and limited cash transfers. This Iranian scenario also confirms that fuel price, consumed quantity and fuel subsidy budgets are strong variables to the implementation of fuel subsidy reforms.

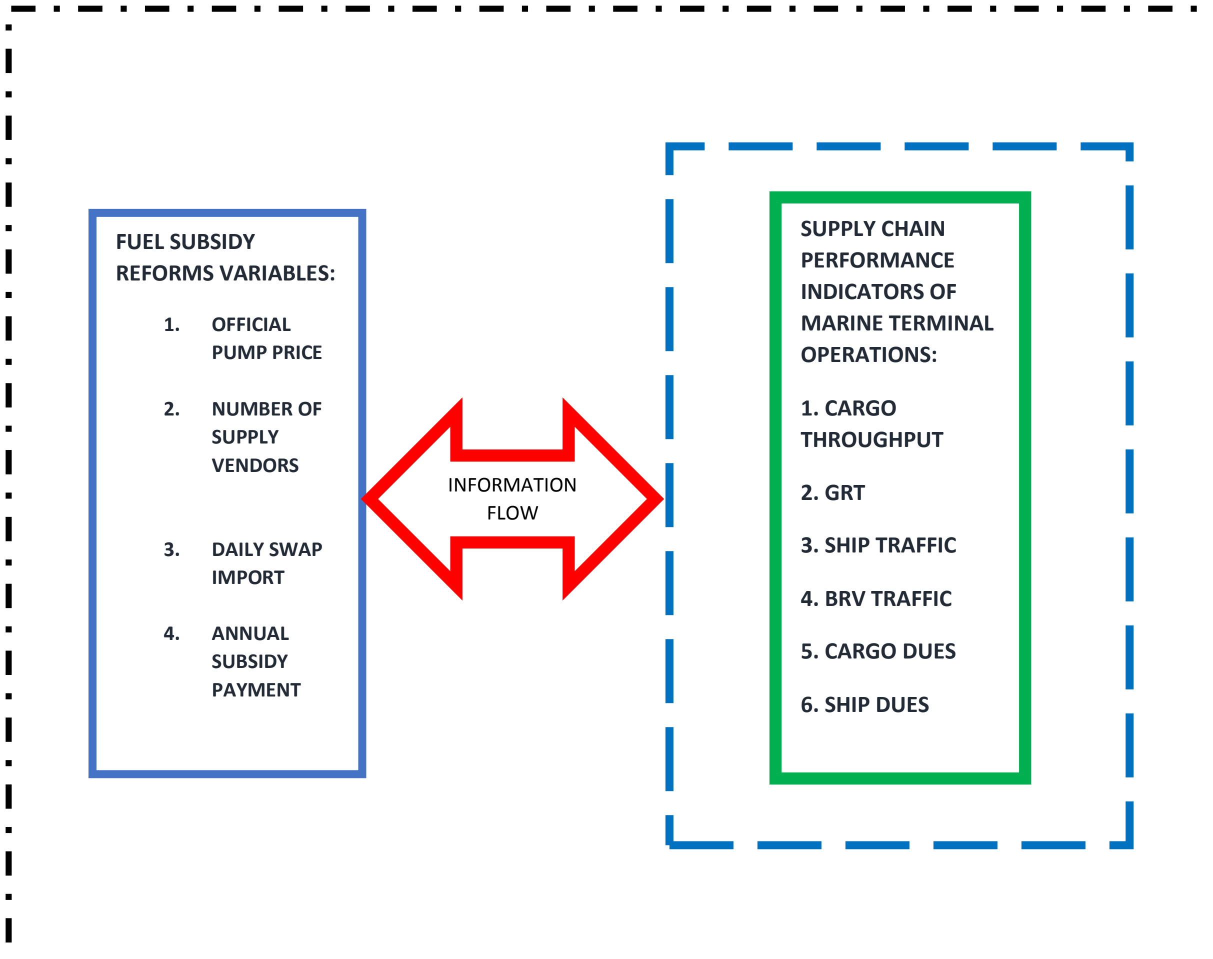
FUEL SUBSIDY REFORMS VARIABLES:
1. OFFICIAL PUMP PRICE
2. NUMBER OF SUPPLY VENDORS
3. DAILY SWAP IMPORT
4. ANNUAL SUBSIDY PAYMENT
INFORMATION FLOW
SUPPLY CHAIN PERFORMANCE INDICATORS OF MARINE TERMINAL OPERATIONS:
1. CARGO THROUGHPUT
2. GRT
3. SHIP TRAFFIC
4. BRV TRAFFIC
5. CARGO DUES
6. SHIP DUES

**Figure 2.1 SCHEMATIC REPRESENTATION OF THE CONCEPTUAL FRAMEWORK**

**Source: Researcher's illustration. 2023**

## 2.2 Theoretical Framework

In recent times, some organizations are under intense threat of extinction due to distortions in their global supply chain, which have led to severe competition and drive for continuous improvement. This have also led such organizations to study and restudy their processes for better understanding of the system's performance and hence introducing policy reforms that promotes continuous improvement in the face of rapidly changing business environment.

The skillful balancing of the organization and its environment will continually create viability for the organization that strives to succeed. The success of the synergy between the organization and its operating environments will be based on the unity of purpose as will be exhibited by the organization and the environment.

For instance, the influence of fuel subsidy policy reforms and international crude price fluctuation on the petroleum supply chain performance is so huge, because it compels all supply chain echelon operators to pursue in one accord a goal that will be beneficial to all the members of the supply chain otherwise termed the stakeholders.

Furthermore, systems that strives to succeed under rapidly changing environment such as the petroleum industry tends to adapt a more robust performance evaluation method.

The monitoring and evaluation of the supply chain performance under different fuel subsidy reforms have helped to confirm the rate and magnitude of viability, profitability, productivity, efficiency and utilization of the supply chain system.

In this study, a combination of theories was suggested to illustrate the performance of the marine terminal operations subject to the effect of fuel subsidy reforms in Nigeria.

### 2.2.1 The Foundational Theories applied in the Study

The foundational theories of interest as applied in this study were mainly, System theory, Contingency theory, and Goldratt's Theory of Constraints.

#### 2.2.1.1 Systems Theory

System theory is applied in this study basically because, it is one of the dominant theories in the studies of supply chain management. It is applied due to its capability of simplifying the complex organizational structures like the oil and gas supply chain while identifying the organizational stakeholders or echelons. The open system approach as first applied by Kalz & Kaln in (1966) in its study on organizational behavior, states the relationship between the organizations and their environment. The system theory seeks to explain and develop hypothesis around the characteristics that arise within complex systems that seemingly could not arise in any single system within the whole (www.wikipedia.com), hence, changing one part of a system may affect other parts or the whole system. The system theory emphasizes on maintenance of long-term organizational survival, as multiple inputs are processed internally into throughput and released as outputs into the environment in an attempt to restore environmental equilibrium.

The application of system theory, actually represents the real-life structure of the petrol supply chain process. For instance, the petrol supply chain is made up of 4 main elements just like the system theory model elements of input, process, output and outcome/feedback. The changes in inputs will definitely affect the outputs, and feedbacks from the whole system. The effect of policy reforms will definitely produce an output. Hence, supply chain seeks feedback to determine if the outputs were effective in restoring system equilibrium or gross distortions. The feedback in the case of petrol supply in Nigeria is symbolized in perennial fuel scarcity.

System theory justifies the application of contingency theory, theory of constraints (TOC), collaborative governance Data Envelopmental Analysis model and Stochastic Frontier Analysis (SFA) as adopted in the study to view the effect of fuel subsidy reforms on the performance of marine terminal operations in Nigeria. It is applied in this study to address the research objectives 1and 6 which is about efficiency of the system.

### 2.2.1.2 Contingency Theory

Contingency theory is sometimes referred to as situational theory or "it all depends" theory or "if" and "then" theory. Contingency theory is considered as a leading branch of management thought made up of an integration of the principles of different schools of thought such as the classical, behavioral and systemic approaches, contingent in tackling situations. Contingency theory is of the opinion that under different conditions different solutions can be effective (Omoluabi, 2016). It is pragmatic in addressing solutions to problems after careful analysis of the problem. It adapts to the principles of continuous improvement as it provides insights into organizations' adaptability to both internal and external environments.

Contingency theory was developed through the development of other concepts of Tayler, Fayol and Weber. Contingency theory was first mentioned in the works of Lawrence and Lersch in 1967, in the context of organizational structure (Omoluabi, 2016), but was made popular by Fiedlier, Hersey and Blanchard.

Contingency theory applies the multivariant analysis technique, where all possible variables or factors are considered as affecting the organizational situation while the best variables in the given environmental circumstances is adapted.

In other words, it is the "if" and "then" approach to situation or organizational management. The "if" represents the independent variables and the "then" represents the dependent variables. For instance, in this study, if fuel subsidy reforms are adjusted by government by way of product price control, daily quantity supplied, number of product suppliers, and amount budgeted and paid as subsidy, then the supply chain performance for marine terminal operations will respond in certain ways to show their effects and relationships. However, the continuous adjustments could let to the desired objective or goal of government.

According to Omoluabi, (2016), contingency theory is an extension of systems theory. It is used in the examination of the relationship between organizational structure and the operating conditions, which also is based on the use of the method of empirical comparative analysis. In otherwords, the relationship between the fuel subsidy reforms conditions and marine terminal operations performance in Nigeria is a case study.

Contingency theory is straightforward and its complex methodology is standardized. The dependent and independent variables can be precisely qualified and quantified. The contingency theory is also consistent in demonstrating the strength of correlation between two sets of variables. However, the theory also have limitations such as, its lack on the principles of universality. It also does not provide a definitive solution to problems which leads to costs and time wastages. They express strongly on formal structures but neglect the informal structure. The theory insists that problems are unique in nature and are also solved applying approaches resulting from due investigation and analysis of the problems. This is also applied in this research to address research questions, 1 to 8.

#### 2.2.1.3 Goldratt's Theory of Constraints (TOC)

The Theory of Constraints (TOC) is a business management tool that links all the production techniques. It is also a scientific methodology that makes it possible to relate the solutions to a firm's main problems notwithstanding its size, and to ensure that its ongoing improvement process is continuously uninterrupted (Pozo et al., 2009).

According to Pozo et. al., (2009), Theory of Constraints (TOC) is defined as a procedure for managing factors, production processes, organizational decisions and situations in which there are constraints in its present state.

Simatupang et. al., (2004) explains that Theory of Constraints (TOC) aims at initiating and implementing improvements by focusing on a constraint that prevents a system from achieving a higher level of performance. It is a system-based assumption that every organization is made up of integrated processes with one or more constraints that impedes the smooth progress of the organization (Simatupang, et al., (2004)).

Constraint here is that activity, element or factor that limits the system from operating as designed to accomplish its set goals (Goldratt & Cox (1992)).

TOC application in management is basically to systemically approach continuous improvement through step-by-step elimination of constraints from concept at point of origin to final consumers (Vargas, et al., (2017)). TOC is focused on system reengineering for the sake of system throughput maximization (Urban & Rogowska, 2020). The TOC application in global supply chain enforces integration of purpose to solving a problem even when there is division of labor amongst the management team for the sake of overcoming competition through continuous improvement. TOC is a technical tool for structuring problems, providing methods of solving the problems and also seeking system improvement (Urban & Rogowska (2020)).

Therefore, TOC is a tool that firstly analyzes capacity of the process before redesigning the processes for value creation and addition in the process (Bushong & Talbott (1999); Krajewski et al. (2007).

The main metrics adopted by the TOC are the production and the financial metrics which help in the monitoring of the system performance. The production metric depicts how much is produced at a certain time while the financial metric is the cost and revenue accrued as a result of the quantity produced over a certain time frame (Simsit et. al., (2014)).

According to Goldratt & Cox (2002), there are two types of critical constraints: physical and political (as cited by Picchiai et. al., (2009)).

According to Simatupang et. al., (2004), TOC application, could be geared toward constraints identified at internal and /or external locations, in a physical/tangible or non-physical/intangible nature for proper mitigation to achieving and promoting overall supply chain profitability improvement. These constraints also can be interwoven.

For purposes of this research, some examples of physical constraints are lack of demand for goods, limited distribution capacity, raw material shortage, limited capacity resources, limited jetty draft, limited port approach channel draft, limited shoretank capacity, limited ship tonnage, limited hose capacity, limited vessel discharge rate, limited speed of loaded tanker vessel, limited number of product suppliers, limited quantity of product to supply, etc.

Examples of non-physical constraints are obsolete policies (government or company), regulations, procedures, training skilled/unskilled.

Internal supply chain constraints are those constraints found within the supply chain system such as raw material constraint, drilling constraint, capacity constraint, transportation constraint, refinery constraint, Warehousing constraint, distribution channel constraint, information flow constraint, point of sale (POS) constraints, etc.

External supply chain constraints are those constraints that are externally influencing internal supply chain existing with a collaborative relationship, such as the supply constraint, market constraints, war constraint, tsunami/ natural disaster constraint.

However, the main aim of TOC is to help organizations increase their throughput while also guiding the organizations on constraint management through process redesigning and optimal utilization of the organization's resources.

Furthermore, TOC is the ability of organizations to be measured and monitored in 3 key Performance measurements namely: throughput, operational expenses and inventory which shows the sequence in the order of priorities (Şimşit et al. (2014)).

Though, the above metrics are pioneer metrics adopted by Dr. Goldratt, but the TOC have been applied in various fields of research, have undergone several scrutinies and has improved from an era to the 5th era over the years. They have also gained wide acceptance in companies seeking continuous improvement (http://en.m.wikipedia.org).

This is possible because constraints in organizations come in different forms such as, stale operational policy, time limitation, skilled workers insufficient, faulty equipment, etc.

However, in the application of the Theory of Constraints (TOC) model, there are 3 approaches mainly used: The 5 Focusing Steps; The Thinking Processes; and The Throughput Accounting.

**The 5 Focusing Steps (Process of Ongoing Improvement)**

According to (Goldratt & Cox 1992) Goldratt (1992) and Krajewski (2007) there are 5 Focusing steps adopted in evaluating a system for constraints and redesigning the system for continuous improvement (Goldratt & Cox 1992, Krajewski et al. 2007).

It is a repetitive methodology for identifying and eliminating system's most significant constraint responsible for the under performance of the system, through the process of tangible investigation and analysis for the purposes of system reengineering.

The 5 focusing steps are:

– Identification of the constraint or constraints in the system;

– Decision on how to rationalize their utilization for the best possible benefit to be achieved;

– Subordinate all other processes or activities to the decision taken in step 2 above;

– Elevate or widen the constraints in the system (i.e., offloading tasks, integrating tasks, simplifying task, eliminating tasks at the constraint);

– If the constraint has been widened, return to the item 1 but do not allow for the birthing of new constraints as a result of sluggishness in changes or redesigning.

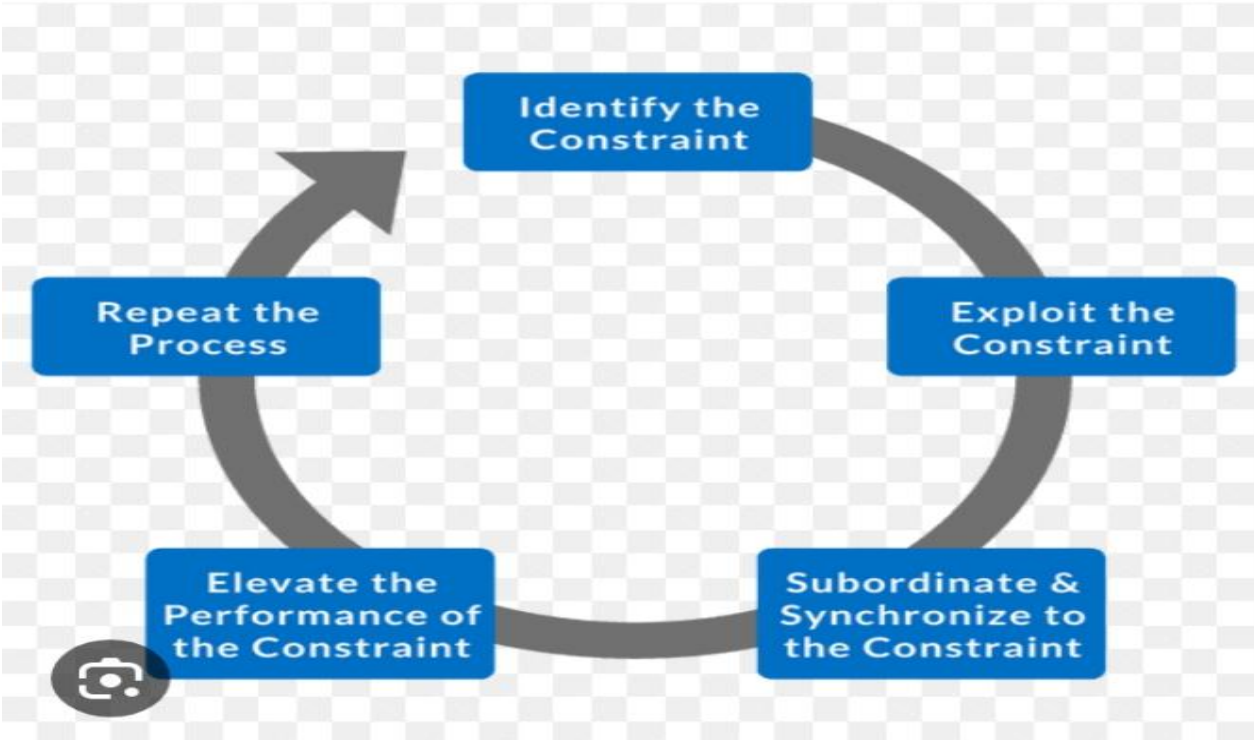


Figure 2.2: Schematic Diagram of 5 Focusing Step Theory of Constraint
Source: Vorne 2023

**The Thinking Processes**

According to Şimşit et. al., (2014) the thinking processes of TOC is a problem-solving technique that applies a question-and-answer approach as adopted in the theory of constraints. It is saddled with the objective of identifying and eradicating the key cause of the undesirable effects in a system without creating or causing a new constraint. Its question-and-answer approach concentrates on 3 main questions which are;

a. What needs to be changed?
b. What will it be changed to?
c. What actions will cause the changes?

The thinking process is best adopted for this study because policy constraints are best addressed through the thinking process framework (Vorne, 2023). Although, the production constraints are best handled by the 3 TOC frameworks.

For instance,

**Step 1 of the 5 focusing steps:** Nigeria government concurred with petroleum industry practitioners that the fuel subsidy policy is the major constraint to fuel availability hence the perennial fuel scarcity and its attendant multiplier effects etc.

**Step 2 and 3 of 5 Focusing Steps:** The government then decided to tweak the policy at different times by adjusting the official pump price, number of supply vendors, annual subsidy payments and the daily swapped import under the below listed headings; Open System Import Account Policy**,** Offshore Processing Agreement (OPA), Refined Petroleum Exchange Agreement (RPEA), and Direct Supply Direct Purchase (DSDP).

The above reforms still did not abet the refined petroleum product scarcity in Nigeria may be because of the infrastructural deficits in the petroleum supply chain in Nigeria.

**Step 4 on the 5Focusing Steps:** The stakeholders' clamor for the complete removal of the fuel subsidy by way of removal of price control, quantity control, vendor entrant control, subsidy budgets payment via Petroleum Industry Act (PIA) implementation, this will confirm if efficient fuel supply or availability will be achieved, by the evaluation of the process.

According to Dettimer (1997), these 5 Focusing Steps exemplified above are also found in the 3 questions as posed by the Thinking Process of TOC. Below is the Nigeria case study of the application of the TOC Thinking process, which are:

1. What to change? (Search for main constraint- fuel subsidy reform metrics).
2. What to change to? (Define how to explore the identified constraint- alter fuel subsidy reform metrics).
3. What actions will cause the change? (Elevate or remove constraint- remove the fuel subsidy reform metrics).

The effect of those changes will be expressed through the evaluation of the metric for monitoring and measuring performance.

The TOC Throughput Accounting metrics used in this study were adopted based on the intermodal interface (-RPOT jetties) of the petroleum supply chain performance measurement in Nigeria.

Therefore, in this research, the Fuel Subsidy Reforms metrics used were Official Pump Price, Daily Swap Import, Number of Supply Vendors, other variables include Annual Subsidy payment, while those for performance measurements were Ships GRT, Ship Traffic, Ship Dues, Berth Rent, Value

Added Tax, Cargo Dues, Cargo Throughput, Bulk Road Vehicle Traffic, Environmental Protection Levy, Fire Coverage.

The RPOT jetty performance metrics actually stood as the TOC Throughput Accounting metrics for this study, because of the intermodal interface (-RPOT jetties) has the provision of both financial and non-financial metrics/ parameters for petroleum supply chain performance measurement in Nigeria.

Furthermore, the above metrics have enabled the application of both Data Envelopmental Analysis Model and Stochastic Frontier Analysis Model in answering all the research questions posed in this study.

**Step 5 on the 5Focusing Steps:**

Repeat the process from step1 to step 5 for the continuous improvement on both the policy constraints and the supply chain infrastructure constraints that influences the petroleum supply chain performance measurement.

This model is applied in this research to justify the approach adapted by government through fuel subsidy reforms by tweaking the variables of the fuel subsidy reforms as operational in Nigeria. This is also applied in this research to address research questions, 1,2,3,4,5,6, 7and 8

**2.3 Empirical Review**

Extensive studies have been done in the area of fuel subsidy impact on Nigerians household, economy, transport, agriculture etc. as shown in the works of (McCulloch, (2021); Siddiq (2015); IMF (2022); Danladi (2016); Moyo & Songwe,(2012); Ezeah, (2016); Nwaogu, (2013); Shagali,(2022); Abdullateef et al., (2018); Obasi, (2018); Omotosho, (2019); Obo et al., (2017); Adeyemi (2017); Nwachukwu et al (2013); Mohammed Al-Malish (2017); Idrisu (2020); etc.).

It is pertinent to mention that studies on supply chain performance in petroleum industry, have also been studied though with no mention of its relationship or interface with the marine terminals for liquid bulk, which is a vital echelon in the petroleum sector in Nigeria.

Adeniran (2018), studied the effect of fuel subsidy on transport costs and transport rates in Nigeria, and he posited that fuel subsidy reduces the overall rate and cost of transportation to longer distances. He also claimed that the overall cost of transportation will be minimal even when using larger carrying unit to convey goods. This is true for transport modes that use subsidized fuel as bunker. He further asserts that the efficiency of the transportation infrastructure such as terminals results in direct impact to transport cost. The efficiency of the terminals translates to reduced delays or leadtime. The efficiency translates to the proper management of the fuel subsidy provisions of government whereby petrol is distributed efficiently to the citizenry at lower subsidy cost to government and the country as a whole. Akinyemi et. al., (2015), examined the impact of Fuel Subsidy Reforms on environmental quality in Nigeria, using 2 step cointegration procedure techniques (the Johansen and the Engle-Granger). The study estimated 3 scenarios of subsidy payment, case of effective subsidy and a case of no subsidy payments. The study disclosed that case scenario one of subsidy payment and case scenario three of no subsidy payments do not significantly influence environmental quality. Inotherwords, the study claim that subsidy payment does not enhance quantity of fuel consumption in Nigeria. The research in testing its hypotheses on impact of fuel subsidy on environment, applied the model specification that included variables such as emissions from liquid fuel consumption which proxies for measurement for environmental damage.

Findings from the study supported evidence of a long run sustainable equilibrium model. Also, our estimation results showed that the first and the last case scenario do not significantly influence environmental quality. This implies that subsidy payment in Nigeria does not enhance access and consumption of liquid fuel. On the other hand, the interaction of sound regulatory framework with subsidy payment (the case of effective subsidy) significantly exerts a responsive influence on environmental quality.

Muthini et. al., (2017) also assessed the role of government economic regulations on petroleum supply chain management by surveying oil marketing companies in Kenya. They used mixed research design. A field survey was carried out while purposive sampling was used to select 180 respondents from thirsty six (36) oil marketing companies located in Nairobi city involved in importation and marketing of oil products in Kenya. They applied Statistical Package for the Social Sciences (SPSS) for descriptive statistics and inferential while Analysis of Moment Structure Software (AMOS) was used for Structural Equation Modeling (SEM). The study findings indicate that there was a positive relationship between government economic regulations and Petroleum Supply Chain Management. The researchers therefore recommended the implementation of government economic regulations by Oil Marketing Companies (OMCs) and Energy Regulation Commission (ERC) to be proactive to ensure full compliance. They suggested that there is need for participation of all stakeholders in the development of policies that will ensure sustainable petroleum supply chain management.

According to (Suleiman, 2020) in his work titled "Crude Oil/Product Swap: Oil for Products Agreement (OPA) Vs. Direct Sales Direct Purchase (DSDP) -The Nigerian Context "claimed that the Nigerian Government changed the Offshore for Processing Agreement (OPA) to the Direct Sales Direct Purchase (DSDP) agreement due to lack of transparency and corruption of the OPA. His research tried to assess the effect of the policy changes on revenue saving for Nigeria. In his research he tried to confirm between the 2 subsidized fuel supply models which was more economical and structurally sound. However, this study did not identify the performance measurement used to adjudge a fuel subsidy reform model better than the other.

Olujobi et. al., (2020) explored the need for total deregulation of the downstream sector of the Nigerian petroleum industry to address inefficiencies in the sector to promote adequate supply of petroleum products through regulatory reforms and by making reference to the experiences of other relatively advanced jurisdictions to strengthen Nigeria's downstream petroleum sector's laws. The work adopts a conceptual approach relying on extant literature with the application of the doctrinal legal research method. The study found the overbearing presence of the Federal Government in the sector as source of corruption and inappropriate pricing of petroleum products as the reason for the sectors unattractive to private investors brought about by excessive regulation of the sector. The research proposed a model to end incessant hike in the price of fuel.

Bello, (2017) in his article titled "Oil and Gas Problems in Nigeria; The Impending Problems and The Preferable Solutions" examined the crux of the oil and gas problem which included volatility of oil prices, obsolete laws and regulation, pipeline vandalisation, corruption and lack of government funding. He confirmed that innermost players (government owned agencies) are responsible for plethora of problems affecting the industry. The Global market external forces are not left out. He recommends that oil and gas industry require a surgical operation and there must be holistic approach in order for the industry to attain the global standard.

McCulloch et. al., (2021), studied the attributes of those in support of subsidies and those against it. They used a new nationally representative household survey that asked Nigerian men and women about their knowledge and attitudes towards subsidies. The researchers constructed and tested a set of hypotheses about the factors associated with support for subsidy reform and their result showed that those who pay more or who experience less availability of fuel, tend to support reform more. On the other hand, people who believe the Government is corrupt or lacks the capacity to implement compensatory programs appear strongly opposed to reform. Finally, being religious and the delivery of reasonable national and local services also improved the acceptance of reform. These results supported the idea that building a social contract is key to reform success.

Chayita & Kaseke (2021) tried to determine the impact of government policy interventions on the survival strategies being implemented by companies in the petroleum sector in Zimbabwe. The study used the observation method to collect and analyse observed market activities. The observation method enabled the researcher to examine the research phenomena and ensured that the researcher did not only rely on views of respondents, but was able to discover important aspects about respondents through observation. The findings of this study reveal that petroleum firms in both developed and developing economies are operating in turbulent economies that are influenced mostly by governments through high regulations, political controls and interventions in the operation of petroleum firms. This has caused uncertainty to operations of petroleum companies. Petroleum firms are surviving by constantly scanning the environment to understand the changes that are taking place and ensuring that their business strategies take these changes into account.

Ochuonu, (2013), investigated the impact of petroleum subsidy on the consumption of petroleum products in Nigeria and it was found that there is more consumption of petroleum products with subsidy than without. Among other recommendations the study opines that government should diversify the economy as quickly as possible and direct its positives to other sector of the economy that have been overlooked. The study also investigated what actually constitute the petroleum subsidy in Nigeria. It tried to analyze the cost to the government if not removed and the welfare of the local consumers. It endeavored to reveal to a greater extent what effect it had on the GDP of the economy, at its full sustenance, partly to be taken in the issue of petroleum subsidy in Nigeria. The research work used a dummy variable to explain its finds (1 when there is subsidy and 0 when there is no subsidy).

Beedell, (2017) studied on the major arguments in favor of subsidies, and tested their validity by evaluating the economic, social and political impacts of Nigeria's subsidy regime. Analysis was based on a literature review supported by data collected from the National Bureau of Statistics and other organizations. Findings suggested that the subsidy regime have created economic inefficiency, exacerbated negative externalities associated with fossil fuels, and worsened macroeconomic stability through pro-cyclical government spending. It has not achieved its desired social benefits, as the subsidies are regressive, and has not improved access to energy, as subsidies divert investment from public power infrastructure. Lastly, the interplay between subsidies, rent-seeking, and patronage has likely worsened Nigeria's quality of governance. Nonetheless, the subsidy regime enjoys widespread popularity as a tangible means by which natural resource wealth is redistributed.

Inegbedion et. al., (2020), investigated petroleum subsidy withdrawal, fuel price hikes and the Nigerian economy to determine the extent to which the removals of petroleum subsidies stimulate hikes in fuel prices and increases in the prices of products of other sectors in the Nigerian economy. It employed input-output model to determine the value added per sector from the computed table of flow of goods. Subsequently, the impacts of reductions in petroleum subsidies (10%, 20%, 30%, 40% and 50%) on the prices of products from the other sectors were computed. Results showed that reduction in petroleum subsidies stimulate increases in prices of petroleum products and such increases trigger increases in transport fares; increases in transport fares subsequently lead to increases in prices of other products owing to the degree of interdependency among the various sectors. The need for policy makers to be mindful of the economic implications of subsidy removal was suggested, among others.

Auwal & Adamu (2012), assessed the impact of the petroleum products supply and domestic prices on the domestic distribution. They applied Vector Auto-regression (VAR) model and Ordinary Least Square (OLS) and based on the lagged and dynamic long run equilibrium, domestically refined and prices of petroleum products remain insensitive to the quantity distributed, while the imported quantity, though with a low coefficient and weak correlation, remained the key mode of supply that is currently sustaining the economy. Hence, they recommended that total return to local refining, diversification of the export base, consistency in and efficiency of government pricing and environmental policies as well as total market concept in the chain of petroleum products supply and distribution be adopted to cushion the non-sustainability of the deregulation policy.

Alam (2017), in his work titled "Government's Influence on Supply Chain Management: A Systematic Literature Review" suggested that future researches can focus on crucial topics such as supply chain performance, and investigate the direct and indirect impact of government on the operations. He reviewed papers that summarizes the role of government and governmental policies in various aspects of SCM. The study used the Porter's Diamond Model as the review framework, and it used the PRISMA Flow framework as the literature review method, From the 32 reviewed papers it is found that the green supply chain management is the most covered topic, analytical modeling is the most used methods, and manufacturing context is the most popular research context. Moreover, it is identified that the significant role of government's policy on SCM includes impact on pricing decisions and competitiveness, impact on environmental decision making related to SCM, impact on energy saving effort, impact on supply chain design decision, impact on legislative compliance, and so on.

The work of Kojima & Koplow on fossil fuel subsidies, approach and valuation 2015 was also instrumental to the interest of this research. Kojima & Koplow (2015) queried the figures emanating from global subsidies of fossil fuel and how the measurements are done, since they appear different in different countries. They further explained that subsidy measurement is mainly achieved using the price-gap approach, and inventory approach. Though these approaches are complementary. Price gap approach entails the quantification of the gap that exist between free market reference prices and the prices as charged consumers, while the inventory approach entails the government actions on inventory variables to benefit production and consumption of fuel. Though it is observed that price gap approach causes economic distortions as quantification is vital to improve pricing policies, inventory approach is vital for the sake of evaluating budgetary allocation. However, the disparities arising from different countries subsidy measurement is a function of assumptions made due to missing data compensation and the scope of the subsidy measurement. Investing resources in continuous collection of data and data analysis for tracking subsidies fosters rich dividends while enabling informed decisions and increasing implementation transparency.

Livohi (2012) examined the extent to which Oil Marketing Companies in Kenya measured their Downstream Supply Chain Performance and identified the Key Performance Indicators used in this measurement and the challenges Oil Marketing Companies (OMCs) faced whilst undertaking the Downstream Supply Chain Performance measurements. Data was collected through questionnaires from a population census of 53 Oil Marketing Companies and was analyzed quantitatively and qualitatively. The findings of the study indicated that many of the Oil Marketing Companies (OMCs) measured their Downstream Supply Chain Performance using KPIs such as unit cost of transportation, and of storage; quality of service, information and quality of products; time for loading, turnaround time, transportation, delivery and time to relay information; and customer feedback. The study concluded that the Downstream Supply Chain Performance Measurement is vital among the Oil Marketing Companies (OMCs) in Kenya with regard to enhancing the performance of their Downstream Supply Chains.

Varma et. al., (2008) evaluated supply chain performance of a process industry supply chain. The purpose of their study was to suggest a method to evaluate the performance of the petroleum industry supply chain. A combination of analytical hierarchy process (AHP) and balanced scorecard (BSC) were applied to evaluate performance. The AHP technique was applied to determine the relative weights of various perspectives as well as the factors under each perspective and the following factors of purity of product, market share, steady supply of raw material and use of information technology were found to be most important respectively.

Lindner et. al., (2009) in a Master's thesis analyzed supply chain performance measurement systems and identified problems and challenges during measuring the performance of a supply chain. A qualitative approach was adopted, hence only interviews were used in this thesis. They found combined theoretical and practical problems and challenges and a final list of challenges for supply chain performance measurement was developed. The developed list included the following nine challenges: communication, trust, strong cost focus, willingness to share information, learning and collaboration among the supply chain participants, reduction of complexity, transparency of processes, advantages and disadvantages, handling of new management approaches and that technology is a supporting tool only. The thesis therefore offers the basis of further research by providing a list of challenges which need to be considered to successfully measure supply chain performance (Lindner, Cui, & Hertz (2009))

Akintokunbo, & Idadokima, (2021) investigated industry 4.0 and supply chain performance. Extant literature was reviewed. Secondary data such as E-books, journal articles projects were used. Exploratory research design was used for the study. Based on the literature reviewed, it was revealed that, integrated supply chain performance measurement system (SCPMS) is paramount for an efficient supply chain management (SCM) at inter-organizational and beyond-the-boundary processes. The recent technological innovations (Internet of Things (IoTs), big data, and web-based communication systems) revamp the SCPMS through effective data collection, information sharing, and framework integration among the different SC partners across nations.

Muturi & Ngugi (2015) highlighted the challenge affecting performance of supply chain systems, chief of which is the rise in fuel shortages in firms that have precipitated the need for oil companies to realign their supply chain systems with a view of doing proper forecasting. The researcher studied how oil companies can perform within the supply chain systems in their processes. Data was gotten from review of relevant literature and interviews. The analysis was based on previously conducted research from books and relevant journals and articles. The findings from the research confirm that oil companies need to implement supply chain systems as a continuous process to achieving sustainability in the supply chain processes. The study concludes that both national and international companies need to enhance the levels of implementing green supply chain practices in managing their operations.

However, Ndubuisi & Nwoloziri, (2021) evaluated the performance of three NNPC jetties in the Niger Delta region of Nigeria, subject to the period of two different crude swap policy regimes in Nigeria. They applied Data Envelopmental Analysis (DEA) Model and Ordinary Regression Analysis, and the study showed that, there were more efficient use of the jetties pre 2016 than post 2016 period. This study encouraged the further probe on this novel topic as the article remains the only pilot survey that addressed the preliminaries of this research.

There is an empirical need to investigate the relationship between fuel subsidy reforms and marine terminal operations supply chain performance in Nigeria. The empirical disclosure from the evaluation will further justifies an urgent shift of policy making and researches in this area. This endeavor will empirically support decisions as taken by policy makers in Nigeria concerning national challenge like fuel scarcity and price hike that has elicited international interest. It is vital to also note that, there are study gaps in the comparative performance analysis between state-managed and privately-managed marine terminals in Nigeria during the former presidents Jonathan and Buhari fuel subsidy reform summersaults. These gaps are bridged by this research, as the study remains the first of its kind in addressing fuel subsidy reforms and its impact on both government managed and privately managed marine terminals in Nigeria.

# CHAPTER THREE

# METHODOLOGY

## 3.1 Method of Data Collection

Primary data for the study were gotten from direct observation during cargo operations at 6 selected marine terminals and through expert responses to open ended questions at these selected marine terminals-jetties.

Secondary data for the study were gotten from review of relevant literatures, data from reports of Ship officers, Shipping agents, Cargo Surveyors, Nigeria Ports Authority (NPA), Nigerian National Petroleum Corporation Limited (NNPCL), Organisation of the Petroleum Exporting Countries (OPEC), Petroleum Products Pricing Regulatory Agency (PPPRA)(now Nigerian Midstream Downstream Petroleum Regulatory Authority (NMDPRA)), Central Bank of Nigeria (CBN), Nigeria Extractive Industries Transparency Initiative (NEITI) Databases, PricewaterhouseCoopers publications and National Assembly audit report.

The data variables used were divided into input (independent), control and output (dependent) variables. Input variables are Number of Subsidy Vendors, Daily Swap Import, Official Pump Price, Annual Subsidy Payments, while control variables are Jetty Draft, Port Channel Approach draft, Berth Distance from FWB, Shoretank Capacity, and Ship Maximum LOA. The Output variables comprises of Ship Dues, Cargo Dues, BRV Traffic, Cargo Throughput, Gross Registered Tonnage, and Ship Traffic.

## 3.2 Research Design

Research design of a study is done with a plan evolved by the researcher to guide in data collection and analysis (Abdellah & Levine, 1979). In trying to navigate through the research to ascertain the effect of fuel subsidy reforms on the supply chain performance of marine terminal operations in Nigeria, below steps were taken.

In this study, exploratory research design was adopted. The qualitative approaches were hinged on direct observations, Focus Group Discussion (FGD) and In-Depth Interviews (IDI), with open ended questions to the marine terminal operators/ boarding team which comprises of cargo surveyors, regulatory agencies, depot operators, shipping agents, vessel captains, pilots etc. They also authenticated some of the quantitative data from the studied marine terminals-jetties as published in Nigerian Ports Authority (NPA) database, NEITI, DPR, etc.

Quantified research design was used in which time series quantitative data on daily swap import, number of supply vendors approved, annual subsidy payment, and pump price per liter, were sourced from. These secondary data were used as proxies for fuel subsidy reforms while cargo throughput, ship call traffic, bulk road vehicles calls, cargo dues payments and ship dues payments of the terminal operators were obtained from the Nigerian port authority statistical reports and used as proxies for supply chain performance of marine terminal operations over the period under consideration. The descriptive and inferential statistical methods of stochastic frontier analysis model and log linear multiple regression analysis were applied in analyzing the data obtained after standardization of the data using natural log transformation.

### 3.3 Population of the Study

The population of the study comprised of male and female practitioners engaged in the selected case study marine terminal-jetties. The selected study population consist of 6 marine terminals; comprising 3 public and 3 privately-managed Marine Terminals across the 3 NPA pilotage districts of Calabar (Cross Rivers State), Port Harcourt/Bonny (Rivers State) and Warri (Delta State) Pilotage Districts all in the Niger delta region of Nigeria.

The 6 selected Marine terminals are: Bitumen Terminal (BJ) Rivers State, PHRC-Okrika Terminal (OJ) Rivers State, NorthWest Terminal (NW) Cross Rivers State, NNPC Terminal (NJ) Cross River State, Rainoil Terminal (RJ) Delta State, and WRPC Terminal (WJ) Delta State

### 3.4 Validity of the instrument

The instrument used in this study were the FGD and IDI templates. The processes were thoroughly perused and certified as appropriate by the professional researchers in the department of Maritime Management Technology of Federal University of Technology Owerri, Imo State. They individually and collectively scrutinized the work after a pilot application of the template, before it was submitted to the research supervisor for final perusal, correction and approval.

### 3.5 Reliability of the instrument

The responses to the open-ended questions from the respondents (depot operators, cargo surveyors, shipping agents, regulatory agencies, ship captain, pilots, cargo owners) reconfirmed the authenticity of the data and the choice of the data. The direct observation and subsequent calculation by researcher at the marine terminals also authenticated some secondary data such as jetty draft, vessel LOA, shoretank capacity, etc. This was to guide against data commission and omission. The FGD and IDI were applied mainly to categorize or rate the constraints hindering the regular refined petroleum product availability in Nigeria.

### 3.6 Sample Size Determination

According to Ezejelue & Ogwo (1990) they claimed that there is no definite rule governing an ideal sample size, hence they posited that the sample size should be dependent upon what use it is to be made of the research result and how much precision the researcher desires. The author selected 6 seasoned and operational marine terminals. The author also selected data from 2012 to 2021 from the operational marine terminals which had commenced PMS Cargo operation on or before 2011 in the Niger Delta region of Nigeria and that are still operational till date. A total of 50 respondents were approached for the interview but 42 respondents were actually interviewed for this study in groups of 7 independent professionals per group per marine terminal.

### 3.7 Method of Data Analysis

Descriptive Statistics was applied in representing the percentage of responses on the categorization of the petroleum supply challenge in Nigeria and also for the choice of data adopted for the study. It was also used to represent the natural log transformation variables for ease of analytical application. In addressing the research questions on the effect of fuel subsidy reforms on supply chain performance of marine terminal operations in Nigeria, correlation test, regression analysis, Stochastic Frontier Analysis (SFA) and Data Envelopmental Analysis (DEA) Models were appropriately applied.

### 3.7.1 Model Specification

#### 3.7.1.1 Pearson correlation

This model is used in this study to address research questions 1,2,3,4,5, and 6. It was applied to empirically establish if there is significant relationship between fuel subsidy reforms and supply chain performance of the marine terminal operations.

In this formula:

$$r = \frac{[n(\sum xy) - \sum x \sum y]}{\sqrt{[n(\sum x^2 - (\sum x)^2][n(\sum y^2) - (\sum y)^2]}}$$

x = independent variable

y = dependent variable

n = sample size

Σ = represents the summation of all values.

#### 3.7.1.2 Stochastic Frontier Analysis (SFA) Model

This model is applied in this study to address research questions 7. The study adopted an econometric approach for estimation of technical efficiency known as Stochastic Frontier Analysis model proposed by Kumbhakar, Lian and Hardaker (2014) and Colombi et al, (2014) and could be specified thus:

$$y_{it} = \beta_0 + f(\mathbf{x_{it}};\boldsymbol{\beta}) + \mu_i + \nu_{it} - \eta_i - \varepsilon_{it} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where for

$y_{it}$ = Logarithm of the i$^{th}$ units of output at time t.

$\mathbf{x_{it}}$ = is a row vector of p regressors (input variables).

$\boldsymbol{\beta}$ = is the column vector of p unknown model parameters

$\beta_0$ = intercept of the model

$f(\mathbf{x_{it}};\boldsymbol{\beta})$ = production or organization (marine terminals) frontier.

$\mu_i$ = latent organizational heterogeneity or random-firm effects.

$\nu_{it}$ = error or white noise component.

$\eta_i$ = persistent (long-run) time invariant inefficiency.

$\varepsilon_{it}$ = transient (short-run) time-varying inefficiency.

$i = 1, 2, ..., n$ represents n production units (6 marine terminals- jetties)
$t = 1, 2, ..., T$ represents time points (here yearly).

For the estimation of model parameter of (1), the three step KLH procedures outlined by Kumbhaker, Lian and Hardaker (2014) is deployed. In this procedure, model (1) is re-written thus:

$y_{it} = \beta_0^* + f(\mathbf{x_{it}}; \boldsymbol{\beta}) + \alpha_i + \omega_{it}$ …………………………………………………………………..(2)

Where,

$\beta_0^* = \beta_0 - E(\eta_i) - E(\varepsilon_{it})$

$\alpha_i = \mu_i - \eta_i + E(\eta_i)$

$\omega_{it} = v_{it} - \varepsilon_{it} + E(\varepsilon_{it})$

Therefore, $\alpha_i \sim \text{iid}(0, \sigma_\alpha^2)$ and $\omega_{it} \sim \text{iid}(0, \sigma_\omega^2)$

The following three steps were applied to model (2).

- **Step 1:** Apply the standard random-effect panel data regression to estimate the unknown parameters $\hat{\boldsymbol{\beta}}$, then predict $\hat{\alpha}_i$ and $\hat{\omega}_{it}$ as estimate of $\alpha_i$ and $\omega_{it}$ respectively.
- **Step 2**: Estimate $\varepsilon_{it}$ with $\omega_{it} = v_{it} - \varepsilon_{it} + E(\varepsilon_{it})$ using standard Frontier Technique with the following assumptions (i) $v_i \sim \text{N}(0, \sigma_v^2)$ (ii) $\varepsilon_{it} \sim \text{N}(0, \sigma_\varepsilon^2)$ (iii) $E(\varepsilon_{it}) = \sqrt{2/\pi\sigma_\varepsilon}$

This gives the transient inefficiencies scores. The residual of technical efficiency was calculated thus: $\exp(-\varepsilon_{it} / \omega_{it})$

- **Step 3**: Follow the same procedure in step 2 to estimate $\eta_i$ using

$\alpha_i = \mu_i - \eta_i + E(\eta_i)$ by assuming (i) $\mu_i \sim \text{N}(0, \sigma_\mu^2)$ (ii) $\eta_i \sim \text{N}^+(0, \sigma_\varepsilon^2)$ (iii) $E(\eta_i) = \sqrt{2/\pi\sigma_\eta}$

This gives the persistent inefficiencies scores. The residual of technical efficiency was calculated thus: $\exp(-\eta_i / \alpha_i)$

Remarks: in step 2 and 3 the difference between $\hat{\omega}_{it}$ and $\hat{\omega}_{it}$ as well as between $\hat{\alpha}_i$ and $\alpha_i$ which is the standard practice in multi-stage estimation procedure.

The output variables served as performance indicators. To measure the extent of change between transient technical efficiency and overall technical efficiency over the period under study, this SFA was used to address this research question 7.

#### 3.7.1.3 Data Envelopment Analysis (DEA)

DEA was applied in this study, to answer research questions 8, to establish the relative performance of the marine terminals under consideration, while also determining the level of inefficiency plus the input/output slack that would have been needed to perfect or improve the systems efficiency.

Data Envelopment Analysis (DEA) is increasingly one of the popular tools to measure performance for transit firms with multiple variables. DEA reduces complex and multi-objective problem of performance measurement to a single number. Here, DEA is applied in a transit system -the marine terminal which is major supply chain infrastructure.

Data Envelopment Analysis is a non-parametric model for measuring the efficiency of Decision-Making Units (DMU) with multiple inputs and or multiple outputs. Charnes, Cooper and Rhodes (CCR) in (1978) first introduced the DEA as a multi-factor productivity analysis module for measuring the relative efficiencies of DMUs. The DEA analysis shows how inputs and output have to be changed in order to maximize the efficiency levels of the target DMU. DEA is used in this study because of its suitability in analyzing supply chain performance of marine terminal operations and their improvement. The proposed model involves the following problem of linear programming.

Input-oriented Primal (BCCp-I)

Min $Zo=\Theta-\epsilon.1\mu\ s+-\ \epsilon.1\mu\ s-$

$\Theta, \lambda, s+, s-,$

s.t. $Y\lambda - s+$

$\Theta Xo - X\lambda-s+$

$1\mu\ \lambda\geq 1$

$\lambda, s+, s-\geq 0$

Input-Oriented BCC Dual (BCCd-I)

Max $Wo = \mu TYo + \dot{u}o$

$\mu,v$

s.t. $VTXo = 1$

$\mu TY - VTX + \dot{u}o\ 1\mu \leq 0$

$- \quad \mu T \leq - \epsilon.1\mu$

- $VT \leq - \epsilon.1\mu$

DEA as developed by (CCR) Charnes et. al., (1978) explain that suppose we have a set of n peers DMUs which produces multiple output vector Y by using observed multiple input vector X respectively.

Where,

X= input vector used in the DMUs.

Y= output vector produced by DMUs.

Є=is a constant non- Archimedean (infinitesimal of the order of 10-6) that ensures no input or output is given a zero weight

s+ and s- are the slack vectors for output and input respectively

Ө=represents the proportional reduction of the input in relation to the amount of the projected input. The optimal value of λ forms a composite unit outperforming the DMU under analysis and providing targets for this DMU to identify sources of its inefficiency. This model is known as input-oriented BCC, the initial being in recognition of its formulators (Banker, Charnes and Cooper) Banker et al (1984)

Then the production possibility set is defined as follows in relation to this study:

Thus:

F = {(Y, X)/X can produce Y}

(As cited by Po- Kyung & Prabir De 2004)

Where in this study:

n = Bitumen Terminal Rivers state, PHRC Terminal Rivers state, NorthWest Terminal Cross- Rivers state, NNPC Terminal Cross-River state, Rainoil Terminal Delta state, and WRPC Terminal Delta state

Y= Official Pump Price, Daily Swap Import, Number of Supply Vendors, Annual Subsidy Payment with control variables like Port Channel Approach draft, Port/Jetty Draft, Berth Distance from FWB, Ship Max Length Overall, Shore Tank Capacity,

X= Bulk Road Vehicle Traffic, Cargo Dues, Cargo Throughput, Ship Dues, Ship GRT, Ship Traffic, According to Cooper et al (2004), the performance of a DMU is efficient if and only if it is not possible to improve any input or output without worsening any other input or output, while the performance of a DMU is inefficient if and only if it is possible to improve some input or output without worsening some other input and output. (Pareto-Koopmans Definition of Efficiency)

Hence, DEA model is a linear programming model applied on the input-output variables to empirically or quantitatively estimate the technical and scale efficiency of the refined petroleum oil terminal jetties.

### 3.8 Description of Data

**Annual Subsidy Payment (ASP):** This is the government annual part payment on behalf of the citizen for the consumption of petrol which is often budgeted and approved by government. It is the indirect payment for the supply of petrol to citizens of a country by government through its commissioned petroleum traders. The data on subsidy payment is gotten from the CBN database, NMDPRA database, National Assembly Reports, etc. the data is applied in this study as a independent variable.

**Bulk Road Vehicle Traffic (BRVT)**: This is the number of Bulk Road Vehicles calling at the terminal to transport petrol to different retail fuel stations in Nigeria within a certain period. This is used as a dependent variable in this study and the data is provided by the Supply and Distribution department of the terminals and confirmed by cargo surveyors report, and NMDPRA terminal representative reports.

**Cargo Dues (CD):** It is a charge levied by NPA to the port users such as exporters, importers, shipping lines etc. for the purposes of using the port facilities in the movement of their goods. It covers all stevedoring, harbor dues and environmental protection levy. This is one of the dependent variables in this study provided by the shipping agent and confirmed from the Nigerian Ports Authority database.

**Cargo Throughput (CT):** This is the total volume of petrol discharged or loaded at the port within a given period. This is the number of cargo handled or transferred between the ship and the depot/ terminal within a certain period but mostly within a period of a year. For the petroleum product, its unit is in cubic meters, litres, metric tons, or barrels. The data serves as a dependent variable in this study. It is a key performance indicator in port and terminal productivity. It is actually furnished by the cargo surveyors or depot managers or NMDPRA, NPA database.

**Jetty Draft (JD):** The jetty draft is actually the depth of the ship's berthing position. It is the depth of the sea at the mooring point of the ship for purposes of cargo operations. It is also a significant factor limiting navigable waterways by larger vessels. It is often confirmed through bathymetric exercise, vessel echo sounder report and confirmed from NPA database. It is applied in this study as a control and as an independent variable at some point.

**Number of Supply Vendors (NSV)**: The data is used in this study as an independent variable. This is the number of approved product vendors or traders contracted to engage in the product swap with NNPC. The data is provided in the reports of NNPC, NEITI, PriceWaterhouse Coopers, etc.

**Official Petrol Pump Price (OPP):** This is the government approved official domestic petrol pump price at filling stations in Nigeria. Its unit of measurement is in naira per litre. This is the price as subsidized by government to its citizens within Nigeria. The data is available in NMDPRA (former PPPRA), NNPC etc. databases. The data is used in this study as an independent variable.

**Port Channel Approach Draft (PCAD):** The Port Channel Approach Draft is actually a very vital part of port infrastructure which ensures that there is navigational safety of all ships entering and departing the port. The size of the port approach channel emphasizes on width and depth. This depth helps the vessels proposing to call at the port to be aware of (loadline restrictions) vessel draft restriction, tidal information, ship maneuverability. It is a significant factor limiting navigable waterways by larger vessels. This is applied as a control variable and at some point as an independent variable in this study. The data is provided in the NPA database.

**Berth Distance from FairWayBuoy (BFWB):** This is the distance covering the Berth to Fairwaybuoy. It is in most climes the official distance covered by the port inward pilot in piloting, vessel calling into the port. It is also the distance that the vessel needs to maneuver with the instruction of the pilot. It is in some cases subject to tidal timing, sailing speed instructions, safety instructions etc. It is measured in nautical mile or kilometers. It is applied as an control and at some time as independent variable in this study.

**Daily Swap Import (DSI):** This is the quantity of crude exchanged for refined petroleum as contracted between NNPC and Product Vendors/ trader for the purposes of domestic consumption under subsidy regime. It is also represented as imported petroleum product for domestic consumption or as Nigerian petrol consumption supplied. It is measured in barrels per day or litres per day. This data is provided mostly in the NNPC, NMDPRA databases. The data is used in this study as one of the independent variables.

**Ship Length Overall (SLOA):** The ship length overall is the maximum length of a ship from fore or bow, to the stern or aft of the ship. It is measured in meters. It is sometimes termed as the overall designed length of the ship's hull perpendicular to the waterline. It is measured from the tip of the ship's bow in a straight line to the stern. It is used in the determination of the seasonal and all year-round dockyard fees and vessel classification. The maximum ship length overall is the longest vessel length that have been berthed at the case study jetties within the study period. It is used as an independent and control variable at some point in this study.

**Shore Tank Capacity (STC):** It is the shore side, above-the-ground storage tank capacity which is measured in volume or cubic meters. It is used for the warehousing of certain quantity of petroleum product over a period of time. The shore tank capacity is the total cargo storage available for the receipt of petroleum product at the shore. Shore tank capacity is of different sizes. It is vital for economic and transactional purposes. This is applied as control and independent variable in this study as the case may be. Its data is provided by the depot/ terminal manager, confirmed by the cargo surveyor and the NMDPRA depot representative. The shoretank capacity is calibrated and also certified by the authority.

**Ship Dues (SD):** Tariff or charges that cover all services normally required by a vessel for movement in and out of the port including the use of tug boats that assist in the movement. This is used as a dependent variable in this study. The tariff is made available from the Nigerian ports authority database.

**Ship Gross Registered Tonnage (GRT):** This is the volume of space within the ship's hull and enclosed spaces that are above the deck of a ship that are available for cargo, stores, fuel/bunker, passenger and crew. It is the vessel's total internal volume that serves as a good indicator of revenue growth in port performance. This data is gotten from marinetraffic website, NPA marketing department, NPA Ship Entry Notice (SEN), shipping agents reports. The data was used as an dependent variable in this study.

**Ship Traffic (ST)**: This is the number of tanker vessels calling at the jetty for cargo discharge operation within a certain period of time. This is used as an dependent variable. The data is found in the reports of the depot managers, shipping managers of the terminals, NPA reports, and NMDPRA reports.

# CHAPTER FOUR
# RESULTS AND DISCUSSIONS

## 4.1 Data Presentation

**Table 4.1.1: Performance indicators of Terminal Operations in Handling Petroleum Products Logistics**

| Year | Cargo Throughput(Mt) | Cargo DUES(₦)m | Ship DUES (₦)m | GRT | BRV Calls | Ship Calls |
|---|---|---|---|---|---|---|
| 2012 | 237351028.77 | 1019935.23 | 216606.34 | 169223.70 | 7192.48 | 64.63 |
| 2013 | 213927132.50 | 919278.32 | 286837.68 | 224091.94 | 6482.63 | 15.87 |
| 2014 | 209561653.17 | 900519.85 | 625095.86 | 488356.14 | 6350.43 | 12.88 |
| 2015 | 171822798.63 | 738349.97 | 476227.94 | 372064.91 | 5206.58 | 15.23 |
| 2016 | 273533298.98 | 1175416.21 | 321704.73 | 251331.85 | 8288.90 | 23.41 |
| 2017 | 296906416.92 | 1275854.23 | 427026.90 | 333614.77 | 8996.85 | 15.04 |
| 2018 | 192219391.04 | 825997.39 | 225918.56 | 176498.88 | 5824.56 | 14.99 |
| 2019 | 179590438.87 | 772178.22 | 312931.88 | 244479.56 | 5613.92 | 16.94 |
| 2020 | 196726562.94 | 846916.13 | 355556.86 | 277780.73 | 6101.03 | 24.52 |
| 2021 | 189512130.95 | 815030.58 | 204802.4 | 232919.72 | 5846.50 | 26.82 |

Sources: NNPC, NPA reports

Table 4.1.1 is the data of performance indicators collected from the maritime terminal operators involved in the supply chain network of petrol importation trade in Nigeria. The table 4.1.1 shows the Cargo Throughput in metric tons handled by the terminals between 2012 and 2021, the Gross Registered Tonnage (GRT) of vessels that supply the petrol through the marine terminals, the Cargo Dues and Ship Dues collected by the Nigerian Port Authority(NPA) from the shippers of petrol as a result of the ship calls, the data on ship calls to the port terminals for discharge of imported petrol and the Bulk Road Vehicle (BRV) calls at the terminals for petrol evacuation and distribution to the fuel stations at the hinterland.

These mentioned performance indicators were used as the dependent variables in the estimation of the relationship between the fuel subsidy regimes and the logistics performance of the marine terminals in the distribution of the petrol over the years covered in the study. The data on table 4.1.1 was transformed into Natural Log equivalents, as shown in table 4.1.2 to make it amenable for use in estimating the relationships stated in the objectives of the study.

However, the figures 4.1.1, 4.1.2, 4.1.3, and 4.1.4 shows the performance indicators trends of the marine terminals under review and shows a peaking in 2017 performance of all the variables under review. This period marks the implementation period of the newly introduced DSDP policy of the Buhari administration.

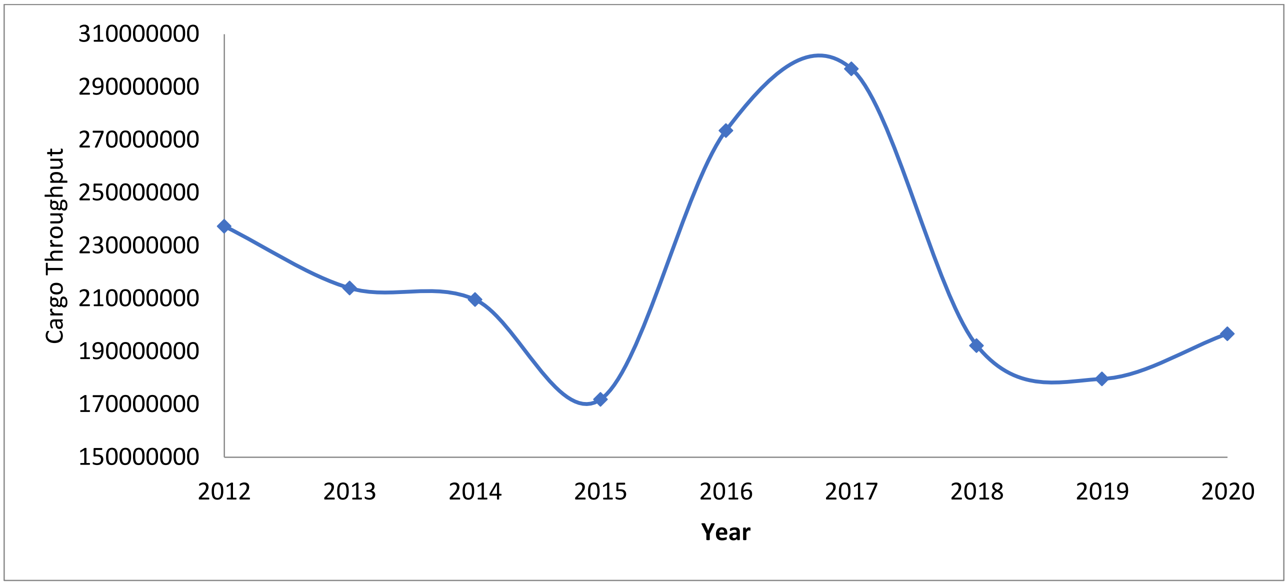


Figure 4.1.1 : Line graph of Cargo Throughput over time

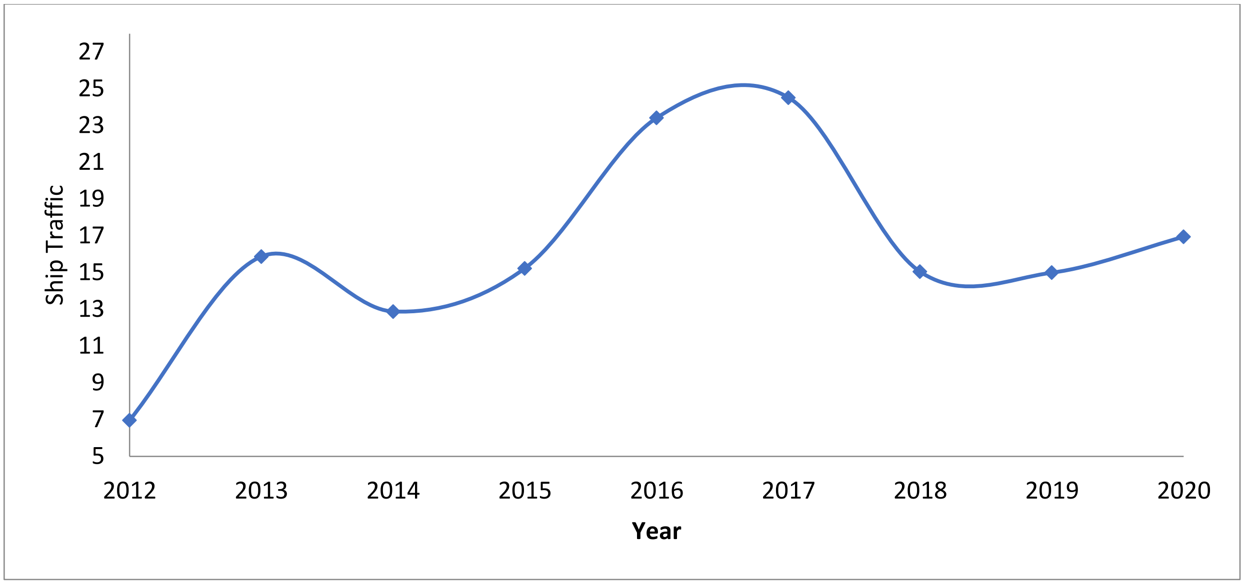


Figure 4.1.2 : Line graph of Ship Traffic over time

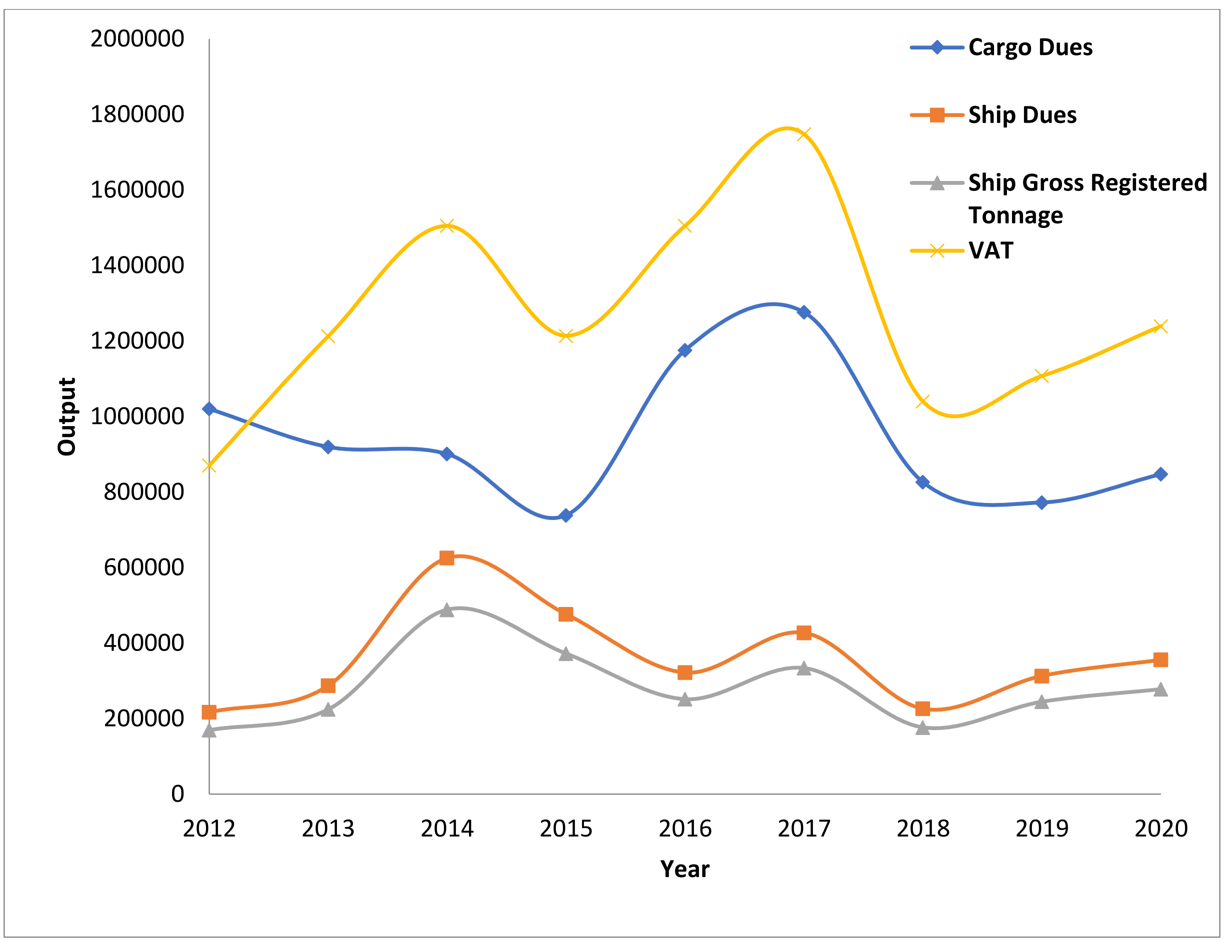


Figure 4.1.3: Line graph of Cargo Dues, Ship Dues, Ship Gross Registered Tonnage and VAT over time

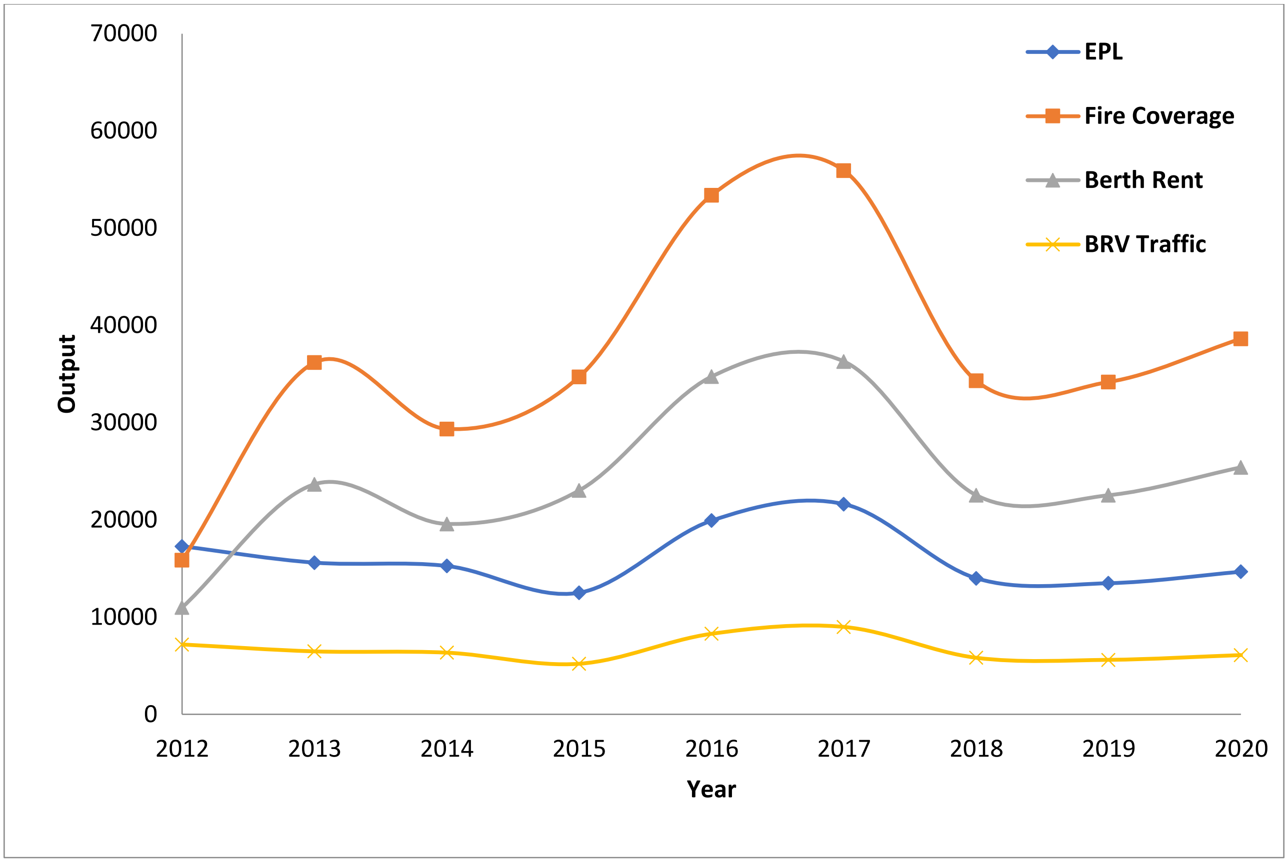


Figure 4.1.4: Line graph of Environmental Protection Levy, Fire coverage, Berth Rent and BRV Traffic over time

**Table 4.1.2: Official Pump Price, Daily Swap Import, Number of Supply Vendors and Annual Subsidy Payments following the Deregulation of Petroleum Products in Nigeria between 2012 and 2021**

| Year | Official Pump Price (₦/Ltr.) | Daily Swap Import (bpd) | Number of Supply Vendors | Annual Subsidy Payment (US$) |
|---|---|---|---|---|
| 2012 | 65 | 286,166 | 7 | 8,550,000,000 |
| 2013 | 86 | 294,095 | 7 | 8,300,000,000 |
| 2014 | 86 | 327,010 | 73 | 7,319,000,000 |
| 2015 | 86 | 441,000 | 27 | 3,340,000,000 |
| 2016 | 145 | 428,000 | 39 | 944,900,000 |
| 2017 | 145 | 428,000 | 34 | 473,900,000 |
| 2018 | 145 | 391,000 | 38 | 3,890,000,000 |
| 2019 | 165 | 442,000 | 76 | 4,670,000,000 |
| 2020 | 165 | 503,012 | 79 | 3,980,000,000 |
| 2021 | 175 | 536,000 | 79 | 4,870,000,000 |

Sources: Researcher's compilation from PwC, CBN NPA, NNPC, NEITI, PPPRA Reports

Table 4.1.2 shows the data collected from the various sources as identified below the Table 4.1.2 on different Official pump prices (OPP) of petrol in the fuel subsidy regime between 2012 and 2021, the daily swap import (DSI) in barrels per day, which indicates the quantum (in barrels per day) of petrol that is the approved quantity that the supply vendors are allowed to import per day, the number of supply vendors (NSV) licensed to supply petrol between 2012 and 2021 in the fuel subsidy regime and the amount spent as annual subsidy payment (ASP) in U.S. dollars paid per annum to the vendors as subsidy payment. These variables are used as proxies for the fuel subsidy regime and as independent variables to estimate the effects of fuel subsidy regime on the supply chain performance of maritime terminal operations in Nigeria.

**Table 4.1.3: Natural Log Transformation of Table 4.1.1**

| Year | LogCargo Throughput | LogCargo DUES | LogShip DUES | Log GRT | LogBRV Calls | LogShip Calls |
|---|---|---|---|---|---|---|
| 2012 | 19.29 | 13.84 | 12.29 | 12.04 | 8.88 | 4.17 |
| 2013 | 19.18 | 13.73 | 12.57 | 12.32 | 8.78 | 2.76 |
| 2014 | 19.16 | 13.71 | 13.35 | 13.1 | 8.76 | 2.56 |
| 2015 | 18.96 | 13.51 | 13.07 | 12.83 | 8.56 | 2.72 |
| 2016 | 19.43 | 13.98 | 12.68 | 12.43 | 9.02 | 3.15 |
| 2017 | 19.51 | 14.06 | 12.96 | 12.72 | 9.1 | 2.71 |
| 2018 | 19.07 | 13.62 | 12.33 | 12.08 | 8.67 | 2.71 |
| 2019 | 19.01 | 13.56 | 12.65 | 12.41 | 8.63 | 2.83 |
| 2020 | 19.1 | 13.65 | 12.78 | 12.53 | 8.72 | 3.2 |
| 2021 | 19.06 | 13.61 | 12.23 | 12.36 | 8.67 | 3.29 |

Source: Author's Calculation

The Table 4.1.3 is the natural log transformation of Table 4.1.1. It shows the natural log equivalents of the dataset on Table 4.1.1. The dataset in Table 4.1.1 was transformed in order to change all the variables to the same units of measurement in order to implement the modeling with variables having the same unit of measurement.

**Table 4.1.4: Natural Log Transformation of Table 4.2**

| Year | LogOPP | LogDSI | LogNSV | LogASP |
|---|---|---|---|---|
| 2012 | 4.17 | 12.56 | 1.95 | 22.87 |
| 2013 | 4.45 | 12.59 | 1.95 | 22.84 |
| 2014 | 4.45 | 12.7 | 4.29 | 22.71 |
| 2015 | 4.45 | 13 | 3.3 | 21.93 |
| 2016 | 4.98 | 12.97 | 3.66 | 20.67 |
| 2017 | 4.98 | 12.97 | 3.53 | 19.98 |
| 2018 | 4.98 | 12.88 | 3.64 | 22.08 |
| 2019 | 5.11 | 13 | 4.33 | 22.26 |
| 2020 | 5.11 | 13.13 | 4.37 | 22.1 |
| 2021 | 5.16 | 13.19 | 4.37 | 22.31 |

Source: Author's Calculation

The Table 4.1.4 is the natural log transformation of Table 4.1.2. It shows the natural log equivalents of the dataset on Table 4.1.2. The dataset was transformed in order to change all the variables to the same units of measurement in order to implement the modeling with variables having the same unit of measurement

## 4.2 Results and Discussion

### 4.2.1 Descriptive Statistics

**Table 4.2.1: Descriptive Statistics of Supply Chain Performance Indicators of Marine Terminals in the Management of the Fuel Subsidy Regime in Nigeria between 2012 and 2021.**

| | N | Range | Minimum | Maximum | Sum |
|---|---|---|---|---|---|
| CARPUT | 10 | 125083618.29 | 171822798.63 | 296906416.92 | 2161150852.77 |
| CARDUES | 10 | 537504.26 | 738349.97 | 1275854.23 | 9289476.13 |
| SHIDUES | 10 | 420293.46 | 204802.40 | 625095.86 | 3452709.15 |
| GRT | 10 | 319132.44 | 169223.70 | 488356.14 | 2770362.20 |
| VEHCALS | 10 | 3790.27 | 5206.58 | 8996.85 | 65903.88 |
| SHICALS | 10 | 51.75 | 12.88 | 64.63 | 230.33 |
| PUPRI | 10 | 110.00 | 65.00 | 175.00 | 1263.00 |
| DSI | 10 | 249834.00 | 286166.00 | 536000.00 | 4076283.00 |
| NSV | 10 | 72.00 | 7.00 | 79.00 | 459.00 |
| ASP | 10 | 8076100000.00 | 473900000.00 | 8550000000.00 | 46337800000.00 |
| Valid N (listwise) | 10 | | | | |

**Descriptive Statistics**

| | Mean | Std. Deviation |
|---|---|---|
| CARPUT | 216115085.2770 | 41195041.59921 |
| CARDUES | 928947.6130 | 176849.10603 |
| SHIDUES | 345270.9150 | 132408.52877 |
| GRT | 277036.2200 | 97233.71411 |
| VEHCALS | 6590.3880 | 1218.17059 |
| SHICALS | 23.0330 | 15.37670 |
| PUPRI | 126.3000 | 40.88752 |
| DSI | 407628.3000 | 83746.41035 |
| NSV | 45.9000 | 28.80374 |
| ASP | 4633780000.0000 | 2781135006.83124 |
| Valid N (listwise) | | |

Source: Author's Calculation using SPSS Version 20.1

Table 4.2.1 gives the summary of the performance of marine terminals in the supply chain of petrol in the fuel subsidy regime in Nigeria. The Table 4.2.1 also shows the summary of the individual variables of proxies of fuel subsidy regime in Nigeria between 2012 and 2021. The table shows that averages Cargo throughput of 216115085.28metric tons of petrol, 277036.22 Gross registered tonnage of vessels, 6590.39 Bulk Road vehicles (road tankers), and 23.03 tanker vessel petrol carriers were handled by the marine terminals per annum between 2012 and 2021 period. The standard deviations of cargo throughput is 41195041.6, for Ship Gross Registered Tonnage is 97233.7 and for BRV is 1218.2 respectively. The average amounts paid to the Nigerian Port Authority as Cargo dues and Ship dues as a result of the size of the ships calling at port and the petrol throughput per annum over the period is 928947.6Million naira and 345270.91Million naira respectively with respective standard deviations of 176849.1 and 132408.53.

The average official amount paid per liter of petrol during the subsidy period under review is 126.3 naira per annum with standard deviation of 40.89. The mean daily swap import per day over the period under consideration is 407628.3barrels per day with standard deviation of 83746.41. The average number of supply vendors that engaged in product supply via the terminals over the period is 45.9 vendors per annum with standard deviation of 28.80; while the average amount paid as subsidy per annum over the period between 2012 and 2021 is 4.633780000 billion U.S. dollars with standard deviation of 2781135006.83.

**Table 4.2.2: Effect of Fuel Subsidy Reforms on Cargo Throughput handled at the Marine Terminals.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .884[a] | .782 | .608 | .11255 | 1.797 |

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .227 | 4 | .057 | 4.485 | .006[b] |
| | Residual | .063 | 5 | .013 | | |
| | Total | .291 | 9 | | | |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | T | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 30.817 | 4.366 | | 7.058 | .001 |
| | LOGPUPRI | .120 | .205 | .239 | .584 | .585 |
| | LOGDSI | -.653 | .352 | -.780 | -1.855 | .123 |
| | LOGNSV | -.012 | .068 | -.061 | -.176 | .868 |
| | LOGASP | -.171 | .047 | -.896 | -3.659 | .015 |

a. Dependent Variable: LOGCARPUT

Source: author's calculation using MATLAB

The coefficient of correlation R measures the degree of correlation between the fuel subsidy reforms and the supply chain performance of the marine terminals in petrol distribution in Nigeria as 0.884. This implies the existence of about 88% correlation between the fuel subsidy reforms proxies represented by pump price per liter, number of supply vendors licensed to import products, daily swap imports and annual subsidy payments made to the vendors and supply chain performance of the marine terminals in petrol distribution in Nigeria.

The model also shows the relationship depicting the effects of fuel subsidy reforms on the performance indicator of the marine terminal operators that handle the petrol supply chain in Nigeria between 2012 and 2021 as:

***LogCARPUT*** = 30.817 ***+ 0.12LogPUPRI - 0.653LogDSI – 0.012LogNSV - 0.17LogASP***

This implies that a 1% annual increase in pump per liter will increase the cargo throughput of petrol handled in the marine terminals by 0.12% while a 1% increase in daily swap import leads to a 0.653%

decrease in cargo throughput handled in the terminals. In a similar manner, a percentage increase in number of supply vendors will lead to a 0.012% decrease in cargo throughput performance of the marine terminals while a percentage increase in annual subsidy payment will lead to a decline of 0.17% in cargo throughput of the terminal operators in the petroleum products supply chain.

The coefficient of determination $r^2$ which measures the explanatory power of the model is 0.782. This indicates that about 78% variation in the cargo throughput handled by the marine terminals involved in petrol supply chain in Nigeria is explained by fuel subsidy reforms.

Beta values shows negative contribution of DSI, NSV and ASP to Cargo throughput. While OPP is the most critical factor relative to cargo throughput in marine terminal operations. This implies that petrol pump price needs to be increased significantly to boost cargo throughput.

**Table 4.2.3: The Influence of Fuel Subsidy Reforms on Ship Gross Registered Tonnage Handled by Marine Terminals between 2012 and 2021.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .858[a] | .736 | .525 | .22548 | 2.468 |

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .710 | 4 | .177 | 5.491 | .001[b] |
| | Residual | .254 | 5 | .051 | | |
| | Total | .964 | 9 | | | |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 18.583 | 8.747 | | 2.124 | .087 |
| | LOGPUPRI | -1.146 | .411 | -1.258 | -2.788 | .039 |
| | LOGDSI | .133 | .705 | .087 | .189 | .858 |
| | LOGNSV | .417 | .135 | 1.180 | 3.079 | .027 |
| | LOGASP | -.173 | .093 | -.500 | -1.855 | .123 |

**Source: Author's Calculation using matlab**

The coefficient of correlation R which measures the degree of correlation between the fuel subsidy reforms and the Gross Registered Tonnage (GRT) of vessels handled by the marine terminals operating in the petroleum products import distribution and supply chain in Nigeria is 0.858. This implies that there exist about 86% correlation between the Gross Registered Tonnage (GRT) of vessels handled in the terminals over the period and the fuel subsidy reform indicators of pump price per liter, number of supply vendors licensed to import products, daily swap imports and annual subsidy payments made to the vendors.

The model showing the relationship depicting the effects of fuel subsidy reforms on the performance of the terminal operators managing the petroleum products supply chain in Nigeria between 2012 and 2021 is:

***LogGRT = 18.583 - 1.146LogPUPRI + 0.133LogDSI + 0.417LogNSV - 0.173LogASP***

The implication is that a 1% increase in petroleum product pump price per liter will lead to a 1.146% decrease in the GRT of vessels handled by the marine terminals while a 1% increase in daily swap import will increase the GRT of vessels handled by the terminals by 0.133%. Similarly, a 1% increase in the number of supply vendors will increase the GRT of vessels handled by 0.417% while a 1% increase in annual subsidy payment to vendors decreases GRT of vessels handled at the terminals by 0.173%.

The coefficient of determination $r^2$ which measures the explanatory power of the model is 0.736. This indicates that about 73% variation in the Gross registered tonnage of vessels handled at the marine terminals involved in petroleum product supply chain in Nigeria is explained by fuel subsidy reforms**.**

Beta values shows negative contribution of OPP and ASP to Gross Registered Tonnage. While NSV is the most critical factor followed by DSI relative to Ship GRT calling at marine terminals.This means that NSV and DSI needs to be significantly increased to achieve economies of scale relative to ships GRT for marine terminal operations

**Table 4.2.4: The effect of Fuel Subsidy Reforms on Ship Calls at the Marine Terminals.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .797[a] | .635 | -.355 | .55410 | 2.189 |

**ANOVA[a]**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .504 | 4 | .126 | 3.911 | .005[b] |
| | Residual | 1.535 | 5 | .307 | | |
| | Total | 2.039 | 9 | | | |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | -13.142 | 21.495 | | -.611 | .568 |
| | LOGPUPRI | -.017 | 1.010 | -.013 | -.017 | .987 |
| | LOGDSI | 1.104 | 1.733 | .498 | .637 | .552 |
| | LOGNSV | -.349 | .333 | -.680 | -1.050 | .342 |
| | LOGASP | .147 | .230 | .292 | .641 | .550 |

Source: Author's Calculation using Matlab

The coefficient of correlation R which measures the degree of correlation between the fuel subsidy reforms and ship calls at the marine terminals is 0.797. This implies the existence of about 80% correlation between the ship calls at the terminals and the fuel subsidy regime in Nigeria, measured by pump price per liter, number of supply vendors licensed to import products, daily swap imports and annual subsidy payments made to the vendors.

The mathematical model showing the effects of fuel subsidy reforms on ship traffic calls at the terminals in Nigeria between 2012 and 2021 is:

***LogSHCALS = -13.142 - 0.017LogPUPRI + 1.104LogDSI – 0.349LogNSV + 0.147LogASP***

This implies that a 1% annual increase in pump per liter will decrease the ship calls to the marine terminals by 0.017% while a 1% increase in daily swap import leads to a 1.104% increase in ship calls to the terminals. Similarly, a one percent increase in number of supply vendors will lead to a 0.349% decrease in ship calls to the marine terminals while a one percent increase in annual subsidy payment will lead to an increase of 0.147% in ship calls to the marine terminals involved in the petrol imports, and distribution in Nigeria.

The coefficient of determination $r^2$ which measures the explanatory power of the model is 0.635. This indicates that about 65% variation in the ship calls to the marine terminals involved in petroleum product supply chain in Nigeria is explained by fuel subsidy reforms.

Beta values show negative contribution of OPP and ASP to Ship Calls, while DSI is the most critical factor followed by NSV relative to Ship calls at the marine terminals.

This therefore means that DSI and NSV needs to be significantly increased to boost Ship Calls to marine terminals

**Table 4.2.5: Relationship between Fuel Subsidy Reforms and Bulk Road Vehicle Calls at the Marine Terminals.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .873[a] | .762 | .572 | .11403 | 1.812 |

**ANOVA[a]**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .209 | 4 | .052 | 4.010 | .080[b] |
| | Residual | .065 | 5 | .013 | | |
| | Total | .274 | 9 | | | |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 19.919 | 4.424 | | 4.503 | .006 |
| | LOGPUPRI | .141 | .208 | .290 | .677 | .528 |
| | LOGDSI | -.635 | .357 | -.782 | -1.781 | .135 |
| | LOGNSV | -.012 | .068 | -.062 | -.170 | .872 |
| | LOGASP | -.163 | .047 | -.882 | -3.448 | .018 |

Source: Author's Calculation using MATLAB

The coefficient of correlation R which measures the degree of correlation between the fuel subsidy reforms and the bulk road vehicle calls at the marine terminals involved in the handling of petrol imports and distribution in Nigeria is 0.873. This implies that there exist about 87% correlation between the bulk road vehicle calls at the terminals and the fuel subsidy regime in Nigeria, measured by pump price per liter, number of supply vendors licensed to import products, daily swap imports and annual subsidy payments made to the vendors.

The model showing the relationship depicting the effects of fuel subsidy reforms on the bulk road vehicle calls at the terminal involved in petroleum products supply chain in Nigeria between 2012 and 2021 is:

***LogVEHCALS = 19.919 + 0.141LogPUPRI - 0.635LogDSI – 0.012LogNSV - 0.163LogASP***

The implication is that a 1% annual increase in pump per liter will increase the number of bulk road vehicle calls at the marine terminals by 0.141% while a 1% increase in daily swap import leads to a 0.635 decrease in bulk road vehicle calls at the marine terminals. Similarly, a one percent increase in number of supply vendors lead to a 0.012% decrease in bulk road vehicle calls to the marine terminals. In a similar manner, a 1% increase in annual subsidy payment will lead to a decline of 0.163% in bulk road vehicle calls to the marine terminals involved in the distribution of petrol in nigeria.

The coefficient of determination $r^2$ which measures the explanatory power of the model is 0.762. This indicates that about 76% variation in the bulk road vehicle calls at the marine terminals involved in petroleum product supply chain in Nigeria is explained by fuel subsidy reforms.

Beta values show negative contribution of DSI, NSV and ASP to Bulk Road Vehicle Calls, while OPP is the most critical factor relative to BRV Calls to the marine terminals.

This result therefore discloses that there is need for significant increase in the OPP to improve BRV Calls to the marine terminals.

**Table 4.2.6: Effects of Fuel Subsidy Reforms on Cargo Dues Paid by Shippers of Petroleum Products at Terminals.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .883[a] | .781 | .605 | .11282 | 1.798 |

**ANOVA[a]**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .226 | 4 | .057 | 4.445 | .067[b] |
| | Residual | .064 | 5 | .013 | | |
| | Total | .290 | 9 | | | |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 25.334 | 4.377 | | 5.788 | .002 |
| | LOGPUPRI | .120 | .206 | .241 | .585 | .584 |
| | LOGDSI | -.651 | .353 | -.779 | -1.845 | .124 |
| | LOGNSV | -.012 | .068 | -.062 | -.176 | .867 |
| | LOGASP | -.170 | .047 | -.896 | -3.643 | .015 |

**Source: Author's calculation using MATLAB.**

The coefficient of correlation R which measures the degree of correlation between the fuel subsidy reforms and the cargo dues paid by shippers of petrol is 0.883. This implies the existence of about 88% positive correlation between the cargo dues paid by shippers of petroleum products and the fuel subsidy regime in Nigeria, measured by pump price per liter, number of supply vendors licensed to import products, daily swap imports and annual subsidy payments made to the vendors.

The equation depicting the effects of fuel subsidy reforms on the cargo dues paid by shippers of petrol between 2012 and 2021 is:

***LogCARDUES= 25.334 + 0.120LogPUPRI - 0.651LogDSI – 0.012LogNSV - 0.170LogASP***

This implies that a 1% annual increase in pump per liter will increase the cargo dues paid by shippers of petroleum products through the marine terminals by 0.12% while a 1% increase in daily swap import leads to a 0.651% decrease in cargo dues paid by the shippers of petroleum products through the marine terminals. Similarly, a 1% increase in the number of supply vendors led to a 0.012% decrease in cargo dues paid by shippers for shipping petroleum products through the marine terminals over the period, while a one percentage increase in annual subsidy payment led will lead to a decline of 0.17% in cargo dues paid to the terminal operators in the petroleum products supply chain.

The coefficient of determination $r^2$ which measures the explanatory power of the model is 0.781. This indicates that about 78% variation in the cargo dues paid to by shippers involved in petroleum product supply chain in Nigeria is explained by fuel subsidy reforms.

Beta values show negative contribution of DSI, NSV and ASP to Cargo Dues. The most critical factor relative to Cargo Dues is OPP. This reveals that to boost Cargo Dues accruable to Ports Authority, OPP should significantly be increased.

**Table 4.2.7: The effect of fuel subsidy reforms on ship dues in Maritime Terminals in Nigeria.**

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|---|
| 1 | .843[a] | .710 | .479 | .26185 | 2.485 |

**ANOVA[a]**

| Model | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | .841 | 4 | .210 | 5.066 | .005[b] |
| | Residual | .343 | 5 | .069 | | |
| | Total | 1.184 | 9 | | | |

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | |
| 1 | (Constant) | 25.673 | 10.158 | | 2.527 | .053 |
| | LOGPUPRI | -1.196 | .477 | -1.185 | -2.507 | .054 |
| | LOGDSI | -.292 | .819 | -.173 | -.357 | .736 |
| | LOGNSV | .453 | .157 | 1.157 | 2.880 | .035 |
| | LOGASP | -.232 | .108 | -.603 | -2.136 | .016 |

Source: Author's calculation using MATLAB

The coefficient of correlation R which measures the degree of correlation between the fuel subsidy reforms and the ship dues paid by shippers in the importation of petrol in Nigeria between 2012 and 2021 is 0.843. This implies the existence of about 84% positive correlation between the ship dues earned by terminal operators handling the import and distribution of petroleum products and the fuel subsidy regime in Nigeria, measured by pump price per liter, number of supply vendors licensed to import products, daily swap imports and annual subsidy payments made to the vendors.

The equation of the relationship showing the effects of fuel subsidy reforms on the ship dues earned by the terminal operators managing the petroleum products supply chain in Nigeria between 2012 and 2021 is:

***LogSHDUES = 25.67 – 1.196LogPUPRI - 0.292LogDSI + 0.453LogNSV - 0.232LogASP + e***

This implies that a 1% annual increase in pump per liter will lead to a decline in ship dues earned by terminal operators by 1.196% per annum while a 1% increase in daily swap import leads to a 0.292% decrease in ship dues earned by marine terminal operators per annum. Similarly, a one percent increase in number of supply vendors will lead to a 0.453% decrease in ship dues earned by marine terminal operators involved in the distribution chain of petroleum products in Nigeria while a one percent increase in annual subsidy payment will lead to vendors will lead to a decline of 0.232% in ship dues spent by marine terminal operators in the petrol supply chain.

The coefficient of determination $r^2$ which measures the explanatory power of the model is 0.710. This indicates that about 71% variation in the ship dues spent by shippers involved in petrol supply chain in Nigeria is explained by fuel subsidy reforms

Beta values show negative contribution of OPP, DSI and ASP to Ship Dues. While NSV is the most critical factor relative to Ship Dues as paid by marine terminal operators.

This discloses that NSV should significantly be maintained for improved Ship Dues payment by marine terminals

**Table 4.2.8: Testing the change between Transient Technical Efficiency and Overall Technical Efficiency of marine terminal.**

| Performance Indicators of the Terminals | Mean Technical Transient Efficiency | Mean Overall Technical Efficiency | Paired t-test | p-value |
|---|---|---|---|---|
| Cargo Throughput | 0.427 | 0.426 | -0.940 | 0.378 |
| Ship Traffic | 0.700 | 0.667 | | |
| BRV Traffic | 0.494 | 9.493 | | |
| GRT | 0.439 | 0.41 | | |
| Cargo Dues | 0.995 | 0.826 | | |
| Ship Dues | 0.421 | 0.406 | | |
| Berth Rent | 0.646 | 0.547 | | |
| VAT | 0.662 | 0.546 | | |

Author’s calculation using STATA

Based on the result of the analysis reported in Table 4.2.8, the p-value of the test statistic of 0.378 is greater than 0.05, the result shows that there is no change between TTE and OTE.

**Table 4.2.9: Technical Efficiencies of the selected Marine Terminals from 2012-2020 using DEA under Output Oriented Model**

| DMU Name | TEvrs | RTS | Inputs Slack | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NSV | DSI | OPP | JD | PCA | PDF | STC | MLOA | ASP |
| BJ2012 | 0.77 | DRS | 1.6 | 67165.2 | 20.2 | 1.7 | 2.6 | 11.3 | 29289100.3 | 43.0 | 2.0 |
| BJ2013 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BJ2014 | 0.97 | IRC | 0.2 | 8234.5 | 2.2 | 0.2 | 0.3 | 1.2 | 3142342.0 | 4.6 | 0.2 |
| BJ2015 | 0.60 | DRS | 1.2 | 178470.3 | 34.8 | 2.9 | 4.5 | 19.4 | 50501835.4 | 74.1 | 1.4 |
| BJ2016 | 0.53 | DRS | 12.6 | 199400.3 | 67.6 | 3.4 | 5.1 | 22.4 | 58138228.4 | 85.3 | 0.4 |
| BJ2017 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| BJ2018 | 0.52 | DRS | 16.2 | 210615.6 | 69.1 | 3.4 | 5.2 | 22.9 | 59463171.3 | 87.2 | 1.9 |
| BJ2019 | 0.69 | DRS | 11.2 | 152810.2 | 58.1 | 2.2 | 3.4 | 15.0 | 38996288.5 | 57.2 | 1.6 |
| BJ2020 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OJ2012 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| OJ2013 | 0.51 | DRS | 3.4 | 143226.4 | 41.9 | 4.5 | 5.4 | 23.4 | 427080867.6 | 89.1 | 4.0 |
| OJ2014 | 0.78 | DRS | 1.5 | 71849.4 | 18.9 | 2.0 | 2.4 | 10.5 | 192680086.5 | 40.2 | 1.6 |
| OJ2015 | 0.66 | DRS | 1.0 | 151906.5 | 29.6 | 3.2 | 3.8 | 16.5 | 302073548.1 | 63.0 | 1.2 |
| OJ2016 | 0.31 | DRS | 18.5 | 293561.3 | 99.5 | 6.3 | 7.5 | 32.9 | 601491945.8 | 125.5 | 0.6 |
| OJ2017 | 0.22 | DRS | 30.3 | 303637.0 | 112.6 | 7.1 | 8.5 | 37.3 | 681008852.1 | 142.1 | 0.4 |
| OJ2018 | 0.63 | DRS | 12.4 | 161671.9 | 53.0 | 3.4 | 4.0 | 17.6 | 320765027.0 | 66.9 | 1.4 |
| OJ2019 | 0.53 | DRS | 16.9 | 229234.0 | 87.2 | 4.3 | 5.2 | 22.5 | 411097673.3 | 85.8 | 2.4 |
| OJ2020 | 0.47 | DRS | 18.6 | 266059.5 | 99.0 | 4.9 | 5.9 | 25.5 | 466581107.2 | 97.4 | 0.5 |
| NWJ2012 | 0.60 | DRS | 2.8 | 113240.6 | 34.0 | 2.8 | 2.5 | 19.8 | 17094951.1 | 73.6 | 3.4 |
| NWJ2013 | 0.78 | DRS | 1.6 | 65187.8 | 19.1 | 1.6 | 1.4 | 11.1 | 9575525.4 | 41.2 | 1.8 |
| NWJ2014 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NWJ2015 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NWJ2016 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NWJ2017 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NWJ2018 | 0.75 | DRS | 8.5 | 110663.7 | 36.3 | 1.8 | 1.6 | 12.5 | 10815996.5 | 46.6 | 1.0 |
| NWJ2019 | 0.83 | DRS | 6.3 | 85401.9 | 32.5 | 1.2 | 1.1 | 8.7 | 7544704.2 | 32.5 | 0.9 |
| NWJ2020 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NJ2012 | 0.58 | DRS | 3.0 | 121271.7 | 36.4 | 2.8 | 2.7 | 21.2 | 22246829.7 | 65.7 | 3.6 |
| NJ2013 | 0.40 | DRS | 4.2 | 175036.4 | 51.2 | 3.9 | 3.8 | 29.8 | 31244077.8 | 92.3 | 4.9 |
| NJ2014 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NJ2015 | 0.44 | DRS | 1.7 | 246249.1 | 48.0 | 3.6 | 3.6 | 27.9 | 29313184.8 | 86.6 | 1.9 |

**Table 4.2.9 cont: Technical Efficiencies of the selected Marine Terminals from 2012-2020 using DEA under Output Oriented Constant Return to Scale Model**

| DMU Name | TEvrs | RTS | Input Slacks | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | NSV | DSI | OPP | JD | PCA | PDF | STC | MLOA | ASP |
| NJ2016 | 0.21 | DRS | 21.4 | 338984.9 | 114.8 | 5.1 | 5.1 | 39.6 | 41577990.4 | 122.8 | 0.7 |
| NJ2017 | 0.20 | DRS | 31.1 | 311421.6 | 115.5 | 5.2 | 5.1 | 39.8 | 41811796.9 | 123.5 | 0.4 |
| NJ2018 | 0.26 | DRS | 25.3 | 329181.4 | 108.0 | 4.8 | 4.8 | 37.2 | 39096682.4 | 115.4 | 2.9 |
| NJ2019 | 0.37 | DRS | 22.8 | 309770.0 | 117.8 | 4.1 | 4.1 | 31.7 | 33255030.9 | 98.2 | 3.2 |
| NJ2020 | 0.29 | DRS | 24.9 | 355949.2 | 132.4 | 4.6 | 4.6 | 35.6 | 37367013.7 | 110.3 | 0.7 |
| RJ2012 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RJ2013 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RJ2014 | 0.96 | IRS | 0.3 | 12661.0 | 3.3 | 0.3 | 0.2 | 2.0 | 1897607.9 | 7.1 | 0.3 |
| RJ2015 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RJ2016 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RJ2017 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| RJ2018 | 0.73 | DRS | 9.1 | 118302.9 | 38.8 | 1.8 | 1.6 | 13.9 | 13118108.5 | 49.0 | 1.0 |
| RJ2019 | 0.77 | DRS | 8.2 | 111705.6 | 42.5 | 1.5 | 1.3 | 11.9 | 11196033.1 | 41.8 | 1.2 |
| RJ2020 | 0.84 | DRS | 5.5 | 79270.3 | 29.5 | 1.1 | 0.9 | 8.2 | 7769305.5 | 29.0 | 0.2 |
| WJ2012 | 0.41 | DRS | 4.1 | 168594.2 | 50.7 | 5.9 | 3.5 | 30.6 | 110435815.1 | 107.8 | 5.0 |
| WJ2013 | 0.12 | DRS | 6.1 | 258101.5 | 75.5 | 8.8 | 5.2 | 45.6 | 164508513.7 | 160.6 | 7.3 |
| WJ2014 | 0.32 | DRS | 4.8 | 223915.9 | 58.9 | 6.8 | 4.0 | 35.6 | 128353958.1 | 125.3 | 5.0 |
| WJ2015 | 0.59 | DRS | 1.2 | 181549.9 | 35.4 | 4.1 | 2.4 | 21.4 | 77169007.4 | 75.3 | 1.4 |
| WJ2016 | 1.00 | CRS | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| WJ2017 | 0.05 | DRS | 37.0 | 370449.5 | 137.4 | 9.5 | 5.6 | 49.3 | 177597824.8 | 173.4 | 0.4 |
| WJ2018 | 0.13 | DRS | 29.7 | 385834.5 | 126.6 | 8.7 | 5.2 | 45.4 | 163630469.8 | 159.7 | 3.4 |
| WJ2019 | 0.22 | DRS | 28.1 | 381454.0 | 145.1 | 7.8 | 4.6 | 40.6 | 146224050.3 | 142.8 | 4.0 |
| WJ2020 | 0.28 | DRS | 25.2 | 360374.9 | 134.0 | 7.2 | 4.3 | 37.5 | 135086972.8 | 131.9 | 0.7 |

Table 4.2.9 shows the DEA under Output Oriented Constant Return to Scale Model results from R software on the technical efficiencies of the selected Marine Terminals for the years under consideration.

The result discloses that there is constant return to scale in 2012 for PHRC, in 2014 for NNPC and in 2016 for WRPC terminals. It also showed constant return to scale in 2013, 2017 and 2020 for bitumen terminals. The result further revealed constant return to scale for northwest terminal in 2014, 2015, 2016, 2017 and in 2020. Rainoil terminal, in 2012, 2013, 2015, 2016 and in 2017 were classified under constant return to scale. This result reveals that both public and privately managed marine terminals were efficient at certain point in time during the different fuel subsidy reforms. A closer look however, shows that each of the 3 publicly managed terminals was efficient ones during the study period under review. This was mainly during the RPEA reform time of the administration of former President Goodluck Jonathan.

A more cursory look at the result, further disclosed that the 3 privately managed marine terminals had more efficient performances than the publicly managed marine terminals within the same years under consideration. The privately managed marine terminals had a total of 13 efficient performances which covered the periods of RPEA and DSDP reforms of both Jonathan and Buhari administrations as against 3 efficient performances by the 3 publicly managed marine terminals.

This result goes to show that the privately managed marine terminal operators are prone to implementing government fuel subsidy reforms more efficiently than the publicly managed marine terminal operators.

The result also indicated that out of a total of 54 operational years, the marine terminals have been efficient only in 16 years and inefficient in 38 years which represents 29.6% of efficient cargo operation and 70.3% of inefficient cargo operations.

## 4.3 Test of Hypotheses

**Table 4.3.1: Test of $H_{01}$: There is no significant Effect of Fuel Subsidy Reforms on Cargo Throughput Handled at the Marine Terminals.**

| **Hypotheses** | **F-cal.** | **F-critical** | **p-value/sig.** | **Decision** |
|---|---|---|---|---|
| **$H_{01}$** | **4.485** | 3.68 | 0.006[b] | Reject ***$H_{01}$*** |
| | | | | |
| **Variable** | **t-cal.** | **t-critical** | **p-value/sig.** | **Decision** |
| LOGPUPRI | .584 | 1.75 | .585 | Not significant |
| LOGDSI | -1.855 | 1.75 | .123 | Significant |
| LOGNSV | -.176 | 1.75 | .868 | Not Significant |
| LOGASP | -3.659 | 1.75 | .015 | Significant |

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Reject null hypotheses if F-cal.< F-critical*

The test of hypothesis $H_{01}$ shown in Table-4.3.1 shows F-score of 4.485, F-critical of 3.68, and p-value of 0.006. Since F-score is greater than F-critical, (4.485> 3.68), we reject the null hypothesis $H_{01}$ and accept the alternate. We conclude that there is significant effect of fuel subsidy regime on cargo throughput handled at marine terminals in Nigeria between 2012 and 2021.

Similarly, t-test was conducted to investigate the significance of the individual effects of pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment on the cargo throughput handled at the terminals over the period covered in the study, and the result indicated that, the annual subsidy payment (ASP) and daily swap import (DSI) has t-cal score greater than t-critical (1.855> 1.75) and (3.659> 1.75) respectively. Thus, only annual subsidy payment (ASP) and daily swap import (DSI) have significant effect on the cargo throughput handled in the marine terminals over the period.

**Table 4.3.2: Test of $H_{02}$: The Influence of Fuel Subsidy Reforms on Ship Gross Registered Tonnage Handled by Marine Terminals is not significant**

| Hypotheses | F-cal. | F-critical | p-value/sig. | Decision |
|---|---|---|---|---|
| **$H_{02}$** | **5.491** | 3.68 | 0.001[b] | Reject $\boldsymbol{H_{02}}$ |
| | | | | |
| **Variable** | **t-cal.** | **t-critical** | **p-value/sig.** | **Decision** |
| LOGPUPRI | -2.788 | 1.75 | .039 | Significant |
| LOGDSI | 0.189 | 1.75 | .858 | Not significant |
| LOGNSV | 3.079 | 1.75 | .027 | Significant |
| LOGASP | -1.855 | 1.75 | .123 | Significant |

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Reject null hypotheses if F-cal.< F-critical*

The test of hypothesis **$H_{02}$** shown in Table 4.3.2 shows F-score of 5.491, F-critical of 3.68, and p-value of 0.001. Since F-score is greater than F-critical, (5.491> 3.68), we reject the null hypothesis **$H_{02}$** and accept the alternate. We conclude that there is significant effect of fuel subsidy regime on Gross registered tonnage of vessels handled by marine terminal operators per annum in Nigeria between 2012 and 2021.

Similarly, t-test was conducted to investigate the significance of the individual effects of pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment on the Gross Registered Tonnage of vessels handled by terminal operators over the period covered indicate that, pump price per liter of petrol, the annual subsidy payment and number of vendors approved by government, all have t-cal score greater than t-critical (2.788>1.75; 3.079>1.75 and 1.855>1.75). Thus, pump price per liter, number of approved vendors and annual subsidy payment have significant effect of the Gross Registered Tonnage of ships handled at the terminals over the period.

**Table 4.3.3: Test of $H_{03}$: There is no significant effect of Fuel Subsidy Reforms on Ship Calls at the Marine Terminals**

| **Hypotheses** | **F-cal.** | **F-critical** | **p-value/sig.** | **Decision** |
|---|---|---|---|---|
| **$H_{03}$** | 3.911 | 3.68 | $0.051^{b}$ | Reject ***$H_{03}$*** |
| | | | | |
| **Variable** | **t-cal.** | **t-critical** | **p-value/sig.** | **Decision** |
| LOGPUPRI | -0.017 | 1.75 | 0.987 | Not significant |
| LOGDSI | 0.637 | 1.75 | 0.552 | Not significant |
| LOGNSV | -1.050 | 1.75 | 0.342 | Not significant |
| LOGASP | 0.641 | 1.75 | 0.550 | Not significant |

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Reject null hypotheses if F-cal.< F-critical*

The test of hypothesis $H_{03}$ shown in Table 4.3.3 shows F-score of 3.911, F-critical of 3.68, and p-value of 0.051. Since F-score is greater than F-critical, (3.911> 3.68), we reject the null hypothesis **$H_{03}$** and accept the alternate. We conclude that there is significant effect of fuel subsidy regime on ship calls to the marine terminals involved in the import and distribution of petrol in Nigeria over the period between 2012 and 2021.

Similarly, t-test was conducted to investigate the significance of the individual effects of pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment on ship calls to the terminals over the period covered indicate that, none of the independent variables have t-cal scores greater than t-critical. Thus we conclude that pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment, individually have no significant effects on ship calls to the marine terminals over the period.

**Table 4.3.4: Test of $H_{04}$: There is no significant effect of Fuel Subsidy Reforms on Bulk Road Vehicle Calls at the Marine Terminals.**

| **Hypotheses** | **F-cal.** | **F-critical** | **p-value/sig.** | **Decision** |
|---|---|---|---|---|
| **$H_{04}$** | 4.010 | 3.68 | 0.080[b] | Reject ***$H_{04}$*** |
| | | | | |
| **Variable** | **t-cal.** | **t-critical** | **p-value/sig.** | **Decision** |
| LOGPUPRI | 0.677 | 1.75 | 0.528 | Not significant |
| LOGDSI | -1.781 | 1.75 | 0.135 | Significant |
| LOGNSV | -0.170 | 1.75 | 0.872 | Not significant |
| LOGASP | -3.448 | 1.75 | 0.018 | Significant |

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Reject null hypotheses if F-cal.< F-critical*

The test of hypothesis **$H_{04}$** shown in Table 4.3.4 shows F-score of 4.010, F-critical of 3.68, and p-value of 0.080. Since F-score is greater than F-critical, (4.010> 3.68), we reject the null hypothesis **$H_{04}$** and accept the alternate. We conclude that there is significant effect of fuel subsidy regime on bulk road vehicle calls to the marine terminals involved in the import and distribution of petroleum products in Nigeria between 2012 and 2021.

Similarly, t-test was conducted to investigate the significance of the individual effects of pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment on bulk road vehicle calls at the marine terminals over the period covered and the result indicate that, only the annual subsidy payment and daily swap import have t-cal scores greater than t-critical (3.448>1.75) and (1.781>1.75) Thus, only the annual subsidy payment and daily swap import has significant effects on bulk road vehicles call to the marine terminals over the period covered in the study.

**Table 4.3.5: Test of $H_{05}$: Effects of Fuel Subsidy Reforms on Cargo Dues Paid by Shippers of Petroleum Products at Terminals is not significant**

| **Hypotheses** | **F-cal.** | **F-critical** | **p-value/sig.** | **Decision** |
|---|---|---|---|---|
| **$H_{05}$** | 4.45 | 3.68 | 0.067 | Reject $H_{05}$ |
| | | | | |
| **Variable** | **t-cal.** | **t-critical** | **p-value/sig.** | **Decision** |
| LOGPUPRI | 0.585 | 1.75 | .584 | Not significant |
| LOGDSI | -1.845 | 1.75 | .124 | Significant |
| LOGNSV | -0.176 | 1.75 | .867 | Not significant |
| LOGASP | -3.643 | 1.75 | .015 | Significant |

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Reject null hypotheses if F-cal.< F-critical*

The test of hypothesis **$H_{05}$** shown in Table 4.3.5 shows F-score of 4.45, F-critical of 3.68, and p-value of 0.067. Since F-score is greater than F-critical, (4.451> 3.68), we reject the null hypothesis **$H_{05}$** and accept the alternate. We conclude that there is significant effect of fuel subsidy regime on cargo dues paid by shippers to the terminal operators per annum in Nigeria between 2012 and 2021.

Similarly, t-test was conducted to investigate the significance of the individual effects of pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment on cargo dues paid by shippers of petrol over the period covered, and the result indicate that, daily swap import and the annual subsidy payment have t-cal scores greater than t-critical (1.85>1.75; 3.64>1.75). Thus, only daily swap import and annual subsidy payment have significant effects on the cargo dues paid by shippers or terminal operators to NPA over the period.

**Table 4.3.6: Test of $H_{06}$: There is no significant relationship between Fuel Subsidy Reforms and Ship Dues of Maritime Terminals in Nigeria.**

| Hypotheses | F-cal. | F-critical | p-value/sig. | Decision |
|---|---|---|---|---|
| **$H_{06}$** | 4.066 | 3.68 | 0.005[b] | Reject ***$H_{06}$*** |
| | | | | |
| **Variable** | **t-cal.** | **t-critical** | **p-value/sig.** | **Decision** |
| LOGPUPRI | -2.507 | 1.75 | .054 | Significant |
| LOGDSI | -0.357 | 1.75 | .736 | Not Significant |
| LOGNSV | 2.880 | 1.75 | .035 | Significant |
| LOGASP | -2.136 | 1.75 | .016 | Significant |

Source: Authors calculation. Reject *null hypotheses if F-cal > f-critical; Reject null hypotheses if F-cal.< F-critical*

The test of hypothesis **$H_{06}$** shown in Table 4.3.6 shows F-score of 4.066, F-critical of 3.68, and p-value of 0.005. Since F-score is greater than F-critical, (4.066> 3.68), we reject the null hypothesis **$H_{06}$** and accept the alternate. We conclude that there is significant relationship between fuel subsidy regime and ship dues spent by the terminal operators per annum in Nigeria between 2012 and 2021.

Similarly, t-test was conducted to investigate the significance of the individual effects of pump price per liter of petroleum products, daily swap import, number of licensed petroleum product vendors, and annual subsidy payment on the ship dues spent by the terminal operators over the period covered in the study, and the results indicate that, pump price per liter of petrol, the annual subsidy payment and number of vendors approved by government, all have t-cal score greater than t-critical (2.507>1.75; 2.880>1.75 and 2.136> 1.75). Thus, pump price per liter, number of approved vendors and annual subsidy payment have significant effect on the ship dues earned by NPA as spent by terminal operators over the period.

**Table 4.3.7: $H_{07}$: There is no significant change between Transient Technical Efficiency and Overall Technical Efficiency of marine terminal.**

| Performance Indicators of the Terminals | Mean Technical Transient Efficiency | Mean Overall Technical Efficiency | Paired t-test | p-value |
|---|---|---|---|---|
| Cargo Throughput | 0.427 | 0.426 | | |
| Ship Traffic | 0.700 | 0.667 | | |
| BRV Traffic | 0.494 | 0.493 | | |
| GRT | 0.439 | 0.41 | -0.940 | 0.378 |
| Cargo Dues | 0.995 | 0.826 | | |
| Ship Dues | 0.421 | 0.406 | | |
| Berth Rent | 0.646 | 0.547 | | |
| VAT | 0.662 | 0.546 | | |

Source: author's calculation using STATA.

Based on the result of the analysis reported in Table 4.3.7 and efficiency scores presented on the appendix and the p-value of the test statistic 0.378 is greater than 0.05, we do not reject $H_{07}$, hence we agree that there is no significant change between Transient Technical Efficiency and Overall Technical Efficiency of marine terminal.

# CHAPTER FIVE

# CONCLUSION AND RECCOMENDATIONS

## 5.1 Conclusions

The study has been able to investigate for the first time, the relationship depicting the effects of fuel subsidy reforms on the performance of marine terminal operators involved in the import and distribution of petrol supply chain in Nigeria between 2012 and 2021, as basis for providing empirical information and knowledge that will guide maritime terminal operators, in navigating through the challenges of the post fuel subsidy era.

The study equally estimated the elasticity coefficients of cargo throughput, bulk road vehicle calls and ship calls handled by the marine terminal operators, to the variations in pump price per liter, daily swap import, number of approved supply vendors, and annual subsidy payments in the fuel subsidy regime between 2012 and 2021. The coefficients of elasticity of cargo dues and ship dues spent by marine terminal operators over the period to the variations in pump price per liter, daily swap import, number of approved supply vendors, and annual subsidy payments in the fuel subsidy regime between 2012 and 2021 were also determined. The study empirical revealed that it is only the increase in petrol price that can cause an increase in cargo throughput of petrol, in other words, increase in fuel price will bring about fuel availability in Nigeria as the present infrastructure provides. This disclosure simply supports the removal of fuel subsidy. However, this result calls for further investigation.

The study also revealed that there is no significant effect of Official Pump Price, Daily Swap Import, Number of Supply Vendors and Annual Subsidy Payment on Ship Calls to the marine terminals under study. The result further indicated that an increase in the number of Supply Vendors and the Daily Swap Imports can bring about significant effect on ship calls to the marine terminals. But the present fuel subsidy policy configuration does not have significant number of vendors and daily swap imports to impact the tanker ship calls at the marine terminals.

Consequently, the study suggests that, to improve fuel supply and distribution through the marine terminal operations in Nigeria, some policy reengineering needs to take place such as:

a) Petrol Pump Price must be significantly increased to boost Cargo Throughput, Bulk Road Vehicle Calls as this will increase Cargo Dues remittance to Port Authority

b) Number of Supply Vendors and Daily Swap Import should be increased significantly to improve Ship Gross Registered Tonnage and Ship Calls. Number of Supply Vendors increase will also boost Ship Dues earnings of Port Authority.

The study further reveals that the Annual Subsidy Payment is not justified and the drive to avert fuel scarcity in Nigeria is most efficiently performed by the privately-managed marine terminals than the publicly-managed marine terminals within the same years under consideration. The privately-managed marine terminals had a total of 13 efficient performances which covered the periods of RPEA and DSDP reforms of both Jonathan and Buhari administrations as against 3 efficient performances by the 3 publicly- managed marine terminals.

This study also shows that in the implementation of fuel subsidy reforms in Nigeria, the privately-managed marine terminal operators are more efficient than the publicly-managed marine terminal operators.

Finally, the study has shown that the marine terminals have been underutilized because, out of a total of 54 operational years of the marine terminals, only 16 years, have the terminals performed efficiently which is just 29.6% of efficient cargo operation, while the remaining 38 operational years represents 70.3% of inefficient cargo operations in the marine terminals under review. This empirical explains that fuel scarcity in Nigeria is as a result of the lack of petroleum supply chain infrastructural decay, annual subsidy mismanagement and inefficient monitoring of the fuel subsidy reforms.

## 5.2 Recommendations

i. It is recommended that the petroleum supply chain infrastructural decay in Nigeria be fixed, this will eradicate cost of overseas to and fro freighting of petrol. This will reduce the supply chain total cost of the product to Nigerians. Hence, reducing externality costs, out of stock cost etc. while petrol will be sold to Nigerians based on local cost of production.

ii. It is recommended that all policy formulation, implementation and monitoring should be collaboratively handled by public and private practitioners. This will promote synergy, accountability and transparency using ICT aided synchronization for real time monitoring of the petrol supply chain for proactive system nmanagement, thereby averting perennial fuel scarcity challenges in Nigeria.

iii. Maritime terminal operators and policy makers should ensure that models of empirical relationships between fuel subsidy reform proxies and supply chain performance indicators of marine terminal operation form the basis for making empirically backed policy, management and operational decisions while also developing policies regarding marine terminals post fuel subsidy era. Such as determining the acceptable benchmark to guide against non-optimal spendings in cargo dues and ship dues by the operators in the face of continued changes in the fuel subsidy reforms conditions.

iv. Stratify the supply chain from supply sources to the distribution destinations of the products from marine terminals to geopolitical regions in Nigeria for easy identification and monitoring.

v. we recommend that more studies be carried out to find out the reasons why the proxies for fuel subsidy reforms are not significantly affecting ship calls to the marine terminals.

## 5.3 Contributions to Knowledge

The findings of the study and the knowledge advanced in the study is applicable in the ports and terminal sector of the maritime industry and will be used by individual terminal operators and industry regulators in the development of port and terminal management policies in the Nigeria maritime industry.

The study has made useful contribution to the growth and development of knowledge in the area as follows:

1.) The first to examine the effect and relationship between fuel subsidy reforms and supply chain performance of marine terminal operations in Nigeria.

2.) The study has also modeled the coefficient of elasticity of fuel subsidy reforms on supply chain performance of marine terminal operations in Nigeria.

(i) The model indicating the effects of fuel subsidy reforms on cargo throughput of the marine terminal operators is: ***LogCARPUT*** = 30.817 ***+ 0.12LogPUPRI - 0.653LogDSI – 0.012LogNSV - 0.17LogASP***

(ii) The model showing the effects of feul subsidy reform on the ship dues earnings of the marine terminal operators is: ***LogSHDUES = 25.67 – 1.196LogPUPRI - 0.292LogDSI + 0.453LogNSV - 0.232LogASP***

(iii) The model depicting the effects of fuel subsidy reforms on Gross Registered Tonnage handled at marine terminals over the period between 2012 and 2021 is: ***LogGRT = 18.583 - 1.146LogPUPRI + 0.133LogDSI + 0.417LogNSV - 0.173LogASP***

(iv) The model depicting the effects of fuel subsidy reforms on cargo dues earnings of marine terminals over the period between 2012 and 2021 is: ***LogCARDUES= 25.334 + 0.120LogPUPRI - 0.651LogDSI – 0.012LogNSV - 0.170LogASP***

(v) The model depicting the relationship between fuel subsidy reforms and bulk road vehicle calls to marine terminals over the period between 2012 and 2021 is: ***LogVEHCALS = 19.919 + 0.141LogPUPRI - 0.635LogDSI – 0.012LogNSV - 0.163LogASP***

(vi) The model depicting the relationship between fuel subsidy reforms and ship calls to marine terminals over the period between 2012 and 2021 is: ***LogSHCALS = -13.142 - 0.017LogPUPRI + 1.104LogDSI – 0.349LogNSV + 0.147LogASP***

(vii) The study also proffered solutions on how to improve from insignificance to significance relationships between the fuel subsidy reforms and supply chain performance of marine terminal operations in Nigeria.

3.) The study also comparatively evaluated and established the relative performances of 3 privately and 3 publicly managed marine terminals in Nigeria subject to 2 different fuel subsidy reform regimes in Nigeria.

## REFERENCES


Abdellah, F.G. & Levine, E. (1979). Better Patient Care through Nursing. *Research Macmillian Publishing* Co. Inc New York.

Adenikinju, A. F. & Falobi, N. (2006). Macroeconomic And Distributional Consequences Of Energy Supply Shocks In Nigeria Aerc Research Paper 162 *African Economic Research Consortium, Nairobi.*

Adeniran, A. O. (2016). Effects of Fuel Subsidy on Transport Costs and Transport Rates in Nigeria. *Journal of Energy Technologies and Policy* www.iiste.org, ISSN 2224-3232 (Paper) ISSN 2225-0573 (Online) Vol.6, No.11, 2016 1

Agami, N., Saleh, M. & Rasmy, M. (2012). Supply Chain Performance Measurement Approaches. Review and classification. Journal Of Organizational Management Studies .DOI:10.5171/2012.872753.

Agrell, P.J. & Hatami-Marbini, A. (2013). Frontier –Based Performance Analysis Model for Supply chain Management State of The Art and Research Directions, Computer and Industrial Engineering Vol 66, Pp 567-583

Aguero-Tobar, M.A., Gonzalez-Araya, M. C., & Gonzalez-Ramirez, R. G. (2023). "Assessment of maritime operations efficiency and its economic impact based on data envelopment analysis: A case study of Chilean ports" research in transportation business and management 46(10). DOI: 10.1016/j.rtbm.2022.100821.

Akintokunbo, O. O. & Idadokima, S. (2021). Industry 4.0 and Supply Chain Performance in the Oil and Gas Industry. *International journal of scientific research and management* | Page No.: 2555-2560 | Google Scholar **DOI** https://doi.org/10.18535/ijsrm/v9i11.em04

Akinyemi, O. (2017). A Simulation of the Removal of Fuel Subsidy and the Performance of the Agricultural Sector in Nigeria using a Dynamic Computable General Equilibrium Approach (2017.) *Covenant Journal of Business & Social Sciences* (CJBSS) Vol. 8 No.1, June,

Akyuz, G. & Erkan, T. (2010). Supply chain performance measurement: a literature review. *International journal of production research* vol 48, issue 17.

Alam, M.N. (2023). Government's Influence On Supply Chain Management: A Systematic Literature Review. www.academia.edu

Alawiye, A. (2019). 15 Companies Win Contract to Lift Nigeria's Crude Oil (Full List) (ICIR 2019)

Aleksandra, C., Anna, B., & Halemba, H. (2017). Lean Supply Chain Management. World Scientific News, 72, 177-183

Alhosani, A., Zabri, S. M., Aljaberi, F., & Almansoori, A. (2023). Supply Chain Management Concepts Applied in the Oil & Gas Industry – *A review of literature *Faculty of Technology Management, Universiti Tun Hussein Onn Malaysia*. 1 amh486712@takreer.com

Allena Leonard (2009). The Viable System Model and Its Application to Complex Organisation

Alora, A., & Barua, M. (2019). Barrier Analysis of Supply Chain Finance Adoption in Manufacturing Companies. Benchmarking: *An International Journal*, 26, 2122-2145.

Altaf, N. (2020). Working Capital Financing, firm performance and financial flexibility: Evidence from Indian Hospitality firms. Global business review. Sage journals http://doi.org'10.1177/0972150920961371.

Althaqafi, T. (2020). The Impact of State-of-The-Art Supply Chain Management Practices on Operational Performance. *International Journal of Supply Chain Management*.

Amadeo, K. (2018). "Government Subsidies (Farm, Oil, Export, Etc) The Balance. Onlinelibrary.wiley.com

Amin, M.A., Rahman, A. & Shahriar, A. (2020). Application of Theory of Constraints in Supply Chain Management. International Conference on Mechanical, Industrial and Energy Engineering 2020 19-21 December, 2020, Khulna, *BANGLADESH*

Aminu, S. A., & Olawore, O. P. (2014). An empirical investigation of challenges of distribution of premium motor spirit (PMS) in Federal Capital Territory (FCT), Abuja and environs, Nigeria. *International Journal of Management Sciences and Humanities*, 2(2), 11-38.

Asgari, N., Nikbakhsh, E., Hill, A., & Farahani, R. Z. (2016). Supply chain management 1982-2015: A Review. *IMA Journal of Management Mathematics*, *27*(3), 353-379. http://dx.doi.org/10.1093/imaman/dpw004.

Atansah, P., Khandan, M., Moss, T., Mukherjee, A. & Richmond, J. (2017). "When Do Subsidy Reforms Stick? Lessons from Iran, Nigeria, and India." CGD Policy Paper. Washington, DC: *Center for Global Development*. https://www.cgdev.org/publication/when-dosubsidy-reforms-stick-lessons-iran-nigeria-and-india.

Auwal, U. & Mamman, J. A. (2012). The Downstream Sector: An Assessment of The Petroleum Products Supply In Nigeria. Proceeding Of the 5th Annual NAEE/IAEE International Conference "Energy Technology and Infrastructure For Sustainable". April 23-24, 2012, *Abuja – Nigeria*, Pp: 118-133.

Badejo, D. (2000). Dynamics of Port Reforms on Ports and Terminal Operations and Management in Nigeria.

Bai, C. & Sarkis, J. (2012). Supply Chain Performance Measurement System using Neighbourhood Rough Sets. International journal of production research 50(9):2484-2500. DOI:10.1080/00207543.2011.581010.

Banker, R., Emrouzanejad, A., Lopez, A.L.M. & Almeida, M. (2012). Data Envelopment Analysis: Theory and Application. Proceedings of the 10th International Conference on DEA, Natal, Brazil Fox School of Business and Management, Temple University Philadelphia, PA 19121 USA. DOI:10.13140/RG.2.1.1780.4322. ISBN:978 1854494375.

Banker, R.D., Charnes, A & Cooper, W.W. (1984). Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, *Management Science*, 30(9), p. 1078–1092

Barr, S. "Seven Principles of Performance Measurement" www.staceybarr.com

Bayraktar, E. Lenny Koh, S. C., Gunasekaran, A., Sari, K. & Tatoglu, E. (2008). "The role of forecasting on bullwhip effect for E-SCM applications," Int. J. Prod. Econ., vol. 113, no. 1, pp. 193–204.

Beamon, B. M. (1999). "Measuring supply chain performance," International Journal of Operations and Production Management, volume 19, no. 3, pp. 275–292. https://doi.org/10.1108/01443579910249714.

Bello, A.T. (2014). Exploration of Oil and Gas Paved Way for Environmental Degradation in The Niger Delta Region- The Intractable Saga. *International Journal of Innovative Research and Development. ISSN 2278-0211(online)*

Bhagwat, R., & Sharma, M. (2007). Performance Measurement of Supply Chain Management: A Balanced Scorecard Approach. *Journal of Computers & Industrial Engineering*, 53, 43-62.

Bian, J., Zhang, G., & Zhou, G. (2020). Manufacturer vs. Consumer Subsidy with Green Technology Investment and Environmental Concern

Bianchi, C., Nasi, G., & Rivenbark W.C. (2021). Implementing Collaborative Governance: Models, Experiences and Challenges. Public Management Review, 23:11.1581-1589, DOI:10.1080/14719037.2021.1878777.

Bititci, U. S., Carrie, A.S. & McDevitt, L. (1997). Integrated Performance Measurement Systems: A development Guide. *International Journal for Operations and Production Management* volume 17(5): 522-534.DOI:10.1108/01443579710167230.

Brewer, P.C. & Speh, T.W. (2000). Using the Balanced Scorecard to Measure Supply Chain Performance. *Journal of Business Logistics, 21,1. CorpusID:167189098*

Brower, D., Wilson, T. & Giles, C. (2022). The New Energy Shock: Putin, Ukraine and The Global Economy. *Financial Times.*

Bryman, A. & Bell, E. (2003). Business Research Methods, Second Edition. *Oxford University Press. Oxford.*

Castles, S. (2001). Studying Social Transformation, Sage journals

Center For Commercial Deployment Of Transportation Technology CCDoTT (2000). MARAD & USTRANSCOM, Marine Terminal Productivity Measures, P/E FY 97-1.4. November 29, 2000.

Chan, F. T. S. & Chan, H. K. (2005). "Simulation modeling for comparative evaluation of supply chain management strategies," International Journal of Advanced Manufacturing Technology. vol. 25, no. 9–10, pp. 998–1006. DOI: http://dx.doi.org/10.1007/s00170-00301920-7

Chan, F. T. S. (2003). "Performance measurement in a supply chain," The International Journal of Advanced Manufacturing Technology. vol. 21, no. 7, pp. 534–548. https://doi.org/10.1007/s001700300063

Charnes, A., Cooper, W.W & Rhodes, E. (1978). Measuring the efficiency of DMUs. *European Journal of Operational Research*, 2, p. 429-444. http://www.sciencedirect.com/science/article/pii/0377-2217(78)90138-8.

Charnes, A., Cooper, W.W., Lewin, A.Y & Seiford, L.M. (1994). Data Envelopment Analysis: Theory, Methodology and Application. Boston: Kluwer Academic Publishers.

Chayita, R. & Kaseke, N. (2021). Impact Of Government Policy Interventions On The Survival Strategies Being Implemented By Companies In The Petroleum Sector In Zimbabwe, *International Journal Of Business, Economics And Law*, Vol. 24, Issue 5 Issn 2289-1552 2021 195

Chen, H. (2018). Supply Chain Risk's Impact on Corporate Financial Performance. *International Journal of Operations & Production Management*, 38, 713-731.

Chen, I.J. & Paulraj, A. (2004). Understanding Supply Chain Management: Critical Research and a Theoretical Framework. International journal of production research 42(1): 131-163. DOI:10.1080/00207540310001602865.

Chima, C. M. (2007). Supply-Chain Management Issues in the Oil and Gas Industry. *Journal of Business & Economics Research* – June 2007 Volume 5, Number 6 27 (E-mail: cchima@csudh.edu), California State University, Dominguez Hills

Chopra, S., Meindl, P. & Kalra, D. V. (2010). Supply chain management: strategy, planning, and operation, Third edit. Pearson Education.

Chris, H., Paul, G. & Alvarez, J. (2015). Quantifying The Implicit Climate Subsidy Received by Leading Fossil Fuel Companies-Working Paper No 02/2015, Cambridge, UK.

Christopher, M. (2005). Logistics and Supply Chain Management, Third Edition. Prentice Hall.

Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *International Journal of Logistics Management*, 15(2), 1-14.

Cooper, D.R., & Schindler, P.S. (2003). Business Research Methods *International Edition McGraw Hill 8th Edition.*

Cooper, W.W., Seiford, L.M. &Tone, K. (2002). Data Envelopment Analysis: A comprehensive Text with Models, Applications, References and DEA-Solver Software, Kluwer Academic Publishers.

Cranmer, F., Lucas, J. Morris, B. (2006). Church and state: A Mapping Exercise *criando redes que agregam valor*. São Paulo: Cengage Learning.

Crimi, T. A. & Ralph, G. K., MARKUS MAU. (2002). The Nature and Scope of Supply Chain Management., Supply Chain Management Marketing Heritage.

De Monie, G. UNCTAD Monographs on Port Management 6 – Measuring and Evaluating Performance an

Denizhan B., & Gormez, I. (2018). Loss Prevention of Fuel Terminal Operations: A Case Study in Turkey.

Dominguez, R., Cannella, S. & Framinan, J. M. (2014). "On bullwhip-limiting strategies in divergent supply chain networks," Computer Ind. Eng., vol. 73, no. 1, pp. 85–95.

Dubey, R. & Samar Ali, S. (2013). An exploratory study on logistics competency and firm performance. *International Journal of Logistics Systems and Management*, *14*(2), 179-199.

Ehinomen, C. & Adeleke, A. (2012). An Assessment of The Distribution of Petroleum Product in Nigeria

ENOW GODWILL BAIYO (2020).

Enow Godwill Baiyo. (2007)**.**

Espinosa, A., Walker, J. & Martinez-Lozada, A. (2023). Viable System Model: An introduction to Theory and practice. Journal of System Thinking ISSN:2767-3847. Volume 3, pp. 1- 19. DOI: 10.54120/jost.000004. scienceopen.com.

Estan Beedell (2017). Evaluating the Impact of Nigeria's Fuel Subsidy Regime. *University Of Ottawa, Graduate School of Public and International Affairs.*

Ezat Ollah Mehri Babadi, Soleiman Iranzadeh, & Kiamars Fathi Hafshejani, (2022). Identifying LARG Supply Chain Performance Measures in Oil and Gas Industries and How They Relate to LARG Practices: A Fuzzy mathematical approach by *International Journal on Nonlinear Analysis Application.*

Ezejelue, A.C. & Ogwo, E.O. (1990). "Basic Principles in Managing research projects" *Africana FEP Publishers Limited, Onitsha*, p.103

Fernandes et al., (2010).

Garay-Rondero, C., Martinez-Flores, J., Smith, N., Caballero Morales, S., & Adrette-Malacara, A. (2019). Digital Supply Chain Model in Industry 4.0. *Journal of Manufacturing Technology Management, 31*, 887-933.

Geels, F.W. (2010). The dynamics of transition: a socio technical perspective.

George, J. & Pillai, V. M. (2018). A study of factors affecting supply chain performance International Conference on Aerospace and Mechanical Engineering, ICAME'18 Journal of Physics: Conference Series 1355 (2019) *012018 IOP Publishing doi*:10.1088/1742-6596/1355/1/012018.

George, J. & Urpelainen, E. (2021). Reforming Global Fossil Fuel Subsidies: How the United States Can Restart International Cooperation. Brookings.

Ghadge, A., Er Kara, M., Moradlou, H., & Goswami, M. (2020). The Impact of Industry 4.0 Implementation on Supply Chains. *Journal of Manufacturing Technology Management*, 31, 669-686.

Steven, G. C. (1989). Integrating the supply chain. *international journal of physical distribution* vol 19, issue 8.

Gray & Purdy (2018). Multistakeholder Partnerships for Solving Complex Problems

Gregoire Garsous (2022). "Getting Started on Phasing Out Fossil Fuel Subsidies" OECD Report

Groen, Wouters and Wilderom, (2012).

Guennette, Justin-Damien (2023). Price Controls, Good Intentions, Bad Outcomes, *World Bank Group*

*Guide Container Terminal* (2023).

Halevi, J., Harcourt, G. C., Kriesler, P. & Nevile, J. W. (2016). Post-Keynesian Essays from Down Under Volume IV: *Essays on Theory Revised from International Encyclopedia of the Social Science*s, 2E, 151–153.

Halevi, J., Harcourt, G.C. Kriesler, P., and Nevile, J.W. (2016). Post-Keynesian Essays from Down Under Volume IV: Essays on Theory. Palgrave Macmillan, Basingstoke, Economic Record/ volume 95, issue 309/p. 265-266. Wiley online library.

Haley, U., & Haley, G. (2013). Subsidy to Chinese Industry. The Economist. London: *Oxford University Press.*

Hope, C. (2023). Measuring fossil fuel hidden costs, News and Insight. Cambridge Judge Business School. University of Cambridge.

http://metaphorum.org/viable-system-model (2023)

http://planuba.orientaronline.com.ar/wp-content/uploads/2010/03/harvard-business-review-kaplan-norton-the-balanced-scorecard-measures-that-drive-performance.pd

https://www.Researchgate.Net/Publication/311900404_The_Downstreamsector_An_Assessment_Of_The_Petroleum_Products_Supply_In_Nigeria.

Huguenin, J. (2012). Data Envelopment Analysis (DEA) A pedagogical guide for decision makers in the public sector IDHEAP – Cahier 276/2012).

Husain, R., Assavapokee, T. & Khumawala, B. (2006). Supply Chain Management In Petroleum Industry : Challenges And Opportunities.

Hussain, M., Al-Aomar, R., & Melhem, H. (2019). Assessment of Lean-Green Practices on the Sustainable Performance of Hotel Supply Chains. *International Journal of Contemporary Hospitality Management*, 31, 2448-2467.

IEA Report (2023). "Fossil Fuel Consumption Subsidies 2022 Analysis"

IEOM Society International (2019). Implication of Fuel Subsidy Reforms. Proceedings of the International Conference on Industrial Engineering and Operations Management Pilsen, *Czech Republic*, July 23-26

IMF (2022). The Impact of Fuel Subsidy Reemergence in Nigeria. International Monetary Fund. *International Journal of Logistics Management*, *15*(2), 1-14. http://dx.doi.org/10.1108/09574090410700275.

Inegbedion, H. E., Inegbedion, E. & Asaleye, A. (2020). Petroleum Subsidy Withdrawal, Fuel Price Hikes and the Nigerian Economy

Itsekor, L. U. (2018). Mitigating Petroleum Product Shortages In The Nigerian Downstream Petroleum Supply Industry. *Doctoral Thesis Walden University*.

Jamaludina, M., Fauzia, T. H. & Nugraha, D.N.S. (2021). A System Dynamics Approach For Analysing Supply Chain Industry: Evidence From Rice Industry. Uncertain supply chain management 9.217-226

Kaplan, R. S., & Norton, D. P. (1992). The Balanced Scorecard—Measures That Drive Performance. Harvard Business Review, 71-79.

Karl, A. A., Micheluzzi, J., Leite, L. R. & Pereira, C. R. (2018). Supply chain resilience and key performance indicators: a systematic literature review. *Productio*n, vol. 28, 2018

Kim, H. & Lee, J. (2019). Can Employment Subsidies Save Jobs? Evidence from a Shipbuilding City in South Korea" Labour Economics. 61:101763.

Kojima, M. & Koplow, D. (2015). Fossil Fuel Subsidies Approaches and Valuation, Energy and Extractives Global Practice Group March, WPS7220.

Kottala, S., & Herbert, K. (2019). An Empirical Investigation of Supply Chain Operations Reference Model Practices and Supply Chain Performance: Evidence from Manufacturing Sector. International Journal of Productivity and Performance Management, 69, 1925-1954.

Kozlenkova et al., (2015).

Kriesler, P. (2008). 'Partial Equilibrium Analysis' With kind permission from Gale. Gale, a part of Cengage Learning, Inc. www.cengage.com

Kruger, J. (2023). Afcap Consulting. Subsidies. World Bank Group.

Kumar, A., Singh, R., & Modgil, S. (2020). Exploring the Relationship between ICT, SCM Practices and Organizational Performance in the Agri-Food Supply Chain. Bench Marking: *An International Journal*, 27, 1003-1041.

Kumar, G., & Goswami, M. (2019). Sustainable Supply Chain Performance, Its Practice and Impact on Barriers to Collaboration. *International Journal of Productivity and Performance Management*, 68, 1434-1456.

Kurien, G. P., & Qureshi, M. N. (2018). House of Sustainable Waste Management: An Implementation Framework. *International Journal of Sustainable Manufacturing*, 4, 79-96.

Laamanen and Tinnila (2002).

Lindner, C., Cui, L. & Hertz, S. (2009). Supply Chain Performance Measurement- A Research Of Occurring Problems And Challenges M.Sc Thesis. Jonkoping International Business School.

Livohi, S. J. (2012). Downstream Supply Chain Performance Measurement, The Oil Marketing Companies In Kenya. *Published Thesis*

Longo, F. & Mirabelli, G. (2008). "An advanced supply chain management tool based on modeling and simulation," Computer and Industrial Engineering, volume 54, no. 3, pp. 570–588,

Mackenzie, W & NNPC (2016). Counter Party Offers NNPC Direct Sale – Direct Purchase (DSDP) Business Arrangement Website Barter Arrangement (OPA) NEITI.

Martinez- Alvarez, C. B. Hazlett, C. Mahdavi, P. & Ross, M. L. (2022). Political Leadership Has Limited Impact on Fossil Fuel Taxes and Subsidies. Proceedings of the National Academy of Science. 119(47).

Matondang, N. & Sitompul, F.R. (2019). Measurement and Proposed Improved Supply Chain Performance approach with PDCA framework. IOP Conference.

McCulloch, N., Moerenhout, T. & Yang, J. (2021). Fuel Subsidy Reform and The Social Contract In Nigeria: A Micro-Economic Analysis, Energy Policy.

Melnyk, S.A., Bititci, U.S., Platts, K., Jutta, M. & Mortlock, T. (2014). Is Performance Measurement and Management Fit for the Future? *Management Accounting Research* 25(2)

Menhat, M. & Yusuf, Y. (2018). Factors influencing the choice of performance measures for the oil and gas supply chain – exploratory study. iCITES 2018 IOP Publishing doi:10.1088/1757-899X/342/1/012091 E-mail: mashanur@gmail.com

Menhat, M. (2017). Performance measurement framework for the oil and gas supply chain A thesis submitted in partial fulfilment for the requirements for the degree of Doctor of Philosophy at the *University of Central Lancashire* December, 2017

Menhat, M., Jeevan, J., Zaideen, I. M. M. & Yusuf, Y. (2019). Challenges in managing oil and gas supply chain – An exploratory study. Proceedings of the international conference on industrial engineering and operations management, Pilsen, Czech Republic, July 23-26. 2019. jagan@umt.edu.my, izyan@umt.edu.my

Mentzer, J. T., Dewitt, W., Keebler, J. S., Min, S. & Nix, N.W.

Meyrick, S. & DÉste, G. (1989). More than the bottom line – how users select a shipping service. Proceedings of the 14th Australian transportation research forum, perth , Australia. September 1989, pp. 65-81.

Ming, N. S. & Shah, M. Z. (2008). Introducing A Method for More Precise Prediction of Berth Occupancy Ration In Bulk Liquid Terminal. *International Journal of Coastal Offshore and Environmental Engineering.*

Miraz, H. M., Saleheen, F., & Habib, M. M. (2017). ICT-Based Business Initiatives for Women: An Outline of Best Practices in E-Commerce/E-Retailing Ventures. Frontiers in Management Research, 1, 31-36.

Miraz, H. M., Saleheen, F., & Rahman, M. (2016). Supply Chain Management in Service Quality. In International Conference on Industrial Engineering and Operations Management (2097-2105). IEOM Society International

Molina-Besch, K. (2016). Prioritization Guidelines for Green Food Packaging Development. *British Food Journal*, 118, 2512-2533.

Muthini, J.N., Namusonge, G. S., Guyo, W. & Shale, N. I. (2017). Role of Government Economic Regulations on Petroleum Supply Chain Management. Journal of Business and Economic Development. Vol. 2, No. 2, 2017, pp. 131-139. DOI: 10.11648/j.jbed.20170202.19

Muturi, W. M. & Ngugi, P. K. (2015). Factors affecting performance of supply chain systems in the petroleum industries in Kenya. *International journal of science and research publications*. Vol 5. Issue 4.

Myers, N. (1998).” Lifting The Veil on Perverse Subsidies” Nature .392(6674):327-328

Myers, N., & Kent, J. (2001). Perverse Subsidies: How Tax Dollars Can Undercut the Environment and The Economy. Washington, Dc: Island Press.

National Council on Development Planning (NCDP)(www.ppiaf.org).

Naylor, J.B., Naim, M. M. & Berry, D. (1999). Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain. *International journal of production economics*, vol 62, issues 1-2.

Ndubuisi, K. E. & Nwoloziri, C. N. (2021). A Performance Evaluation of Nigeria National Petroleum Corporation Jetties: A Maritime Transport Perspective Using Data Envelopment Analysis (DEA) International Journal of Advanced Engineering and Management Research Vol. 6, No. 01; 2021 ISSN: 2456-3676 www.Ijaemr.Com Page 19

Neely, A. D. (1998). Measuring Business Performance. Virtual Learning Resource Centre.

Nguyen, B. H., Sickles, R. C. & Zelenyuk, V. (undated). "Efficiency Analysis with Stochastic Frontier Models Using Popular Statistical Softwares" working paper 1. International society for efficiencny and productivity analysis. RePEcasa:wpaper.wp0001.

Nottenboom, Theo; Athanasios Pallis; and Jean-Paul Rodrigue (2020).

Nyor, N. et al., (2022). Structuring Wicked Problems in Nigeria: The Operations Research Approach.

Nze, O. N., Okeudo, G. N. & Ejem, A. E. (2021). Trend Analysis of the productivity of Nigerian seaports, *journal of sustainable development of transport and logistics*.6(2),81-95.

Ochuonu, I. G. (2013). The Impact of Petroleum Subsidy on the Consumption of Petroleum Products in Nigeria by Ec / 2009 / 755. A Research Project Presented in Partial Fulfillment of The Requirement for The Award of Bachelor of Science (B.Sc.) Degree In Economics Department Of Economics, Faculty Of Management And Social Sciences. *Caritas University, Amorji-Nike, Enugu, Enugu State,* August 2013

OECD (2022). "Getting Started in Phasing Out Fossil Fuel Subsidies"

OECD (2022). Government Support Subsidies Portal

Ogbuigwe, A. (2018). Refining in Nigeria: history, challenges and prospects. *Applied Petrochemical Research*, 8(4), 181-192. http://doi.org/10.1007/s13203-018-0211-z

Olanrewaju Oyedeji (2021). Much Ado about Subsidy: What it means and why Nigerians should care. Extractive. www.dataphyte.com

Olanrewaju Oyedeji, (2022). How Has Nigeria's Oil Business Fared under President Buhari's Administration. Extractive.

Olujobi, O. J., Olujobi, O. M. & Ufua, D. E. (2020). A Critical Appraisal Of Legal Framework On Deregulation Of The Downstream Sector Of The Nigerian Petroleum Industry. *International*

*Journal of Management*, 11 (6), 2020, Pp. 252-268. http://Iaeme.Com/Home/Issue/Ijm?Volume=11&Issue=6

Omar, A. (2023). Efficiency and Effectiveness in Management, *Journal of Survey in Fisheries Sciences* 10(3S) 3382-3392 2023 3382.

Osoro, A., Muturi, W. M. & Ngugi, P. K. (2015). Factors Affecting Performance of Supply Chain Systems in the Petroleum Industries in Kenya. *International Journal of Scientific and Research Publications*, Volume 5, Issue 4, April 2015 1 ISSN 2250-3153 www.ijsrp.org*ansoroh@gmail.com

Osoro, A., Muturi, W. M. & Ngugi, P. K. (2016). Determinant Affecting Performance of Supply Chain Systems in the Petroleum Industries in Kenya. European Journal of Logistics Purchasing and Supply Chain Management Vol 4, No.4, Pp.44-63, August 2016. *Published by European Centre for Research Training and Development UK.* (www.Eajournals.Org)

Ozili, P. K, (2021). Sources of Economic Policy Uncertainty in Nigeria: Implications for Africa (November 13, 2021). Managing Risk and Decision Making in Times of Economic Distress, Part A. CSEF, Vol 8, Emerald, Available at SSRN: https://ssrn.com/abstract=3962727

Palmer, S. & Torgerson, D. J. (1999). Economics notes Definitions of efficiency

Pamulety, T. C. & Pillai, V. M. (2011). "Impact of information sharing in supply chain performance," Technol. Syst. Manag., vol. 145, pp. 327–332.

Pamulety, T. C. & Pillai, V. M. (2011). "Statistical process control-based inventory management in serial supply chains," in International Conference on Advances in Supply Chain and Manufacturing Management. p. 29.

Pamulety, T. C., & Pillai, V. M. (2011). "Impact of information sharing in supply chain performance," Technology Systems Management., vol. 145, pp. 327–332.

Pamulety, T. C., & Pillai, V. M. (2011). "Statistical process control-based inventory management in serial supply chains" in International Conference on Advances in Supply Chain and Manufacturing Management. p. 29.

Pamulety, T. C., George, J. & Pillai, V. M. (2017). "An inventory position-based policy for better supply chain performance," Journal of Industrial Production Engineering. vol. 34, no. 3, pp. 180–198.

Pamulety, T. C., George, J. & Pillai, V.M., (2017). "An inventory position-based policy for better supply chain performance," J. Ind. Prod. Eng., vol. 34, no. 3, pp. 180–198.

Panahifar, F., Byrne, P., Salam, M., & Heavey, C. (2018). Supply Chain Collaboration and Firm's Performance: The Critical Role of Information Sharing and Trust. *Journal of Enterprise Information Management*, 31, 358-379.

Panova, Y., & Hilletofth, P. (2018). Managing Supply Chain Risks and Delays in Construction Project. *Industrial Management & Data Systems*, 118, 1413-1431.

Parker, (2000). Performance Measurement. *Work Study*. 49,63-66, Scientific Research

Parry, I., Black, S., & Vernon, N. (2015). Measuring fossil fuel subsidies View- A Global and Country. IMF e Library

Paulauskas, V., Paulauskas, D., Birute P., & Barzdziukas, R. (2019). Research on The Methods for Calculating the Width of The Approach Channel to The Port

Petkova, N., Michalak, K. & Oharenko, Y. (2023). Review of energy subsidies in the context of energy sector reforms in Ukraine. Environmental working paper no 228. OECD 2023.

Phan, A., Nguyen, H., Trieu, P., Nguyen, H., & Matsui, Y. (2019). Impact of Supply Chain Quality Management Practices on Operational Performance: Empirical Evidence from Manufacturing Companies in Vietnam. *Supply Chain Management*, 24, 855-871.

Pillai, M., Talari, P. C. & Elluri, P. V. (2013). "Performance analysis of some supply chain replenishment strategies," International Journal of Logistics Research and Application vol. 17, no. 5, pp. 357–376.

Pillai, V. M., Lavanya, K. & Pamulety, T.C. (2014). "Bullwhip effect analysis using supply chain role play game and ranking of supply chains," *Int. J. Procure. Manag*., vol. 7, no. 3, p. 299.

Pozo, H., Elio Takeshi Takeshy Tachizawa, & Djair Pichiai (2009). The Theory of Constraints and the small firm: An Alternative Strategy In The Manufacturing Management. RAI-Revista dde administracao e inovacao, sao Paulo, v.6, n.3, p.05-27, set. /dez.

Rahmanian, N., Agar, D.Y., Bin Dainure, M. F. & Mujtaba, I. M. (2018).

Rakhman M. (2006).

Ramaa, A., Rangaswamy, T. M., & Subramanya, K.N. (2009). A Review Of Literature On Performance Measurement Of Supply Chain Network. Second International Conference On Emerging Trends In Engineering And Technology, ICETET-09.

Rodrigue et al. (2013).

Roshan, D., & Jenson, J. E. (2014). Study on Performance Measurement Systems –Measures and Metrics. *International Journal of Scientific and Research Publication* Vol 4, Issue 9,

Sabiu, M., Ringim, K., Mei, T., & Joarder, M. (2019). Relationship between Human Resource Management Practices, Ethical Climates and Organizational Performance, the Missing Link: An Empirical Analysis. *PSU Research Review*, 3, 50-69.

Saleheen, F. & Habib, M. (2022). Integrated Supply Chain Performance Measurement Model for the Manufacturing Industry. *Journal of Service Science and Management*, **15**, 55-70.

Saleheen, F., Habib, M. M. & Hanafi, Z. (2018). Supply Chain Performance Measurement Model: *The Literature Review*

Salvatore, C. Ciancimino, E. & Ashayeri, J. (2010). "On the Significance of Demand and Inventory Smoothing Interventions in Supply Chain". SSRN Electronic Journal. CentER Discussion Paper series no 2010-126.DOI:10.2139/ssrn.1736526.

Sayne, A. (2017). Securing Fair Value from Natural Nigeria's DSDP contract. Natural Resource. *Governance Institute Publication* NRGI. (Accessed on 20/01/2020).

Sayne, A., Gillies, A. & Katsouris, C. (2015). Inside NNPC Oil Sales: A Case for Reform in Nigeria Natural Resource. *Governance Institute Publication NRGI*. (Accessed on 15/01/2020)

Schwaninger, M. (2016). System Dynamics and the Evolution of the Systems Approach. Encyclopedia of complexity and systems science. Pp1-18

Schwartz, G. & Clements, B. (1999). "Government Subsidies" *Journal of Economic Survey*. 13(2):119. Seaport Chapter Draft (2015),

Seaport Chapter Draft (2015).

Sezen, B. & Kitapci, H. (2007). "Spreadsheet simulation for the supply chain inventory problem," Production planning and Control, volume 18, no. 1, pp. 9–15. Doi:10.1080/09537280600940622

Shokouhyar, S., Seddigh, M., & Panahifar, F. (2020). Impact of Big Data Analytics Capabilities on Supply Chain Sustainability: A Case Study of Iran. *World Journal of Science, Technology and Sustainable Developmen*t, 17, 33-57.

Shokri Kahi, V., Yousefi, S., Shabanpour, H., & Farzipoor Saen, R. (2017). How to Evaluate the Sustainability of Supply Chains? A Dynamic Network DEA Approach. *Industrial Management & Data System*s, 117, 1866-1889.

Siddig, K., Aguiar, A., Grethe, H., Minor, P., & Walmsley, T. (2014). Impacts of removing fuel import subsidies in Nigeria on poverty. *Energy Policy*, 69, 165-178.

Sillanpaa, I. (2011). Supply Chain Performance Measurement In The Manufacturing Industry A Single Case Study Research To Develop A Supply Chain Performance Measurement Framework

Sillanpaa, I. (2012). Empirical Study Of Measuring Supply Chain Performance. Managing transformation with creativity. Proceedings of the 13th Management International Conference Budapest, Hungary.

Simatupang, T. M. & Sridharan, R (2002). The Collaborative Supply Chain. International Journal of Logistics Management, 13, 15-30

Simatupang, T. M., Wright, A. C. & Sridharan, R. (2004). Applying the Theory of Constraints to Supply Chain Collaboration. Supply Chain Management: *An International Journal*, Vol. 9 No. 1, 2004.

Simchi-Levi, D., Kaminsky, P. & Simchi Levi, E (2004). Managing the Supply Chain. The Definitive Guide for The Business Professional Mc Graw-Hill, New York,

Sink & Turtle, (1989). Seven Performance Criteria, effectiveness vs efficiency

Smith Adam (2019). The Wealth of Nations: A Translation into Modern English. Google Book P.300.

Smith, C. D. & Zacharia, Z. G. (2001). Defining Supply Chain Management , Journal Of Business Logistics/ Volume 22, Issue 2, P1Wiley Online Library.

Sreedharan, V. R., Sunder, M. V., Madhavan, V., & Gurumurthy, A. (2019). Development of Lean Six Sigma Training Module: Evidence from an Emerging Economy. *International Journal of Quality & Reliability Management*, 37, 689-710.

Stefanovic, N. (2014). Proactive Supply Chain Performance Measurement with Predictive Analytics

Stephens, (2001). the scor project road map

Sterman, J. (2002)." System dynamics modelling tools for learning in a complex world" *IEEE, Engineering Management Review.*

Steven, G.C. (1989). Integrating the Supply Chain, *International Journal of Physical Distribution*, vol 19, issue 8.

Sundram, V., Bahrin, A., Abdul Munir, Z., & Zolait, A. (2018). The Effect of Supply Chain Information Management and Information System Infrastructure: The Mediating Role of Supply Chain Integration towards Manufacturing Performance in Malaysia. *Journal of Enterprise Information Management*, 31, 751-770.

Suranovic, S. (2018). Welfare Effects of a Vie/ Import Subsidy: Large Country, *International Trade Theory and Policy*

Taghipour, M., Taghipour, M., Khodarezaei, M., & Farid, F. (2015). Supply Chain Performance Evaluation in the IT Industry. *International Journal of Recent Research and Applied Studies*, 23, 144-156.

Tangen, S. (2004). Evaluation and Revision Of Performance Measurement Systems, Doctoral Thesis Written By Stefan Tangen, Royal Institute Of Technology Stockholm, Sweden.

Temporary Wage Subsidies, *International Labour Organization*. (2023).

Timperley, J. (2021). "Why Fossil Fuel Subsidies Are So Hard to Kill" Nature

Tokar, T. & Swink, M. (2019). "Public policy and supply chain management: using shared foundational principles to improve formulation, implementation, and evaluation" *Journal of Supply Chain Management*, Vol. 55, Issue 2.

Tongzon, J. (1995). Determinants of port performance and efficiency. Transportation research, part A. policy and practice.

Tripathi, S., Rangarajan, K. & Talukder, B. (2018). Benchmarking supply chain performance – a case study in Indian petroleum sector.

Tripathi, S., Rangarajan, K. & Talukder, B. (2018). Do Supply Chain Performance Influence Firm Profitability? A Predictive Approach In The Context Of The Indian Pharmaceutical Industry. *Sage Journal*.

Trisnawati, N. & Pujawan, I. N. (2021). Analysis Of Supply Chain Performance Based On The Supply Chain Management Maturity Level In Manufacturing Industry. proceedings of the international conference on industrial engineering and operations management Sao Paulo, Brazil .

UNCTAD EASTS International Symposium on Sustainable Transportation incorporating Malaysian *Universities Transport Research Forum Conference* 2008 (MUTRFC08). *Universiti Teknologi Malaysia*. 12-13 August 2008. 8 will then be performed.

Urban, W. & Rogowska, P. (2020). Engineering Management in Production and Services Methodology for bottleneck identification in a production system when implementing TOC

Van Duijn (2009).

Vargas, P.R., et al., (2017). TOC'S Five Step Cycle: An Approach to Instant Results and Cultural Change.

Varma, S. , Wadhwa, S. & Deshmukh, S.G. (2008). Evaluating petroleum supply chain performance: Application of analytical hierarchy process to balanced scorecard. *Asia Pacific Journal of Marketing and Logistics*___ISSN: 1355-5855 Vol. 20 No. 3, pp. 343-356. https://doi.org/10.1108/13555850810890093

Varma, S., Wadhwa, S. & Deshmukh, S.G. (2008). "Evaluating petroleum supply chain performance: Application of analytical hierarchy process to balanced scorecard", Asia Pacific Journal of Marketing and Logistics, Vol. 20 No. 3, pp. 343-356. https://doi.org/10.1108/13555850810890093

Vorne (2023). Theory of Constraints, the BIG IDEA.

Hausman, W. H. (2002).

Wilson et al 1986. (as cited by Jose Tongzon (1995))

World Bank (2022). Subsidies, Trade and International Cooperation

WTR (2006). Subsidies, Trade and the WTO: Defining Subsidies. World Trade Report

www.earthtrack.net (2022). Protecting Nature by Reforming Environmentally Harmful Subsidies: The Role of Business. Earthtrack"

www.wikipedia.com

Zenjiro Imaoka (2008). Understanding Supply Chain Management. Published by KOUGYOUCHOUSAKAI, Asprova Corporation.10th International Strategic Management Conference, Social and Behavioural Sciences.

Zeynep Tuğçe Şimşita, Noyan Sebla Günayb, Özalp Vayvayc, A.C Marmara (2014). Theory of Constraints: A Literature Review. Procedia - Social and Behavioral Sciences 150, 930 – 936, 10th International Strategic Management Conference, Social and Behavioural Sciences.