IHEUKWUMERE, O.E. 2022. *Analysis of the performance challenges affecting state-owned refineries in Nigeria: a systems thinking approach*. Robert Gordon University, PhD thesis. Hosted on OpenAIR [online]. Available from: https://doi.org/10.48526/rgu-wt-1712811

Analysis of the performance challenges affecting state-owned refineries in Nigeria: a systems thinking approach.

IHEUKWUMERE, O.E.

2022

ANALYSIS OF THE PERFORMANCE CHALLENGES AFFECTING STATE-OWNED REFINERIES IN NIGERIA: A SYSTEMS THINKING APPROACH

BY

OBINNA EMMANUEL IHEUKWUMERE

A thesis submitted in partial fulfilment of the requirements of the Robert Gordon University for the degree of Doctor of Philosophy

MARCH 2022

ABSTRACT

Purpose – This thesis aims to understand how the significant factors that lead to performance challenges across Nigeria's state-owned refineries operationalise to drive their sub-optimal performance. As such, unlike previous studies, it sought to develop a decision-support model to inform policy intervention measures to address the refining problems from a holistic viewpoint.

Design/methodology/approach - Using a literature search, the study identified several challenging factors, which it initially categorised within a political, economic, social, technical, environmental, and legal (PESTEL) framework. A mixed methods approach incorporating the analytical hierarchy process (AHP) validated through interviews was applied using a multi-case study research strategy to prioritise and rank the factors according to their significance. These factors were used to develop a causal loop model based on systems thinking to identify potential leverage points that informed a policy intervention framework capable of addressing the performance challenges of the refineries.

Findings - The result of the study showed that the most significant factors limiting the performance of the refineries lie within the political, economic, social, and technical (PEST) issues. The leverage points for fixing these issues rests mainly within the political, social, and technical factors. As such, the adoption of management efficiency was proposed to address the political issues through full deregulation and the introduction of private sector partnership with the refineries. Secondly, stakeholder satisfaction through a coherent and successful implementation of the recently passed Petroleum Industry Act (PIA) was proposed as a social approach to quell communal agitations and safeguard oil infrastructure located within the Niger Delta areas. Lastly, the adoption of maintenance best practices through a change in the operating philosophy of the refineries was proposed as a technical approach to address recurring equipment breakdowns associated with poor maintenance culture within the organisation.

Practical implications - The study argued that the implementation of this framework will lead to marginal incremental gains over time that will close the performance gaps across the refineries.

Originality/value - The causal loop model developed in this study alongside the policy intervention framework provide a new approach for understanding and resolving the performance implications arising from the interdependencies of the causal factors.

Keywords: *Nigerian refineries, Capacity utilisation, Systems thinking, Policy intervention, Leverage points, PESTEL framework, Productivity and Performance Management.*

Dedication

This thesis is dedicated to God almighty, who made this research journey possible by keeping and sustaining me and my family all through.

ACKNOWLEDGMENTS

I wish to express my deepest gratitude to my family, especially to my beloved wife, Mrs Daberechi Happiness Iheukwumere, whose enormous support, patience, and love for me throughout this journey cannot be overstated. I also appreciate my three lovely children Bethel Iheukwumere, Michelle Iheukwumere and Daniel Iheukwumere for their understanding of my inability to be with them as much as I wanted during this process.

I sincerely appreciate all my supervisors – Dr David Moore, Professor Nadimul Faisal and Dr Temitope Omotayo – whose immense support, guidance and mentorship during my research journey has been exceptional. I am truly lucky to have been guided by such an amazing team and I remain ever grateful.

I am also thankful to my father, Chief Ibeabuchi Iheukwumere, whose love for education for his children helped inspire me to work hard to get to a doctorate degree level. To my late mother, Late Mrs Victoria Nnalu Iheukwumere, who could not witness the completion of my PhD, having passed away due to ill health in 2020, I am forever grateful for all her sacrifice and love towards me. She nurtured and raised me well to become the hardworking man I am today; and may her gentle soul continue to rest in peace. Amen!

I also acknowledge my extended family, particularly my elder sister Mrs Oluchi Oriaku and her husband, Pastor Chinwendu Oriaku for their counsel and prayers for me and my family throughout my study period.

I truly appreciate all my senior PhD friends and colleagues for their guidance and feedback during my research journey, particularly Dr Temitope Omotayo (for his keen interest in my career growth), Dr Prince Boateng (for his initial guidance and insights), Dr Ama Lawani (for all her advice and encouragement), and Dr Oluyomi Osobajo (for his initial pointers). To my fellow research-hub students - Dr Mansur Hamma-Adama, Valentine Matthews, Ikechukwu Uchehara, Kwadwo Obiri, James Gyasi-Addo, Joy Agbeti, Jonas Duku, and Mercy Ogunnusi, for all their friendly and constructive feedback (both formal and informal). I love them all.

Lastly, but not the least, to all my friends in the industry, all of whose names I cannot mention here, and without whose help data collection for this study would have been difficult. I sincerely appreciate them all.

TABLE OF CONTENTS

List of Tables

List of Figures

LIST OF MY JOURNAL PUBLICATIONS AS A RESULT OF THIS RESEARCH

1. Iheukwumere, O., Moore, D. and Omotayo, T. (2021), "Analysis of multi-factors affecting the performance of Nigeria's refineries: a systems thinking approach", International Journal of Productivity and Performance Management, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJPPM-11-2020-0585
2. Iheukwumere, O., Moore, D. & Omotayo, T. A meta-analysis of multi-factors leading to performance challenges across Nigeria’s state-owned refineries. *Applied Petrochemical Research* 11, 183–197 (2021). https://doi.org/10.1007/s13203-021-00272-0
3. Iheukwumere, O.E., Moore, D. and Omotayo, T. 2020. Investigating the challenges of refinery construction in Nigeria: A snapshot across two-timeframes over the past 55 years. *International journal of construction supply chain management*, *10*(1), pp.46-72. https://doi.org/10.14424/ijcscm100120-46-72

LIST OF ABBREVIATIONS/ACRONYMS

AGO	Automotive Gas Oil
AHP	Analytical Hierarchy Process
API	American Petroleum Institute
ATK	Aviation Turbine Kerosene
BPD or B/D	Barrels per day
BPSD	Barrels per stream day
CLD	Causal Loop Diagram
DPK	Dual Purpose Kerosene
DPR	Department of Petroleum Resources
EIA	Energy Information Administration
FCC	Fluid Catalytic Cracker
GDP	Gross Domestic Product
IOC	International Oil Company
LPFO	Low Pour Fuel Oil
LPG	Liquified Petroleum Gas
NLNG	Nigerian Liquefied Natural Gas Company
NNPC	Nigerian National Petroleum Corporation
NOC	National Oil Company
NPDC	Nigerian Petroleum Development Commission
OECD	Organisation for Economic Cooperation and Development
OEMs	Oil Equipment Manufacturers
OPEC	Organization of Oil Exporting Countries
PIA	Petroleum Industry Act
PMS	Premium Motor Spirit
PPMC	Pipeline and Product Marketing Company
PPP	Public-Private Partnerships
RPPs	Refined Petroleum Products
SOEs	State-owned Enterprises
UKPIA	United Kingdom Petroleum Industries Association

CHAPTER ONE: BACKGROUND AND INTRODUCTION

1.0 Introduction

Presently (2021) there has been a growing pressure on world leaders through various organisations such as the United Nations (UN), the European Union (EU), and others to shift the world's energy dependence from fossil fuels to alternative renewable energy (Dittmeyer et al., 2019 and Carrara & Massetti, 2014). This is as a result of the increasing recognition for climate change due to high carbon emissions from fossil-based fuels. While this phenomenon is backed by scientific evidence and is deserving of responsible actions for control, it is, however, important to recognize that global reliance on fossil fuels and alternative energy vary. As the West comprise the heaviest users and emitters of fossil fuels due to their heavy industrialisation (Dignon, 1992, and Gillis & Popovich, 2017), the rest of the developing world, especially the countries with significant deposits of these resources do not only emit relatively less of these pollutants but also significantly rely on these resources as their economic mainstay. As such, the motives for switching from fossil-based fuels will expectedly vary politically across the globe.

Accordingly, it is important to note that aside from the fact that the oil industry enormously support millions of people directly and indirectly globally (PWC, 2013), the emergence of alternative energy-based transport systems such as electric vehicles (EVs) is yet to provide sufficient power to support the global fleet. This is because major scientific breakthroughs are yet to establish more reliable ways of powering heavy equipment such as aviation engines, marine vessels, heavy-duty generators, and industrial machines with alternative fuels (Gross, 2020). Studies from academic research and major consultancy organisations such as PWC (2017) and McKinsey (2019) recognise that the world will continue to significantly rely on fossil-based energy up to 2035 before it begins to gradually taper off from the West with the rest of the world coming in at a slower pace. Hence, the pursuit to net zero targeted by some countries in 2050, will be better achieved on a global scale when all oil and gas organisations pursue a more responsible path towards the efficient operations and optimised use of their existing built assets. The need to continue to improve the operational efficiency of these assets, such as oil refineries, including efforts to mitigate their impact on the environment through policy frameworks, highlights the importance of this research study.

1.1 An overview of Nigeria's state-owned refineries

Nigeria has four state-owned oil refineries operated by its National Oil Company, the Nigerian National Petroleum Corporation (NNPC), with a combined installed capacity of 445,000 barrels per stream day (bpsd). The refineries are strategically located across the country with various capacities as shown in Table 1.

Table 1 Nigerian refineries, locations, and year of commission. NNPC (2018).

Refinery Name	Location	Capacity (bpsd)	Year of Commission
Port Harcourt Refining Company I (PHRC-I)	Rivers State	**60,000**	1965
Warri Refining and Petrochemical Company (WRPC)	Delta State	**125,000**	1978
Kaduna Refining and Petrochemical Company (KRPC)	Kaduna State	**110,000**	1980
Port Harcourt Refining Company II (PHRC-II)	Rivers State	**150,000**	1989
Total Capacity		**445,000**	

Presently, these refineries have sufficient theoretical installed capacity to meet at least 60% of Nigeria's 630,000 – 700,000 b/d demand for refined petroleum products (RPPs) (Siddig et al., 2014; Ogbuigwe, 2018; Iheukwumere et al., 2020). Unfortunately, capacity utilisation (ratio of actual production to installed capacity) across the refineries have dropped to sub-20% levels across the period from 2015 - 2020 due to gross neglect and mismanagement resulting in Nigeria becoming significantly reliant on imports of Refined Petroleum Products (RPPS) for its domestic energy needs (NNPC ASB, 2015 - 2020). This is particularly worrisome as Nigeria's downstream sector, mainly the refining sector consistently generates less than 1% of the country's Gross Domestic Product (GDP) unlike the upstream sector, which contributes up to 10% of the nation's GPD (Omoregie, 2018; NBS, 2020; Siddig et al., 2014; Wapner, 2017). Despite the various measures (discussed in Section 2.5) undertaken since 2001 by the government to address this problem, a solution has remained elusive, necessitating another approach to the problem. Expectedly, this development has attracted the attention of various scholars from different backgrounds, each applying a different reductionist approach to the study and analysis of the problem (see discussions in Section 2.9). None of these studies have attempted to examine these problems from a holistic viewpoint, which can be argued for on the basis that the formulation of any meaningful solution for this problem requires a careful identification of all the significant factors that interact to generate such a level of inefficiency. Hence, this study attempts to bridge this research gap by examining all the factors leading to the performance challenges of the refineries from a holistic viewpoint.

To achieve this, the study adopted a framework that incorporates a multi-faceted approach covering Political, Economic, Social, Technical, Environmental and Legal (PESTEL) factors to categorise the identified challenges. This is because the identified factors affecting the performance of the refineries were found to cut across these areas (Ogbuigwe, 2018; Nkaginieme, 2005; and Iheukwumere et al., 2021). In addition, PESTEL provides a more comprehensive framework over other tools such as Strengths, Weaknesses, Opportunities and Threats (SWOT) for analysing the challenges of the refineries (see discussions in Section 3.9). The idea is to understand how these factors interplay to drive the inefficiency in the management of the Nigerian refining sector. This understanding is essential to help develop an effective decision-making model for policymakers while seeking to address the problems of the refineries.

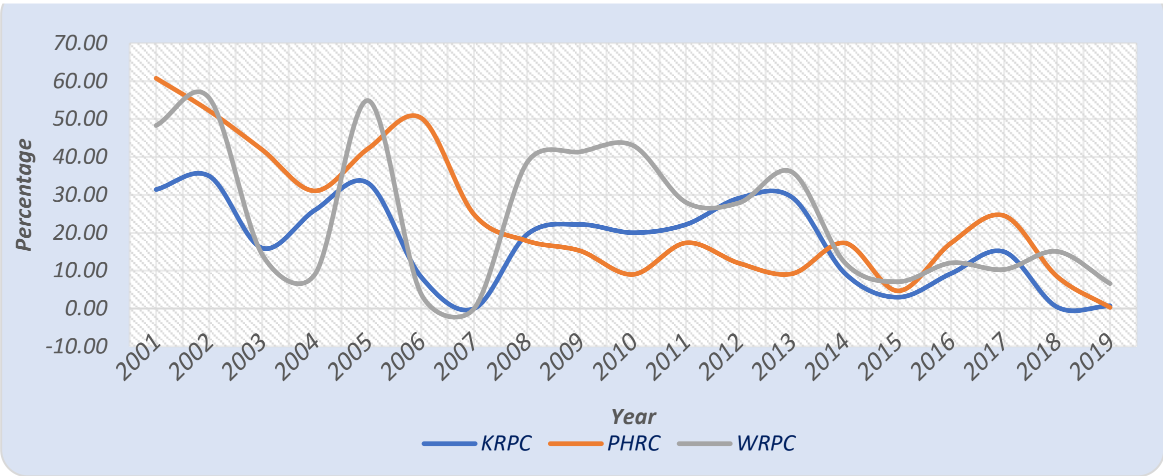
1.2 Problem Statement

The problem statement of this study is focused on the performance challenges of the factors affecting Nigeria's state-owned refineries from a holistic viewpoint. This will help bridge the gap in previous studies that have only attempted to resolve these issues as isolated cases without any attempt to study their causal interrelationships. Some of these performance challenges are framed under the following categories:

1.2.1 Poor capacity utilisation

With its 445,000 b/d refining capacity, Nigeria has the potential to satisfy at least 60% of its 630,000 - 700,000 b/d local demand for RPPs (Ogbuigwe, 2018 and Iheukwumere et al., 2020). Unfortunately, the sub-optimal performance of NNPC refineries has made this impossible due to their declining capacity utilisation. Records from NNPC Annual Statistical Bulletins show that the capacity utilisation of the refineries has fallen from about 60% to less than 20% in the last twenty years since 2001 as shown in Fig 1 (NNPC ASB, 2001 – 2019). This is uneconomical and has led to significant imports of RPPs into the country which is detrimental to the national economy.

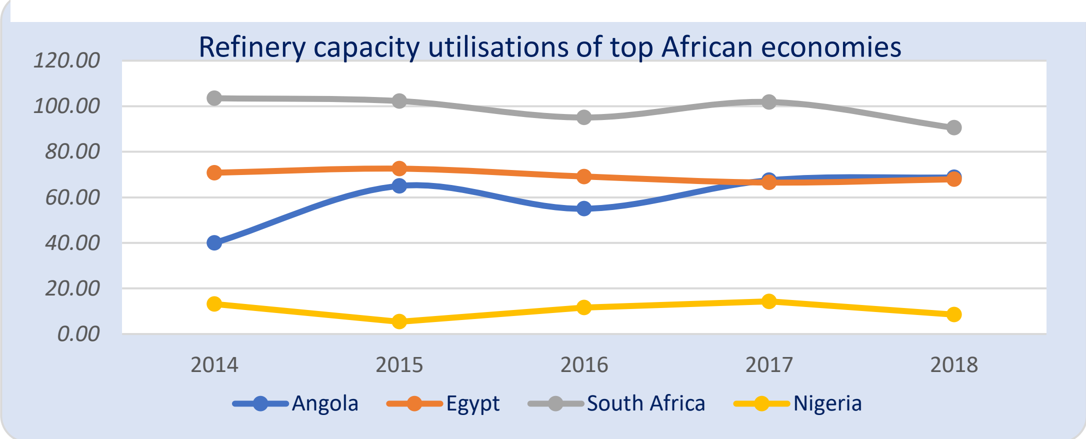
Figure 1 Combined capacity utilisation of Nigerian refineries, NNPC ASB (2001 -2018).



Source: Author, adapted from NNPC ASB 2001 – 2019.

Fig 1 shows that utilisation rates at KRPC and WRPC were at zero level during the year 2007. This is because of the breakage of the Escravos-Warri pipelines (which supply the refineries) occasioned by attacks from vandals (NNPC ASB, 2008). In addition, the overall production levels of the refineries do not compare well with the case for similar economies in Africa such as Egypt, Angola, and South Africa. Figure 2 shows a comparison of Nigeria's refinery capacity utilisation for the period 2014 – 2018, with Angola, Egypt and South Africa, which are among the top African Economies (Oyekunle, 2019). From the figure, it can be observed that Nigeria's refinery capacity utilisation is the lowest when compared to its peer countries.

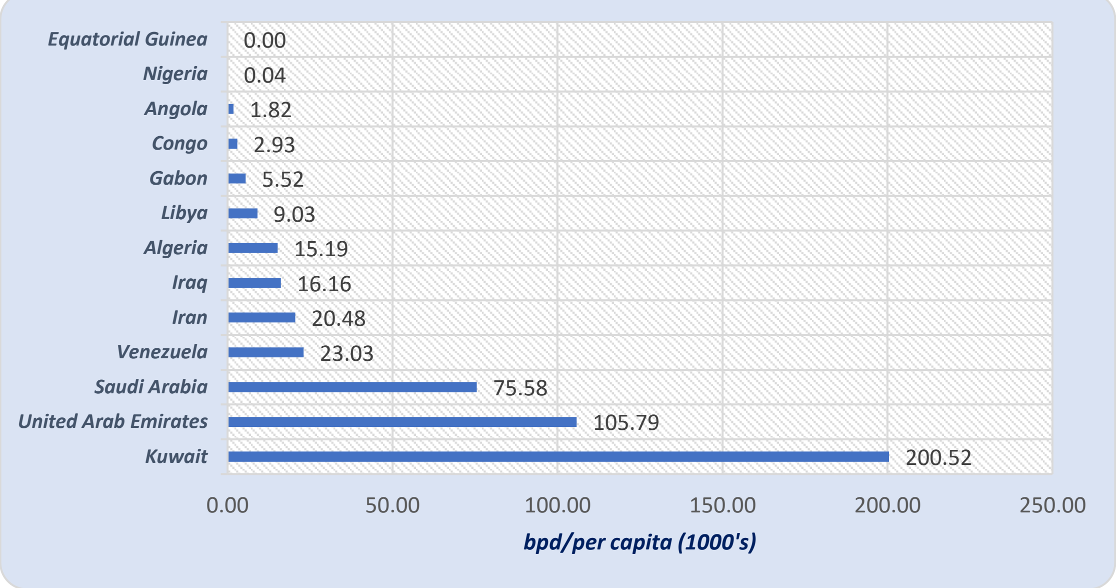
Figure 2 Refinery capacity utilisation of top African economies.



Source: OPEC Annual statistical bulletin, 2019

Furthermore, Nigeria appears to also have the least per capita refining capacity amongst OPEC member countries with only about 0.04 locally refined barrels of petroleum products for every 1000 persons in the country for 2019, which pales in comparison to that of Libya, Algeria, Saudi Arabia, and Kuwait (to mention but a few) with 9, 15, 75 and 200 barrels per 1000 persons respectively as shown in Fig 3. Although it can be argued that Nigeria's population is much higher than these countries, its figure for per capita refining capacity is significantly much less than expected by analysts (PWC 2017).

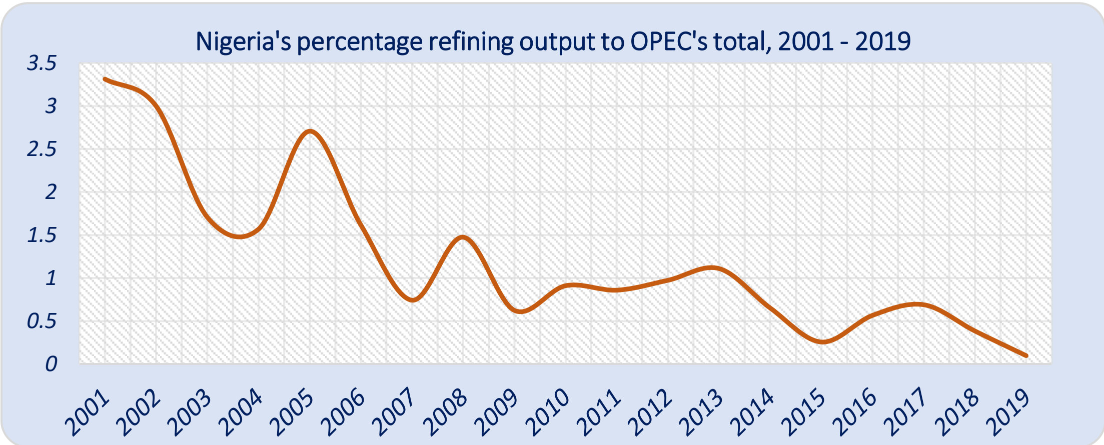
Figure 3 Per capita refining capacity for OPEC countries, 2019



Source: Author, adapted from OPEC Annual statistical bulletin, 2019

In addition, Nigeria's oil production of 1.74m b/d in 2019, was nearly 5% of OPEC's 35.6m b/d, whereas its average refining output to OPEC's total has declined from 3.3% to less than 0.2% in the last 20 years as shown in Fig 4 (OPEC ASB, 2001 – 2019).

Figure 4 Nigeria's percentage refining output to OPEC's total, 2001 - 2019



Source: Author, adapted from OPEC ASB 2001 – 2019

This is clearly the reason behind the rising imports of Nigeria's refined petroleum products since the early 1990s, which has further contributed to the weakening of the economy. This is because refined oil imports accounts for more than 30% of foreign exchange demand in Nigeria, which puts enormous pressure on the local currency and harms the Nigerian economy in turn (Omoregie, 2019).

1.2.2 Production vs Imports of Refined Petroleum Products (RPPs) in Nigeria.

The low-capacity utilisation across state-owned refineries in Nigeria informs their low production output and as such leads to increased pressure for imports. RPPs imported in Nigeria are mainly: Premium Motor Spirit (PMS) popularly known as petrol; Dual Purpose Kerosene (DPK), known as Kerosene; and Automotive Gas Oil (AGO) commonly referred to as diesel. There are a few other products in moderate to minimal demand such as Aviation Turbine Kerosene (ATK) locally known as Aviation Fuel; Low Pour Fuel Oil (LPFO); Base Oil and Bitumen. Unfortunately, there is scant historical data about the detailed consumption of these moderately demanded products in Nigeria. The relative lack of data for these moderately demanded products do not present any challenge for this study as there is sufficient data for the main products (PMS, AGO and DPK) from the refineries.

Presently, the import figures for these products (PMS, AGO and DPK) have remained significantly high in the last decade as shown in Table 2.

Table 2 Import versus local production volumes for refined petroleum products in Nigeria (Litres).

Year	Import Records	Production Records	% Imports	Import Records	Production Records	% Imports	Import Records	Production Records	% Imports
	Petrol (Litres)			**Diesel* (Litres)**			**Household Kerosene (Litres)**		
2010	15,961,278,917.00	1,148,800,451.54	93.29	3,032,555,360.00	1,299,068,721.38	70.01	1,863,074,838.00	829,055,748.07	69.20
2011	20,489,006,536.02	1,611,279,865.13	92.71	2,392,413,699.72	1,416,294,623.00	62.81	1,813,335,339.20	914,248,338.68	66.48
2012	15,219,858,496.68	1,161,143,364.20	92.91	2,099,774,147.52	1,171,019,517.00	64.20	2,160,077,538.08	734,836,404.33	74.62
2013	16,616,098,068.30	1,361,897,160.51	92.42	2,495,511,496.08	1,194,887,171.00	67.62	2,632,329,786.24	887,449,739.15	74.79
2014	18,110,829,530.52	674,975,574.49	96.41	3,786,763,037.40	1,156,913,283.00	76.60	2,853,546,104.64	576,571,023.10	83.19
2015	17,960,783,002.20	377,896,000.22	97.94	4,395,841,099.56	276,002,000.00	94.09	1,885,162,639.36	201,567,000.13	90.34
2016	18,180,247,870.62	800,102,983.32	95.78	4,461,980,149.92	985,551,350.00	81.91	595,481,532.80	516,330,202.08	53.56
2017	16,709,992,689.06	927,572,322.00	94.74	4,249,311,529.92	1,038,747,125.00	80.36	326,904,707.36	689,391,662.00	32.17
2018	19,647,782,753.24	745,720,418.00	96.34	4,424,817,932.53	378,359,544.00	92.12	317,461,912.35	332,567,020.00	48.84
		Average	**94.73**			**76.64**			**65.91**

**Diesel records excludes those from the privately owned Niger Delta Petroleum refinery.*

Source: *Data combined by Author from DPR publications, Pgs 82 and 88*

It is clear from Table 2, that the ratio of percentage imports for PMS, AGO and DPK averages above 90%, 75% and 65% respectively to their local production, which is unhelpful for the Nigerian economy. Odutola (2020) observed that records from Nigeria's national bureau of statistics (NBS) show that the value of RPPs imported by Nigeria stood at N2.52 trillion naira (more than USD 6 billion) for the period between January to September 2021, which significantly contributed to Nigeria's growing trade deficits.

However, it is important to note that the importation of these products is carried out across three market segments in Nigeria. As a group, Independent marketers (essentially non-branded private companies) imported 45% of the products while NNPC and Major marketers (branded public or private companies) imported 42% and 13%, respectively (DPR ASB 2017). This arrangement in which the Independent and Major marketers control a combined higher share of the import market was considered one of the reasons why subsidy payments ballooned since 2012 (Bazilian and Onyeji, 2012; and Siddig et al., 2014). As a result, the government, in 2018, suspended product imports by Independent and Major markerters and willed the rights solely to NNPC. However, this initiative was halted in 2020 with the govermment re-issuing import license to independent and major marketers once again. The reasons behind this decision remains unclear (Nnodim, 2020).

1.2.3 Petroleum Subsidy in Nigeria

Imported petroleum products in Nigeria have long been subsidised by the federal government through its agency - the Petroleum Product Pricing and Regulatory Agency (PPPRA). According to Siddig et al., (2014), PPPRA makes regular determination of subsidy payments by estimating the difference between the expected price of imported products, including margins and the establshed local pump price of refined petroleum products (RPPs). This way, the government is able to maintain a stable price for RPPs in the country. Unfortunately, the cost of maintaining petroleum subsidy payments in Nigeria has increasingly become unsustainable over the years. This is because Nigeria spends between US $3 - 5bn per annum to subsidise imported RPPs for local consumption (Akinola, 2018). In 2012, the figure was US $5.6 bn and constituted 20% of the federal budget for the year, while in 2017 it was US $3.85bn, a quarter of the total government revenue for that year (Financial Times, 2018; Umar and Umar, 2013). Clearly, this is a considerable burden on the country's financial budget.

Some studies have identified courruption and bad governance as the main drivers for Nigeria's worsening subsidy situation, while proposing reforms that embrace accountability and transparency as solutions (Stober, 2016; Akanle, Adebayo & Adetayo 2014). These recommendations appear to be logical in the face of the growing evidence of product diversion to neighbouring countries, where Nigeria's subsidised petroleum products are sold in the black market by oil cabals (Financial Times, 2018). The agents who collude to perpetrate these crimes are incentivised by the higher margins they make by selling these products at higher prices across the border as opposed to selling them within the country (Siddig et al., 2014 and Lewis, 1996). This development has led some scholars to argue that Nigeria's petroleum subsidy does not constitute an effective policy for poverty reduction but rather serve as a tool for enriching the corrupt cabal who control Nigeria's fuel imports (Chikwe, 2016; Siddig et al., 2014 and Umar and Umar, 2013).

Since the non-performance of Nigeria's refineries is shown to contribute to growing subsidy payments by the government, which is detrimental to the economy, this study will evaluate the impact (if any) of subsidy payments on the performance of the refineries.

1.2.4 Escalating operating costs.

Despite their poor capacity utilisation, the operating costs of the NNPC refineries have steadily increased. Operating costs for refineries are usually measured in USD/barrel and are normally of two categories: fixed costs (any costs that do not vary with throughput such as labour and equipment costs) and variable costs (any costs that depends on the level of throughput such as energy, catalysts, and chemicals). According to a 2020 audit report by NNPC, the refineries registered a combined operational expenses of 142bn naira (US $367mn) between June 2019 and June 2020 without processing a single barrel of crude oil. NNPC excuses this as costs accrued due to the ongoing revamping of the refineries since 2019. However, a previous audit report published for the first time in 43 years by NNPC, showed that the four refineries' costs totalled N1.64trn (US $4.28bn) in the five years between 2014 and 2018 while overall average capacity utilisation was below 20% (Udo, 2020).

Such high costs represent more than US $70 per barrel for the circa 60.9m barrels of mostly PMS, AGO and DPK produced by the refineries in those four years (NNPC ASB 2014 – 2018). On the other hand, IEA ETSAP (2014) data show that the average operating costs in the ten years between 1999 and 2009 for refineries in the US Gulf Coast was only about US $3.30 per barrel. For Mediterranean Europe, it was US $4.00 per barrel, while for Asia, the figure was only US $3.00 per barrel. These figures are significantly much lower than the figures for Nigeria, hence indicating that Nigeria's refineries spend approximately 2,200% more to refine a single barrel of oil than their global counterparts.

1.2.5 Damage to the Environment

The shortage in local supply of refined petroleum products in Nigeria has given rise to illegal artisanal refining activities in the Niger Delta region. This practice is often carried out by the locals who break into oil company's pipelines, siphoning all or most of the products away and transporting them to their local refining hubs with barges or local boats (Ikelegbe, 2005 and Boris, 2015). From there, the products are primitively subjected to heating to vaporize it at elevated temperatures allowing certain range of product-mix to emerge as crudely refined petroleum products mostly sold in the black markets. Figure 5 shows examples of some of the environmental damage that results from these practices.

Figure 5: Pictures showing environmental damage from illegal/artisanal refining activities

Source: Galaxy TV and Defence web.

This practice frequently results in the production of heavy smokes and sometimes accidental bush fires which often kill the artisans themselves and damage the local ecology (Boris, 2015; Asimiea & Omokhua, 2013 and CNN, 2010). There have been some calls from researchers to review and legalise this practice or convert these facilities to modular refineries (Umukoro, 2018 and Angela et al., 2019). The argument from these researchers appears reasonable since these facilities will help boost local production of RPPs and increase employment opportunities in the region. However, this argument has been hard to win given other efforts the government is making to encourage local industries to invest in small-to-medium scale modular refineries (Iheukwumere et al., 2020 and Nkaginieme, 2005). Although a laudable initiative, most of the companies already licensed to build these facilities appear to be struggling to do so. Iheukwumere et al. (2020) outlined some of the challenges encountered by these companies and recommended a review of the licensing scheme. Indeed, any steps taken to address the refining problems in Nigeria will in turn contribute towards the reduction of petroleum-induced environmental damage due to illegal crude oil refining.

1.2.6 Missed Economic Opportunities

With more than 80% volume of RPPs consumed in Nigeria imported from foreign countries, there is a clear incentive for investment into Nigeria's downstream sector towards the revitalization of its ailing refineries and/or the building of additional refining capacity (Ogbuigwe, 2018, and PWC, 2017). According to projections from McKinsey and Company (2019), while developed nations are likely to see a decline of about 0.3% per annum in demand for RPPs up to 2035, developing countries in Africa, Asia and Latin America will likely continue to see a general rise in demand of about 2% per annum up to 2035. Ogbuigwe (2018) suggests a Nigerian growth rate of 3% per annum based on previous trends. This is quite remarkable and promises great opportunities for investments. In addition, PwC (2017) identified large economic potential for RPPs in Nigeria's West African neighbours and estimates a gap of 39 billion litres (245.3m barrels) annual demand, which exceeds the local production capacity of the other regional refineries in Ivory Coast, Gabon, and Senegal.

Such a gap presents an opportunity for Nigeria, Africa's largest oil producer, to leverage on and maximize its benefits from the petroleum resources. It is important to note that some state-run refineries in other countries have made important gains through such international operations. For example, Petrobras (Brazil) owns a 100,000-bpd refinery each in Texas, US and Okinawa, Japan, and another 30,000-bpd in Bahai Blanca, Argentina. Saudi Aramco (Saudi Arabia) owns about 1.2mn bpd refining capacity via joint ventures and outright ownership in US, Japan, and South Korea, while Kuwait Petroleum International (KPI) owns about 200,000 bpd refining capacity in Vietnam and Italy altogether (Oil and Energy Trends, 2019). NNPC can strategically achieve the same success regionally if well positioned to capture these markets.

From the foregoing, it can be argued that a contextualisation of the challenges of the NNPC refineries would reveal that the issues are sufficiently complex and multifaceted, requiring a thorough understanding of how they operationalise to derive their low productivities. Ito et al. (2021) suggest that the production problems experienced by sector-specific industries are usually masked by fundamental root causes. The researchers further argue that the understanding of these root causes require a prioritization of their causal factors to develop effective solutions. This notion supports the findings of previous studies that a lack of understanding of specific root causes of organisational issues often result to the treatment of their problem symptoms that end up setting off unintended consequences that eventually compound the issues (Senge, 1990; Goodman, 1991; and Meadows, 2008). In addition, Baldoni (2008) acknowledged the dangers of management misdiagnosis of complex organisational problems and cautioned of their costly consequences. For example, significant time and resources could be wasted by organisations that fail to address specific industry issues and result to the implementation of wrong policies that do not achieve any desired outcomes. Studies show that such consequences are also common across multiple sectors. For example, in the health sector, Muhrer (2021) show that wrong diagnosis of underlying medical problems result to prescriptions of incorrect treatments with debilitating health consequences. In education, Ingersoll (2002) recount the dangerous impact of misunderstanding the root causes of high teacher turnover in the US in the late 90s and the failure of its resulting policies to effectively address the issue. In the energy sector, Zhu et al. (2020) highlight the importance of developing broader awareness of underlying systemic issues in the Norwegian oil and gas industry to preclude unwanted and costly solutions.

How then can the fundamental issues underlying the challenges of the NNPC refineries be ascertained and resolved? Spradlin (2012) and Baldoni (2008) recommend asking specific questions as opposed to describing the problems in more generic terms. This is because generic problem description is a precursor to wrong decision-making informed by a lack of deeper understanding (Spradlin, 2012). It is therefore logical to break down the challenges of the refineries from the broad categories already outlined to their specific causes to enhance a deeper understanding of their fundamental modes of operation. It is on this basis that the following research questions are proposed to guide this study:

1. What are the specific factors that drive the low productivity of the NNPC refineries?
2. How can these factors be prioritised such that effective decision making can be inferred?

3. How do these factors significantly interrelate and how can these be modelled?
4. How can these analyses produce outcomes that will guide policymakers to inform solutions that will improve future practice in Nigeria's refining industry?

These questions are intended to provide some boundaries that will afford the opportunity for a systemic view of the problems.

1.3 Research Aims and Objectives

The purpose of this research is to develop a model that takes into consideration all the significant factors that drive sub-optimal performance across Nigeria's refineries. The proposed model is expected to enhance decision-making processes through a framework that will guide Nigerian policymakers regarding efficiency improvement across the refineries. Consequently, the aims of this research are broken into two steps:

1. To explore the challenges of the Nigerian crude oil refining industry with a view of understanding the causal interrelationships of the factors that affect its performance.
2. To develop a model that will provide the basis for a policy intervention framework to guide Nigerian policymakers for addressing the challenges of the refineries.

These aims will be achieved through the following objectives.

1. To critically review the measures undertaken by the Nigerian government in addressing the challenges of the crude oil refining sector.
2. To establish and evaluate the significant factors across various categories that contribute to inefficiency in Nigeria's oil refining sector.
3. To develop and validate a model that will enhance the understanding of systemic interrelationships of the significant factors affecting the refineries' performance.
4. To use this model to inform a policy intervention framework for addressing the refinery challenges.

1.4 Research Methodology Employed

An overview of the research methodology for this study is presented in this section as an introductory guide for this thesis. Further details of the research methodology are discussed in Chapter Four of this study.

To address the research objectives, it was considered necessary to adopt a suitable research approach that will enable the researcher to obtain sufficient reliable data, which will allow for detailed analysis and interpretation of findings. To this end, this study began with an extensive literature review to understand the broader challenges of Nigerian refineries and how they interweave with government policies within the Nigerian petroleum sector. This literature review allowed the researcher to become grounded in the general knowledge, challenges, and theories around the Nigerian petroleum sector. It also provided the researcher with the opportunity to identify gaps, conflicts, and inconsistencies on existing literature within the research area, hence guiding how this study can help address some of these gaps with appropriate theoretical framework (Hart, 2018; Saunders et al., 2016 and Bryman, 2011).
The literature review informed the adoption of a pragmatic research paradigm, which would allow the researcher some flexibility to access as much data from Nigeria's refineries.

A mixed-methods approach was adopted in a multiple case study involving the all the NNPC refineries (PHRC I&II, WRPC & KRPC) to collect both quantitative and qualitative data sequentially in this study. This decision was informed by the experience of Jesuleye (2007) and Badmus et al (2013) who had some difficulties regarding data collection from the NNPC refineries using one method of enquiry. As such, the researcher considered a two-pronged enquiry approach in which one method validates the other as is the case for mixed methods, a more effective approach to counter this challenge (Creswell, 2003). According to Bryman (2011), a mixed methods research approach affords a researcher the flexibility to incorporate different research strategies to answer the relevant research questions. To this end, this study employed an online questionnaire survey to sample the expert opinions of relevant stakeholders in the industry regarding the performance challenges experienced across the NNPC refineries. A semi-structured interview was subsequently adopted to investigate further and to validate the findings of the questionnaire.

1.5 Scope of the Study

This study is focused on achieving performance improvement across Nigeria's state-owned refineries. The thesis is presented as an academic research study based on primary data obtained from the professionals who work in these refineries. The outcome of the thesis is expected to assist Nigerian policymakers towards efficiency improvements on the refineries. The Nigerian public would also benefit from this study through the resulting optimised use of the state oil refineries which would potentially make the supply of refined oil products readily available.

As an academic research, the study was limited to a four-year research timeline based on available literature from academic sources, government, and industry documents, including data obtained from experts who work in this industry in Nigeria. The methodology employed for this study is limited to the knowledge and resources available to the researcher. The reliability of the study was improved through a pilot test carried out on a sample of 25 experts from the target industry representing about 10% of the sample target.

1.6 Research Significance

Previously the interdependencies of the factors that drive inefficiency across Nigeria's state-owned refineries has been unexplored. This study helps to improve the understanding of these interrelationships with a view of identifying potential leverage points where policy intervention can be applied to improve performance in this industry. The findings of this study will potentially ensure the efficient use of Nigeria's oil refining infrastructure which can be beneficial to the national economy through reduced importation of RPPs. The study is also expected to benefit the Nigerian ecological environment through recommendations that would reduce environmental impact due to social issues related to pipeline vandalization, illegal oil refining and wastage of oil resources through spillage. In addition, the approach developed by this study will potentially contribute to improved decision making within the management of Nigeria's oil refining industry.

1.7 Research Limitations

Saunders et al. (2019) acknowledged that it is common for researchers to confront some limitations in their research process. The limitations encountered in this study are presented in this section.

Some of the materials used for this study were of non-academic sources as the lack of relevant data from academic sources regarding aspects of this research were compensated by those from reputable research and consultancy organisations, industry reports and source documents, and in some cases, reports from reputable news sources. This research also encountered time and resource constraints, including those presented by the pandemic for the researcher and the target organisation. As a result, this study was carried out using online questionnaires and telephone interviews. This approach does not constitute a barrier to the effectiveness of this study as these modes of data collection has been proven effective for carrying out reliable studies in management sciences (Bryman, 2012 and Saunders et al., 2019). In addition, since this study was self-sponsored without the formal sanction of the NNPC, a high level of cooperation was difficult to establish between the researcher and the senior management of the organisation, some of whom claimed busy schedule as reason for being unable to participate in data collection. However, the researcher overcame this challenge by identifying key middle to senior level officials in the organisation through his contacts at the refineries to obtain reliable data which were also validated for this study.

Lastly, this study adopted the concept of systems thinking for building causal loop diagrams to model the interrelationships of the factors generating inefficiency in the refineries. A future study will benefit from this model to simulate the effects of dynamic changes in the factors established in this study on actual production performance of the refineries.

1.8 Originality and contribution

This study sought to establish the causal interrelationships amongst the significant factors driving sub-optimal performance across the NNPC refineries. It fills the gap in literature by showing how these factors operationalise to produce underperformance in terms of production from the refineries. Unlike previous studies in this area which have adopted reductionist approaches, it adopted a multifaceted approach to examine these issues from a holistic viewpoint. Consequently, it proposed three approaches based on political, social, and technical issues to inform a policy intervention framework to address the problems of the refineries.

It argues that the implementation of the framework developed from this study (See section 6.8, Figure 50) will lead to marginal gains over time to close the performance gaps across the refineries.

1.9 Thesis Structure

This research is presented in Eight Chapters for clarity and ease of comprehension. The chapters are outlined as follows:

a. **Chapter One:** Introduced the background of the study, including the problem statements, scope, significance, limitations as well as the research aims and objectives.
b. **Chapter Two:** Presented the context of the study in a literature review by discussing the Nigerian oil and gas industry as it pertains to this study, including the challenges of all the state-owned refineries.
c. **Chapter Three:** Presented the underpinning theory of the research and its conceptual framework bordering on systems thinking.

d. **Chapter Four:** Outlined the detailed methodology employed by this study. It covers the quantitative and qualitative data collection (mixed methods) approach employed and also discussed the concept of the analytical hierarchy process.
e. **Chapter Five:** Discussed the detail of data collection and analyses based on the mixed methods identified in Chapter Four.
f. **Chapter Six:** Discussed the process for model development and validation based on the concept of systems thinking using the causal loop diagram as a tool to identify points of leverage.
g. **Chapter Seven:** presented the analyses of the interdependencies of the causal factors in the model and their policy implications.
h. **Chapter Eight:** Summarised and concluded the research study while highlighting how the various aims and objectives have been met.

1.10 Chapter Conclusion

This chapter provided the background and introduction to this study. It highlighted the problem statement leading to the research, including its scope, and significance. It further developed a discussion that led to the study's aims and objectives.

An overview of the challenges of the NNPC refineries presented in this chapter revealed that the performance of the NNPC refineries compares poorly with those from Nigeria's peer OPEC member states. In addition, the chapter argues that these problems are multifaceted and recurrent, requiring a holistic approach to their understanding and solution. As such, it argued that the understanding of the mode of operationalisation of these challenges with regard to how they derive sub-optimal performance across the refineries is crucial to developing effective solutions to address the issues. Hence, the chapter proposed relevant research questions, which provide the boundary within which the aims and objectives established can be achieved.

CHAPTER TWO: CONTEXT, PROSPECTS AND CHALLENGES OF THE NIGERIAN REFINING INDUSTRY

2.0 Chapter Introduction

This chapter builds on the background of this study presented in chapter one by providing additional context. It further develops a discussion on the challenges of Nigeria's state-owned refineries, including their supporting infrastructure. The chapter will also highlight some of the prospects of the Nigerian refining industry in terms of their potential and possible approaches to address the performance issues. Lastly, a review of previous government efforts to address these challenges is presented. The chapter closes with a summary of the identified gaps in the literature.

2.1 The significance of oil in Nigeria

Crude oil was first discovered in Nigeria in 1956 by Shell-BP at Oloibiri in present day Bayelsa State in Nigeria's Niger Delta region (Wapner, 2017). The field was first produced in 1958 placing Nigeria among the group of oil producing countries in the world (Odularu, 2008 and Watts, 2004). Subsequently, Nigeria joined the Organisation of Petroleum Exporting Countries (OPEC) on July 10, 1971 as the eleventh member and later formed its National Oil Company (NOC), the Nigerian National Petroleum Corporation (NNPC) in 1977 (Campbell, 2013; Odularu, 2008 and Squalli, 2007).

Nigerian crude is classified as light-sweet grade and is mostly traded as Bonny Light, Forcados blend and Qua Iboe Light (Nordhaus, 2009 and Pinto, 1984). These grades of oil are highly desirable to refineries all over the world and are sold at better premium prices compared to heavier crudes. This is because of their less impurity-containing sulphur properties as well as their desirable American Petroleum Institute (API) gravity which yields higher-value refined petroleum products (Badmus et al., 2012; Gary, Handwerk and Kaiser, 2007).

The export of crude oil from Nigeria created a major economic shift by displacing agriculture as the traditional mainstay and foreign exchange earner for the nation's economy. The production and export of crude oil usually accounts for more than 80% of government revenue and more than 90% of its foreign exchange earnings (Watts, 2004, PWC, 2016; Wapner, 2017; and DPR, 2017). However, in terms of GDP, crude oil contributes up to 10% of Nigeria's GDP behind agriculture's 20% contribution and the figure normally varies with fluctuations in global crude oil prices (Omoregie, 2019; Wapner, 2017, and NBS, 2017).

The Nigerian petroleum industry has grown since the first production of oil, attracting foreign investments from various international oil companies (IOCs) (Ogbuigwe, 2018 and Akinola, 2018). These companies operate the Nigerian oil fields in different forms of partnership agreements with the state oil company, NNPC. These agreements cut across Joint Ventures, Service Contracts and Production Sharing Contracts (DPR, 2018; Khan, 1994 and Atsegbua, 1993). All these arrangements involve the NNPC holding a 50+% of the stake, while the IOCs, which provide the technical capabilities required to produce the oil fields hold the remainder of the stake (Umar, 2005; Ite, 2004; Khan, 1994; Johnston, 1994 and NNPC, 2016). The benefit to each partner in these agreements comes from their contractual share of the profits on the dollar value of the crude exports.

Unfortunately, despite the significant earnings accruing from Nigeria's sale of crude oil since the late 1950s, the country still grapples with poverty and a lack of infrastructural development across both the public sector and the processing downstream oil sector (Iwayemi 2008, Akinola, 2018). This is in sharp contrast from what is obtainable from some oil producing states in the Middle East such as Saudi Arabia, Oman and Kuwait with better infrastructure development and welfare programme for their citizens (Estache et al., 2013; and Mellahi et al., 2011). Findings from Al-Hanawi et al. (2018), El-Katiri et al. (2013), and Alshishtawy (2010) suggest that oil producing Gulf states such as Kuwait, Saudi Arabia, Oman, United Arab Emirates and Qatar are politically, socially, and economically stronger than other OPEC oil producers given the rich infrastructural development of these states and better welfare programmes for their citizens through free healthcare, education and social security supported by oil proceeds. Whilst it can be argued that these countries have relatively smaller populations compared to other oil producing states, especially Nigeria whose 200+ million persons is at least three times the combined population of these countries (World Bank, 2020), the scale of infrastructural development, as well as poverty eradication in these nations evidences a long-term commitment to growth from their efficient resource use (Alshishtawy, 2010).

On the contrary, the regular injection of petroleum dollars from crude oil sales has not contributed as much to Nigeria's infrastructure development. This can be evidenced across multiple sectors of the economy from power sector, through roads and highways, hospitals, and schools, and even the oil sector, especially the downstream refining sector, all of which have suffered from gross infrastructural decay (Ogbuagu et al., 2014 and Iwayemi 2008). It is, therefore, no surprise that Nigeria's downstream sector has been dysfunctional as evidenced by the current state of the NNPC refineries (see Section 2.4).

Before proceeding further in this chapter, it is essential to introduce some key definitions to provide relevant context to guide the understanding of this thesis. This is especially important given the multi-disciplinary nature of this study and the considerable breadth of the petroleum industry.

2.2 Context and Sense Making

The operations of the oil industry, which extends from exploration and production through transportation & storage to refining and distribution, is usually classified under three major segments in the energy supply chain as shown in Table 3 (Devold, 2013; and Fanchi & Christiansen, 2017).

Table 3 Energy supply chain segments of the oil industry

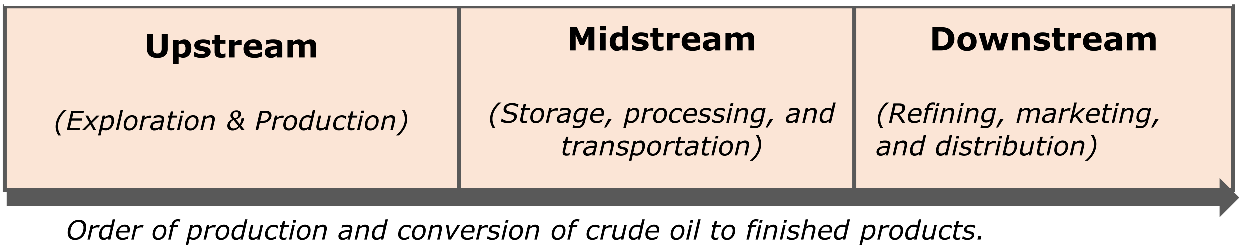
Energy Segment	Remarks
The upstream sector	This sector deals with the oil exploration using various scientific techniques in the field of geology and geophysical sciences to locate, map and estimate the hydrocarbon finds (oil deposits) in the ground. It also incorporates the production of the hydrocarbons (oil and gas) by the petroleum engineers using a range of mathematical techniques to drill, lift and manage the oil reservoirs by maintaining the relevant pressures and flowrates over the life of the oil fields. The produced crude oil must then be transported where it will be further treated.
The midstream sector	This sector deals with all the activities encompassing the storage, processing, and transportation of the produced oil. Essentially, it deals with the movement of crude oil from the oil fields via pipelines to the processing surface facilities, where the oil and gas are separated into distinct components and kept in storage tanks.

	Petroleum production engineers, Chemical engineers as well as Instrumentation, Mechanical and Electrical engineers mostly oversee these activities. Finally, the separated crude oil has very little use in this form and must be transferred to another unit where it will be further processed.
The downstream sector	This sector comprises the activities that transforms the oil into usable petrochemical products for everyday consumption. It deals with the refining, marketing, and distribution of petroleum products. Chemical and Petrochemical engineers are mainly responsible for the technologies that deal with crude oil refining, while other specialists may be more involved in marketing and distribution of the products.

Source: Adapted from Fanchi & Christiansen, 2017 and Devold, 2013.

Essentially, the entire energy supply chain is structured sequentially from the upstream to the downstream sector in order of production to the conversion of crude oil to usable petroleum products. The focus of this research study lies within the downstream sector of the energy supply chain - investigating the performance challenges of Nigeria's petroleum refining industry with a view of developing a framework to guide decision-making in the sector as outlined in the aims and objectives (See section 1.3). The sequence of oil conversion from upstream to downstream is as shown in Figure 6.

Figure 6: The three segments of the energy supply chain



Source: Author generated

2.2.1 Integrated Oil and Gas Companies Vs Independents

Within the global oil and gas industry, organisations with operations that span across the three major segments of the energy supply chain are referred to as *Integrated oil companies*, while those that operate in one or more of the segment areas but not all, are referred to as partially integrated or *Independents* (Beyazay-Odemis, 2015). As such, there are *Independents* in every sector of the energy segment. It is also important to note that *Integrated* companies are either usually privately owned as listed public companies or state-owned under full or majority government control (Antill, 2000). Nigeria's NNPC is an *Integrated* oil company with activities that span from *Exploration and Production* (upstream) overseen by its NPDC; *Storage, Processing and Transportation* (midstream) overseen by its PPMC and *Refining, Marketing and Distribution* (downstream) under the control of the refineries (PHRC, KRPC, and WRPC). It is important to note that Integrated state-owned oil companies usually comprise of full or majority stake of national government ownership and as such, are significantly influenced by their government policies. Some examples of state-owned integrated oil companies include Saudi Aramco (Saudi Arabia), Equinox (Norway), Gazprom (Russia), and China National Offshore Oil Corporation (CNOOC), to name a few.

Lastly, both *Integrated* companies and *Independents* may have operations that focus entirely domestically, internationally, or both (Beyazay-Odemis, 2015).

2.2.2 National Oil companies (NOCs)

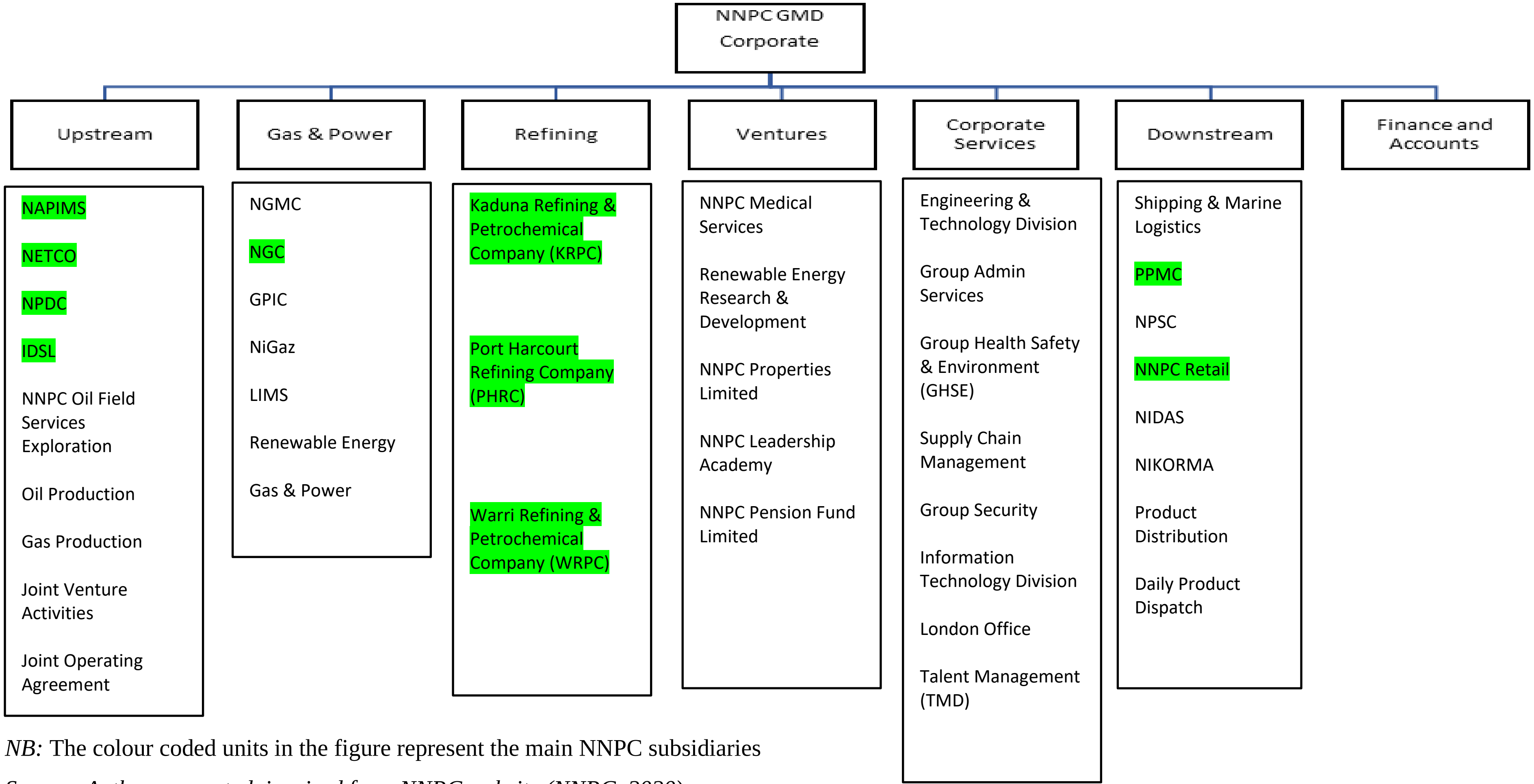
A national oil company (NOC) is a fully or majority state-owned oil and gas entity. NOCs are usually *Integrated* in their operations as indicated earlier (Section 2.2.1) and play an increasingly dominant role over global oil and gas production. NOCs maintain control over most of the global proven oil reserves followed by international oil companies (IOCs) (Hartley and Medlock, 2008). According to the International Energy Administration (IEA, 2020), NOCs controlled 57.8% of global oil production and 65.7% of proven oil reserves in 2018. In addition, it is common to find NOCs with expanded operations that extend beyond national borders (Beyazay-Odemis, 2015). Leading NOCs in this category include Saudi Aramco (Saudi Arabia), Petrobras (Brazil), and PDVSA (Venezuela). Others include China National Petroleum Corporation (CNPC), and Kuwait Petroleum Corporation (KPC), to name a few. However, some NOCs maintain sole domestic operations despite operating an *Integrated* structure. Some of these NOCs include National Iranian Oil Company (NIOC) and Nigerian National Petroleum Corporation (NNPC) (Antill, 2000).

2.2.3 Nigerian National Petroleum Corporation (NNPC)

The Nigerian National Petroleum Corporation (NNPC) is Nigeria's national oil company. The corporation was established by a special Petroleum Act on the 1st of April 1977, which conferred autonomy on it as a corporation to coordinate the oil activities of the nation (NNPC Act, 2004). Unfortunately, due to changes in government administrations over the years, the NNPC is reported to have lost most of its autonomy and has become increasingly subjected to government interference (Ogbuigwe, 2018). The details of this change and its impact on the organisation's performance are reviewed under the challenges of Nigerian refineries (Section 2.4).

Nonetheless, the operations of the NNPC span across exploration, production, pipeline transportation, refining and petrochemicals (Wapner, 2017). As such, the organisation operates as an Integrated Oil and Gas company with sole domestic operations. The activities of the NNPC are coordinated under its 12 subsidiary business units spread across its 7 operational divisions (Figure 7)

Figure 7: NNPC subsidiary units



NB: The colour coded units in the figure represent the main NNPC subsidiaries

Source: Author generated, inspired from NNPC website (NNPC, 2020)

Figure 7 was developed by the author using information gleaned from NNPC website describing the various operational units of the NNPC along its 7 divisions. However, Duke Oil and Hyson were not placed under any unit on the website.

Table 4 presents the acronyms of these main subsidiaries.

Table 4: Meaning of NNPC Subsidiaries Acronyms.

NPDC	Nigerian Petroleum Development Company
NGC	Nigerian Gas Company
PPMC	Products and Pipelines Marketing Company
IDSL	Integrated Data Services Limited
NETCO	Nigeria Engineering and Technical Company
HYSON	Hydrocarbon Services Nigeria Limited
WRPC	Warri Refinery and Petrochemical Co. Limited
KRPC	Kaduna Refinery and Petrochemical Co. Limited
PHRC	Port Harcourt Refining and Co. Limited
NNPC Retail	Nigerian National Petroleum Corporation Retails
NAPIMS	National Petroleum Investments and Management Service
DUKE OIL	Duke Oil trading

Source: NNPC, 2018 and NNPC, 2020

The most relevant subsidiaries of NNPC to this study include the three refineries – PHRC, WRPC, and KRPC. In terms of its operations across the energy supply chain, the organisation has the Nigerian Petroleum Development Company (NPDC) at the upstream, the Pipeline and Products Marketing Company (PPMC) at the midstream and the refineries together with NNPC Retail at the downstream sector.

The matrix shown in Table 5 depicts the location of Nigeria’s NNPC within the international oil and gas industry ownership structure.

Table 5: Matrix for industry ownership structure

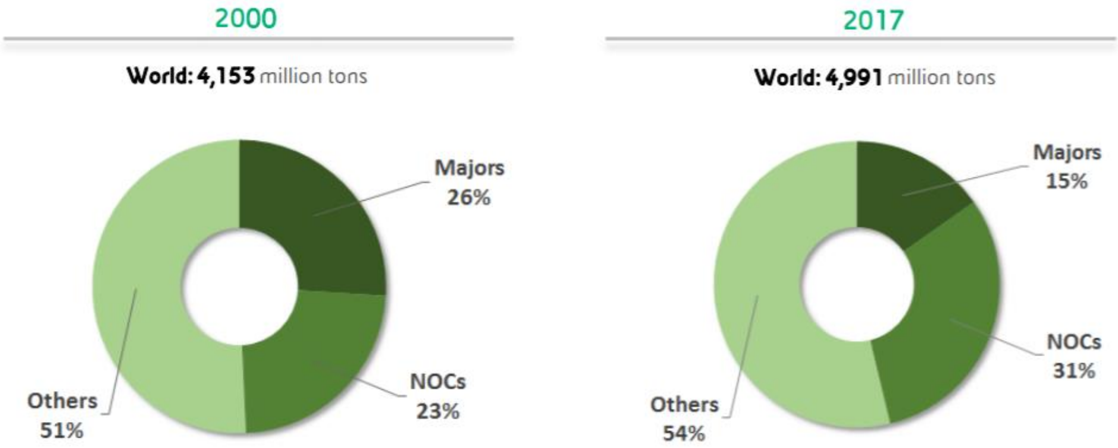
	Public Company	*State-Owned*	
Integrated	Shell, BP, Total, Chevron, Lukoil etc	Saudi Aramco, Petrobras, Petronas, Equinox, Gazprom, Rosneft, CNPC, Sinopec	*International Operator*
	Most Integrated companies operate internationally	**NNPC,** SONANGOL, Qatar Petroleum, Pemex, NIOC	*Domestic Operator*
Independent	Marathon, ConocoPhillips, Apache	Independent oil companies are usually publicly incorporated.	*International Operator*
	Philadelphia Energy Solutions, PBF Energy, Motiva Enterprises	Independent oil companies are usually publicly incorporated.	*Domestic Operator*

Source: Author generated

2.2.4 Changing Trends.

Traditionally, the petroleum industry had been dominated by *Integrated* oil and gas companies, and in particular by a handful of supermajors (largest publicly traded oil corporations in the industry by revenue) from the West, mainly Shell, Chevron, BP, Total, ExxonMobil, ConocoPhillips, and Eni (Gary et al. 2007; Stacey and Crooks, 2016). These companies (except for Eni) refined nearly all the oil products in the US before 1980 (World Oil Review, 2018). However, the operating model of the global oil refining industry has undergone significant changes in the past four decades, giving rise to a more diverse and diminished ownership structure. For example, in the US, the percentage of refined oil products under the control of *Independents* rose from 51% in 1990 to 64% in 2005. Also, the role of Majors (large publicly traded oil corporations) in crude oil refining is shown to have shrunk from 26% in 2000 to 15% in 2017 (Figure 8). While the percentage of refined oil products for Independents have grown from 51% to 54%, and that of National Oil Companies (NOCs) have also risen from 23% to 31% respectively for the same period as shown in Figure 8 (World Oil Review, 2018).

Figure 8: Global crude refining proportions for NOCs, Majors, and Independents (Others)



Source: World Oil Review, 2018

The foregoing indicates that the role of NOCs in global crude oil refining is on the increase alongside that of *Independent* corporations as opposed to the decline of *Integrated* corporations in crude oil refining. This is consistent with the assertion of Hartley and Medlock (2008) that NOCs appear to have a growing control of the global oil and gas value chain. Unfortunately, Nigeria's NOC - NNPC, is clearly not a part of this global trend. The reason for this derives mainly from NNPC's unimpressive performance in the downstream sector, which is discussed in more detail in Sections 2.3 – 2.4.

2.2.5 Nigeria – Country Profile

Nigeria is located in West Africa with an estimated population of about 206 million persons, making it the most populous nation in Africa and the seventh largest in the world, only behind China, India, US, Indonesia, Pakistan, and Brazil (The World Bank, 2020). With a land mass of 923,768 sq. km, the country has a population density of 215 inhabitants per square kilometre - the sixth most densely populated in Africa. According to Awuzie and McDermott (2019), Nigeria's population make up about 47% of the entire sub-Saharan Africa's population. Geographically, Nigeria is bounded in the Northeast by Chad, in the East by Cameroun, in the West by Benin Republic and in the North by Niger Republic as shown in Figure 9 (Campbell and Page, 2018).

Figure 9: Political map of Nigeria

Source: UN Cartographic Section

Nigeria also has a coastline of 853km in the Gulf of Guinea, which abuts the Atlantic Ocean. More than 50% of this coastline (450km) bounds the Niger Delta region, which contains more than 90% of Nigeria's oil deposits (Egberongbe et al., 2006 and Awuzie and McDermott, 2019), and the country overall.

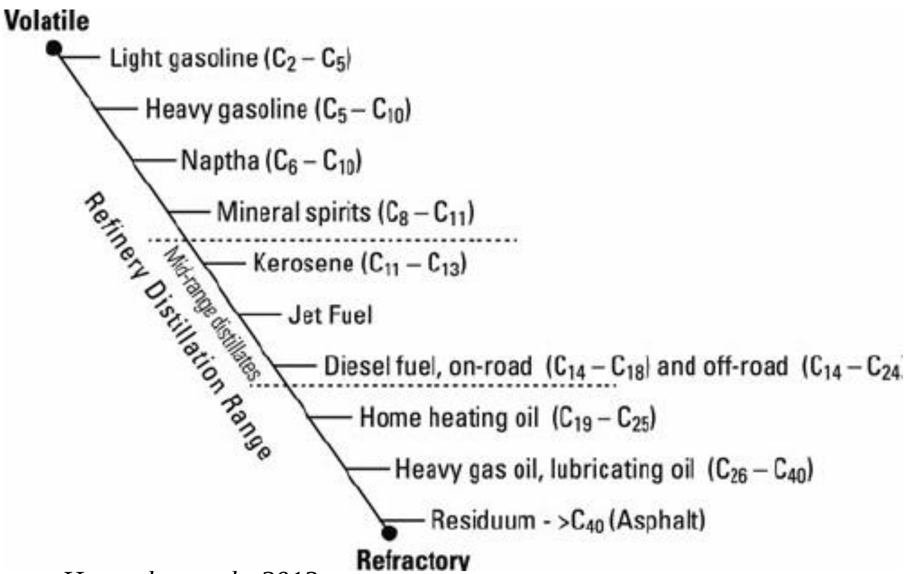
Nigeria is blessed with significant proven reserves of crude oil and natural gas, about 37 billion barrels of oil and 187 trillion cubic feet (tcf) of natural gas as of 2019 (Zabbey, Giadom and Babatunde, 2019). The Nigerian economy is essentially dependent on oil, which generates more than 90% of its foreign earnings. With a GDP of about US $450bn, the country is amongst the top 25 largest economies of the world (Campbell and Page, 2018). Despite the abundance of oil resources, the country still grapples with significant levels of poverty with about 40% of its citizens living below the country's poverty line of US $381.75 per year (World Bank, 2020). This implies that greater percentage of the country's population would be living below the United Nations' poverty line of US $693.50 per year (UN Reports, 2021).

The social imbalance where wealth is concentrated on a few hands while the majority of the population struggle, often breeds tension and strife in the country. Consequently, Nigeria's oil and gas sector has often experienced aggressions from disgruntled youths, especially in the impoverished Niger Delta regions (Ikelegbe, 2005/2006; and Arowosegbe, 2009). Some of the challenges brought about by these grievances are presented as part of the social factors affecting the refineries as indicated in Section 2.4.3 of this study.

2.2.6 An oil refinery and its operations

An oil refinery is essentially a complex petrochemical processing plant which takes in crude oil as an input and converts it to outputs of various usable petrochemical products. These products may be classified as *Light distillates* such as Liquefied Petroleum Gas (LPG), Premium Motor Spirit (PMS) or gasoline, naphtha, and petroleum gases (methane and ethane); *Middle distillates* such as Dual-Purpose Kerosene (DPK), jet fuel, Automotive Gas Oil (AGO) or diesel; and *Heavy distillates* such as lubricating oils, heavy fuel oils, wax and asphalt as shown in Fig 10 (Hostettler et al., 2013; Cross et al., 2013 and Gary et al., 2007).

Figure 10: Refinery Distillation Range



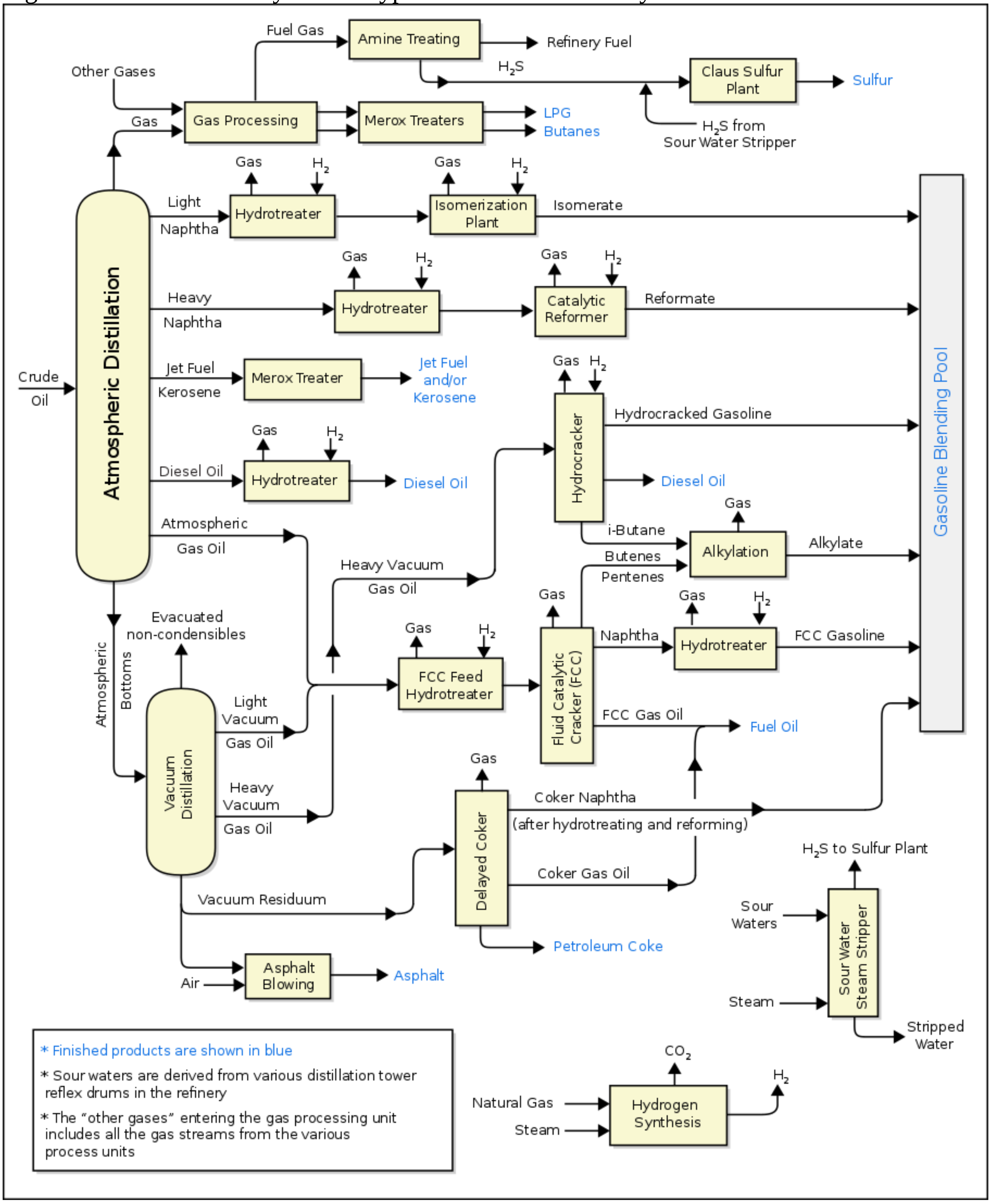
Source: Hostettler et al., 2013

Duffuaa and Ben-Daya (2004) report that refineries are usually operated on a 24-hourly basis for 365 days in a year until there is a need for a partial or total shutdown due to maintenance operations, which is usually done every 24-36 months of continuous operation. Practically, the production capacity of oil refineries is measured in either barrels per stream day (BPSD) or barrels per calendar day (BPCD). According to Gary et al. (2007), BPSD measures the capacity, which a refinery can process while in 24-

hour continuous operation; whereas the BPCD measures the capacity the refinery can process in a given year divided by the number of days in the year irrespective of downtimes. BPSD is usually a few percentage points higher than the BPCD and is usually the measure referenced to when barrels per day (bpd) is stated for an oil refinery. Johnston and Johnston (2006), claim that oil refineries become profitable at capacity utilisations above 80%. Most refineries in the US, Western Europe and Northeast Asia operate above or near 90% capacity utilisations, making them the most profitable refining hubs outside the Middle East (Johnston and Johnston, 2006). In contrast, Iheukwumere et al. (2021) report that average capacity utilisation of NNPC refineries has been below 20% since 2013.

Considering that the configuration of every refinery is unique, it is reasonable to outline the basic components of a typical modern refinery (see Fig 11).

Figure 11: A schematic layout of a typical modern oil refinery



Source: Beychok (2007)

The figure 11 shows the process flow diagram of an oil refinery. It is important to note that while all the NNPC refineries have most of the units shown in Fig 11 in varying layouts, none has a coking unit as shown. Some of the main components of an oil refinery alongside their functions are summarised Table 6.

Table 6: The main process units for an oil refinery

Process Units	***Functions***
Crude Distillation Unit (CDU)	This unit is also referred to as Atmospheric Distillation Unit (ADU) and is virtually the first process unit of all refineries where the incoming crude oil is distilled into various fractions of different boiling ranges, which are then processed further in other process units.
Vacuum Distillation Unit (VDU)	This is the unit where the heavier residue oil at the bottom of the CDU is further distilled into purer petroleum products to increase the product yield.
Hydrotreating Units	This can be Diesel-hydrotreating, Naphtha-hydrotreating or Kero-hydrotreating units. It is essentially the unit where hydrogen is used to remove sulphur (desulfurize) from the incoming product fractions from the CDU or other process units.
Fluid Catalytic Cracking Unit	This is one of the most important conversion process units in every refinery. In fact, it has been referred to as the heart and soul of every modern refinery (Johnston and Johnston, 2006). Its purpose is to convert the heavier fractions of crude oil (under the action of heat and catalyst) into the lighter fractions to obtain the more valuable products such as PMS (gasoline) and other products.

Source: Gary et al. (2007); Cross et al. (2013) and Johnston and Johnston (2006)

Table 6 was made from information obtained from Gary et al (2007), Cross et al. (2013) and Johnston and Johnston (2006) and shows the main components of the process units found in a typical conventional refinery like the NNPC refineries. Johnston and Johnston (2006) note that some oil refineries typically have more configurations of process units than others. The level of complexity of a refinery is related to the process technologies present at the facility. Refineries can range from simple hydro-skimming plants that produce mostly diesel and atmospheric residue to the most complex coking plants that produce a wide range of RPPs with little or no residue (Gary et al., 2007). Aside from the first Port Harcourt refinery (PHRC-I) which is a simple hydro-skimming plant, the other three NNPC refineries (WRPC, KRPC and PHRC-II) are complex cracking refineries. Section 2.3.4 outlines these differences.

2.2.7 Nelson Complexity Index (NCI)

The factor for measuring the complexity of an oil refinery is the Nelson Complexity Index (NCI). According to Johnston and Johnston (2006), the NCI provides a reliable measure of the relative construction costs of an oil refinery. Developed by Wilbur Nelson in 1960, the NCI quantifies the relative construction cost of the components of an oil refinery by comparing the cost of its various upgrading units to the cost of the distillation unit. Essentially, the NCI uses a scale of 1-20 (old reports) to measure the sophistication of an oil refinery, where the more complex refineries with higher values on the scale possess the capacity to produce more valuable products from the lowest quality crudes (Nelson, 1976 and Johnston and Johnston, 2006). Table 7 shows the generalised NCI for refinery equipment.

Table 7: The Nelson complexity Index for oil refinery equipment

Unit	NCI (1998 Reports)	NCI (Older Reports)
Distillation capacity	1.0	1.0
Asphalt	1.5	1.5
Vacuum distillation	2.0	2.0
Thermal processes	2.75	5.0
Catalytic hydrorefining	3.0	3.0
Catalytic reforming	5.0	5.0
Catalytic cracking	6.0	6.0
Catalytic hydrocracking	6.0	6.0
Alkylation / Polymerization	10.0	10.0
Oxygenates	10.0	10.0
Aromatics / Isomerisation	15.0	15.0
Lubes	60.0	10.0

Source: Adapted from Nelson, 1976, & Johnston, and Johnston, 2006

Typically, the higher the NCI of a refinery the more costly it is to build. Most refineries, including the NNPC refineries rarely publish their Nelson Complexity Index. However, given the known process units at each of the NNPC refineries (discussed in Section

2.3), it appears the PHRC-II and KRPC refineries would have much higher NCIs compared to PHRC-I and WRPC.

Another important way to classify refineries is by their mode of construction. In this regard, there are two main kinds: conventional and modular.

2.2.8 Conventional and Modular Refineries

A conventional refinery is a standard refinery facility built to fully process variable crude slate (different kinds of crude oil) into several different product yields. Usually built onsite, these types of refineries take substantial resources and time (usually 3+ years) to be completed (Gary *et al*., 2007 and Cross *et al*., 2013). Given their processing ability, they have higher profit margins (Singh, 2021). The capacity range of these refineries usually runs from 100,000 barrels to 1,000,000+ barrels. As such, it may take a relatively longer time for these refineries to break even since their development costs usually run into billions of dollars (PWC, 2017). Currently, the world's largest refinery - the Jamnagar refinery with a capacity of 1.24 million bpd, which is located in Gujarat, India and owned by Reliance Industries - is a conventional refinery (Ondrey, 2009).

On the other hand, a modular refinery is a crude oil processing plant that has been constructed entirely on skid mounted structures. Each structure contains a portion of the entire process plant, and through interstitial piping the components link together to form an easily manageable process facility (Cenam Energy, 2012). Modular refineries are ideal for providing a quick-fix solutions when there is an urgent need to adapt rapidly to local demand. This is because they can be built offsite in modules and transported to the site where they can be assembled. Singh (2021) reports that the main advantage of this kind of construction lies in the lower capital costs afforded by their speed and flexibility. As the capacity of modular refineries can range from 1,000 bpd up to 50,000 bpd, an average 20,000 - 30,000 bpd modular refinery is reported to cost between $180 – 250 million and may take between 12 - 18 months to build (PWC, 2017).

Essentially, while all NNPC refineries can be regarded as conventional refineries, two of the private sector-led refineries completed to date (2021) in Nigeria are modular refineries. These refineries include the 1000-bpd diesel refinery plant owned by Niger Delta Petroleum Resources and the 5,000-bpd diesel Waltersmith Petroman Oil refinery

(Bala-Gbogbo, 2020). Although efforts from private investors to boost local refined oil production in Nigeria have been hailed by the government and private sector alike, experts, believe these efforts are far from adequate and would hardly enable Nigeria to attain energy sufficiency (Oweh, 2018). The main reason for this challenge appears to be that there are hardly any modular Fluid Catalytic Crackers (FCCs). This is because these process units, which are mainly responsible for processing most of the demanded lighter product fractions such as PMS rarely comprise smaller modules. As such, smaller modular refineries in Nigeria can technically produce mainly diesel which is in much less demand in Nigeria compared to PMS. The implication being that more conventional refineries like the NNPC refineries, and the new Dangote oil refinery are necessary to ultimately solve Nigeria's petroleum product import problems.

2.2.9 Dangote oil refinery and other private refineries

According to Gupte (2019), the Dangote oil refinery is a private sector-led 650,000 bpd refinery and petrochemical complex being constructed on a 2,635 hectares site in the Lekki Free Zone area of Lagos State, Nigeria. The facility is owned by the Dangote Group and is reported to be the largest single-train (i.e., having only one crude distillation unit) refinery facility in the world and the largest refinery in Africa when completed. Construction of this facility commenced in 2013, with the refinery reported as expecting to cost an estimated US 12 - 14 billion dollars. When completed, the refinery should enable Nigeria to attain refined product sufficiency with some potential for export (Reuters, 2018c)

However, one could argue that if the large Dangote refinery was to come on-stream, Nigeria may no longer need the NNPC refineries. The question then becomes: what capacity can the refinery bring on-stream at start-up and how many years would it take the new refinery to attain full capacity? Gary et al. (2007) notes that no refineries come on-stream with immediate maximum production at start up. This means that it normally takes time for a new refinery to hit its full capacity from commencement of operations. This then raises the question for Dangote of what would be the future consumption figure for refined petroleum products in Nigeria when the plant attains full capacity? Various projections done by industry experts, such as PWC (2017), show that Nigeria has the market to absorb more petroleum products due to its ever-growing population and energy demand and can potentially become the refining hub for West Africa by 2030. This postulation is also supported by a McKinsey study (2019) that refineries in developed countries of Europe and North America are confronted with increasing stringent environmental compliance requirements with the potential for a 0.3% per annum decline in operations. Whereas refineries in developing countries of Africa, Latin America and Asia are increasingly adding new capacities and will continue to do so at a rate of about 2% per annum up to 2035 and beyond. In fact, Nigeria's actual demand growth rate for refined petroleum products is estimated at 3% per annum based on past trends (Ogbuigwe, 2018). In addition, PWC (2017) observes that there is a significant market gap for refined petroleum products (RPPs) across West Africa in the amount of 39 billion litres per year (more than 245 million barrels per year), which the region fills with imports from Europe and the Middle East. This implies that if Nigeria attains excess capacity, there is sufficient market within neighbouring African countries for the export of these RPPs, which will yield more economic value and benefits for the nation. This is especially true considering that Nigeria's RPPs are partly being smuggled to help supplement the supply shortfalls for these countries. The potential benefit for exporting RPPs from Nigeria will equally benefit the smaller private companies in Nigeria building small-scale (mostly diesel) modular refineries. This is due to more demand for the products in neighbouring African countries.

Ideally, it is reasonable to expect a market glut that will affect prices, if the production of refined oil in Nigeria is not managed, especially given the growing global calls for alternative fuels. The implications for extra capacity of refined petroleum products (RPPs), including their management in Nigeria, when achieved, is discussed in Section 2.6.

2.2.10 Valuation of oil refineries

Given that this study is focused on the improvement of Nigeria's state-owned refineries, it would be essential to provide an approximate estimate of the economic value of these assets to justify their national importance. Johnston and Johnston (2006) noted that providing the valuation of oil refineries can be difficult as most refining and marketing operations are often part of an integrated company with limited disclosure of segment data. In addition, while a few refineries may change hands each year, it is not often common for oil refineries to be sold. However, Johnston and Johnston (2006) further indicated that it is more convenient for marketing analysts to estimate refinery values based on prices paid per stream day barrel capacity. Considering that Shell sold its

156,400-bpd Martinez California oil refinery for US $960 million to PBF Energy in February 2020, analysts point that this sale represented a refining asset price of about US $6000 per daily barrel capacity (Seba, 2020). Similarly, the sale of El Paso's 315,000-bpd refinery to Valero at US $315 million in 2004, represented a price of US $1,159 per daily barrel (Energy Intelligence, 2004). Given that refinery sale values can vary with time and location, including the fact that Nigeria has not sold any refineries previously, it may be difficult to correctly estimate the value of the NNPC refineries. However, using the most current data of $6000 barrel per stream day capacity for the Martinez Refinery and ignoring other variations, the 60,000-bpsd PHRC-I would be worth about US $360 million, while the 150,000-bpsd PHRC-II would be worth about US $900 million. Whereas the 110,000-bpsd KRPC would be worth an estimated US $660 million, and the 125,000 WRPC would be worth about US $750 million. Based on these estimates, the total value of the NNPC refineries would be worth $2.67 billion. This implies that the current US $1.5 billion loan raised by the Nigerian government to refurbish the PHRC (I and II) appears to be over-budgeted (Onuah, 2021). It can also be argued that given the total value of these assets, it would be more economical to refurbish these facilities on their existing locations re-using components that are still fit for purpose to provide fully functional refineries.

Based on the foregoing, it is imperative at this point to fully review the current state of Nigeria's State-owned refineries.

2.3 The Nigerian state-owned refineries – a summarised history

Nigeria has four refineries owned by the federal government and operated by its National Oil Company, the NNPC. The refineries include: The Port Harcourt Refining and Petrochemical Company (PHRC-I and PHRC-II), Warri Refining and Petrochemical Company (WRPC), and Kaduna Refining and Petrochemical Company (KRPC). The process technologies of these refineries range from simple to very complex configurations such as topping refineries, hydro-skimming refineries, cracking or conversion refineries and coking or deep conversion refineries (Atris, 2020). A brief overview of each of these refineries is necessary to understand their resource contributions and situations.

2.3.1 Port Harcourt Refinery I (PHRC-I)

The Shell-BP consortium built the first oil refinery in Port Harcourt, Nigeria using a consortium of several British and American contractors (Turner, 1977). The option to build a refinery was initially awarded to Shell-BP as part of the terms of their Oil Prospecting License awarded in 1954 from the colonial government in Nigeria (NPRC, 1966). According to Turner (1977), this agreement was updated in 1958 with a thirty-year Oil Mining Lease (OML) awarded to Shell-BP to commence the refinery when the company's daily oil production reached 10,000 b/d. The establishment of the refinery was favoured by both the company and the new Nigerian government, which came into office in 1960. This is because the investment would not only put Nigeria on a new developmental course but also save the nation some $40 million ($364m in 2020, Bank of England rates) in foreign exchange due to refined petroleum products being imported at the time (Turner, 1977 and Pearson, 1970).

Global developments post second world-war, especially from the early 1950s up to the 1960s, saw a boom in refinery construction as countries tried to rebuild their economies. In developing countries, this drive was further fuelled by competition from smaller oil companies against the more established majors in order to gain entry into new markets (Iheukwumere et al., 2020). In addition, as more African countries gained independence, Turner (1977) noted that the appeal to own large public assets and infrastructure such as airports and refineries was quite significant. Hence, there was a willingness from these governments to liaise with relevant companies to achieve their developmental objectives. The ensuing economic upheaval forced a shift in the business strategy of the established majors which seemed to have a more relaxed approach of building refineries only near major markets with subsequent export to underdeveloped small African markets. Combined with the push from the more aggressive smaller companies such as the Italian Eni, the majors began to build smaller refinery plants in Africa to retain their interests in the smaller but resource-rich African markets (Turner, 1977 and Herman, 1974).

The earliest and most comprehensive account for the details of the transaction between Shell-BP and the newly formed Nigerian government in 1960 was presented by Turner (1977). Hence, the construction of the first Port Harcourt refinery was eventually commenced after a service agreement was signed by the federal government and Shell-

BP in 1962 allowing the company to coordinate the construction works through a series of bids involving various international construction companies. Subsequently, the refinery was commissioned in 1965 and became Nigeria's premier oil refinery with initial ownership stakes of 50% to the Nigerian government and 25% each to Shell and BP.

The cost of the project was about US $28.6 million ($252m in 2021, Bank of England inflation rates) with an initial capacity of 38,000bpsd (Turner, 1977; NNPC, 2018 and Wapner, 2017). Presently, this facility is commonly referred to as the old Port Harcourt refinery (PHRC-I). The refinery was later expanded to increase its capacity up to 60,000bpsd in 1973. This increment was to accommodate the growing domestic demand in Nigeria for refined oil (Kahn, 1994 and Wapner, 2017). PHRC-I is co-located with the new Port Harcourt refinery (PHRC-II) at Alesa-Eleme and has been mostly inoperative since the year 2001 due to maintenance issues (NNPC ASB, 2001 – 2018). Fig 12 shows some areas of the PHRC-I facility.

Figure 12: Some pictures of Port Harcourt refinery

Source: Vanguard Nigeria, 2017

Ogbuigwe (2018) notes that the PHRC-I was completely acquired by the Nigerian government in July 1979, through an outright buyout. Hence, the refinery inherited a new management structure led by the government. This development in combination with the growing demand for refined petroleum products in the country led to invitations by the government for bids from international petrochemical construction companies to build more refineries in Nigeria (Atumah, 2016; and Turner, 1977).

2.3.2 *The Warri Refinery (WRPC)*

The Warri refinery (WRPC) was the first refinery in Nigeria to be built under full government ownership. Unlike the PHRC-I, the project for the construction of Warri refinery was awarded by the federal government of Nigeria to the Italian construction company, Snamprogetti in 1975 (Wapner, 2017). The intention of the government was to increase the production of motor oil for Nigerian consumption and to meet the growing need for other RPPs in the country. The project was a semi-packaged contract using a six-man project team and the French BEICIP (French Petroleum Institute's Bureau of Industrial Studies) as consultant advisories to act on the government's behalf from site selection through a range of licensing and technology issues to contractor selection. After deciding on the general design of the refinery, the consultants commenced a tendering process to choose a contractor for the construction of the main refinery plant. With the project team supplying the philosophy and BEICIP in charge of developing the detailed tender documents, Turner (1977) notes that invitations for bids were eventually trimmed down to three companies out of the 20 that prequalified for the contract. This was due to the companies' willingness to use a fixed-term contract over the cost-plus that others preferred (Tanzer, 1969). Eventually, the award went to the Italian company, Snamproghetti, for the design, procurement, and construction of a new 100,000 bpsd capacity refinery at an initial cost of $285 million. According to Turner (1977), this cost later escalated to $478 million due to changes to add a catalytic cracking unit (CCU). In 1978, Snamproghetti successfully completed the project, and the plant was commissioned by the federal government in the same year (Turner, 1977; NNPC, 2018).

Chima et al. (2002) and Turner (1977) agree that the knowledge and experience gained by the federal government and some Nigerian engineers from the first Port Harcourt refinery (PHRC-I) helped shore up the ability for Nigerians to fully manage the setup of the Warri refinery. Also, the growing revenue from the sale of crude oil, which by then had risen to 95% of Nigeria's total revenue provided a significant financial boost for Nigeria to embark on this project with plans also made for similar future projects at the time (Tanzer, 1969 and Herman, 1974).

The 100,000 bpsd Warri refinery, which was built to be supplied by crude oil pipelines from Escravos was subsequently expanded in 1987 to process 125,000 bpsd in order to help meet the growing demand for RPPs in Nigeria (Ogbuigwe, 2018; NNPC, 2018b; Wapner, 2017). Much later (1988), a merger with the neighbouring Ekpan Petrochemical plant through a business incorporation officially led to the present name change of the facility to Warri Refining and Petrochemical Company (WRPC) (NNPC, 2020).

With its catalytic cracking unit, the Warri refinery may be regarded as a *complex cracking refinery* that produces PMS, Kerosene (Domestic/Aviation), AGO, LPG, Polypropylene Pellets (Nipolene) and Carbon Black Pellets. After the 1987 capacity expansion, the refinery continued to function at near-optimal capacity (above 70%) until 1991 when it started experiencing production cuts due to a lack of maintenance (NNPC 2018b and Wapner 2017).

Recently, the refinery has experienced significant production interruptions due to several challenges arising from attacks on its crude oil supply pipelines and frequent plant breakdowns due to mismanagement (Wapner, 2017, and Akinola 2018). As such, since 2019, the refinery has been on a shut down for an ongoing maintenance operation.

2.3.3 The Kaduna Refinery (KRPC)

The federal government of Nigeria awarded the Kaduna refinery project in 1976 to Chiyoda Engineering and Construction Company of Japan. The project was awarded at the cost of $525m for a 36-month duration (Wapner, 2017). According to NNPC (2019), the project comprised of two distinct plants – a 50,000-bpsd Fuels plant and another 50,000-bpsd Lubes plant, altogether making a 100,000-bpsd capacity refinery and was completed in 1979. Later in 1987, the refinery was expanded at the Fuels plant from 50,000 to 60,000 bpsd, making the overall capacity of the facility 110,000 bpsd. This was also done to match the growing demand for petroleum products in Nigeria (Ecowas, 2007, and Wapner, 2017).

The Kaduna refinery was designed to be supplied by a crude oil pipeline from Escravos via Warri (Ogbuigwe, 2018). The refinery produces regular fuels as well as lube oils for lubrication. It is important to note that it was the production of lube oils that led Nigeria to import heavy crudes as raw materials from Venezuela in 1982 (Atumah, 2016). This is because, unlike the Nigerian light-sweet crude, which is ideal for producing the more desirable regular fuels, the heavy Venezuelan crude was more suited to produce lubricating oils, waxes, and asphalts. According to Wapner (2017), this arrangement was, unfortunately, short-lived mainly due to the inability of low asphalt prices to justify the cost of production.

However, the location of Kaduna refinery in the northern part of Nigeria, far away from the oil-producing South, was criticised as an unnecessary political strategy by the government to please northern Nigeria, despite constituting a waste of resources (Ogbuagu, 1985; Ekwe-Ekwe, 1985; Owojori, 2011). This criticism obviously stemmed from the considerable amount of money invested in constructing oil pipelines (about 600km) from the Southern part of the country (Escravos near Warri) to the Northern region (Kaduna), which could have been avoided if the facility were sited in southern Nigeria. This is a clear contradiction of Weber's theory of industrial location, which recommends the location of industries where the cost of their raw material transportation is a minimum (Weber, 1982; and Ogbuagu, 1985). Hence it appears this was a political decision with potential consequences on productivity. As such, the need to supply crude oil to KRPC via pipelines running from south to north, has created several vulnerable points of attack along the pipeline route for vandals (Eboh, 2010).

The Nigerian government, on the other hand defends their position for building the Kaduna refinery as a strategic way of ensuring an effective distribution of petroleum products across the country in a timely and efficient manner (KRPC, 2015; McCann and Sheppard, 2003). This objective seems to be quite well-intentioned. Regrettably, the difficulties experienced over the years with transporting crude oil to KRPC via pipelines seem to defeat this objective and tends to justify the position of its critics.

It is, however, important to note that presently (2021), KRPC does not process any crude due to a shutdown for a maintenance pre-inspection (Iheukwumere et al., 2021).

2.3.4 The Port Harcourt Refinery II (PHRC-II)

The award for the second Port Harcourt refinery was driven by a federal government initiative conceived in 1985 to export refined petroleum products from Nigeria (Atumah 2016). Wapner (2017) notes that the project was awarded to a consortium of JGC & Marubeni Corporation of Japan and Spie Batignolles of France at the cost of \$850m (\$2.195B, in 2021). It was completed in 1989 and became the most modern and largest refinery facility in Nigeria with a capacity of 150,000-bpsd. Production from this plant created a surplus capacity in Nigeria, allowing the export of refined petroleum products for the first time in 1991 (Ogbuigwe, 2018). By 1992 the country had made about US $280m from the export of RPPs alone (Atumah, 2016 and Akinola, 2018). This achievement was, however, short-lived due to production cuts from Warri and Kaduna refineries, which necessitated the redistribution of production from Port Harcourt refinery to other parts of the country rather than continuing to export these products.

PHRC-II is a *complex cracking refinery* comprising of four process areas each of which houses different process technologies. The refinery produces a wide range of RPPs such as LPG, Kerosene (aviation and domestic), PMS, AGO and HPFO (NNPC, 2018). Presently, PHRC-I and PHRC-II are run together as a single entity under the name, Port Harcourt Refining and Petrochemical Company Ltd and are supplied by crude oil pipeline from Bonny (Ogbuigwe, 2018). The capacity utilisation of PHRC-I and PHRC-II have remained below 25% since 2016 (NNPC ASB, 2016 – 2020). Table 8 summarises the process technologies of the NNPC refineries.

Table 8: Refinery classification based on complexity and process technologies.

Complexity	Refinery Types	Process Technology	Type of output products	
Simple	Topping	Atmospheric Distillation (AD)	Naphtha and middle distillate fuels	PHRC-I
Simple	Hydro-Skimming	AD + Catalytic Reforming	PMS or gasoline	PHRC-I
Complex	Cracking Refinery	AD + Vacuum Distillation & Catalytic Cracking	Light and middle distillates such as jet fuels, heating kerosene and gas and diesel oils	PHRC-II, WRPC and KRPC
Very complex	Coking Refinery	AD + Residue Destruction	Light, middle & heavy distillates (PMS, Kerosene, diesel, jet fuels and heavy fuel oils).	Currently, no govt-owned refinery in Nigeria has this level of complexity

Source: Author generated, inspired from Gary et al., 2007.

Table 8 shows the classification of oil refineries from Gary et al (2007) and where each of the NNPC refineries fall under these classifications. As such, the Table indicates that PHRC-I is a simple hydro-skimming refinery, while PHRC-II, WRPC, and KRPC are complex conversion refineries with catalytic cracking units. None of the refineries are of the very complex coking configurations. The construction details of the NNPC refineries are summarised by Table 9.

Table 9: Project details for the construction of Nigeria's refineries

Refinery Name	Location in Nigeria	Initial Capacity	Expanded Capacity (bpsd)	Award Date	Completion Date	Construction Company	Cost of Project Award (USD)	Remarks
Port Harcourt Refining and Petrochemical Company I (PHRC I)	Port Harcourt, Rivers State	38,000	60,000 (*Expanded in 1973*)	1962	1965	Procorn Ltd, George Wimpey and Taylor Woodrow, Lloyds' Examiners & Surveyors	$39.6 M ($336M in 2021)	Built by a private consortium of Shell-BP to provide domestic supply
Warri Refining and Petrochemical Company (WRPC)	Warri, Delta State	100,000	125,000 (*Expanded in 1985*)	1975	1978	Snamproghetti	$478 M ($2.46B in 2021)	Built to increase domestic production of PMS
Kaduna Refining and Petrochemical Company (KRPC)	Kaduna, Kaduna State	100,000	110,000 (*Expanded in 1985*)	1976	1979	Chiyoda Engineering & Construction Company	$525 M ($ 2.56B, in 2021)	50,000 b/d regular fuels and 50,000 b/d lubricating fuels, waxes, and asphalts
Port Harcourt Refining and Petrochemical Company II (PHRC II)	Port Harcourt, Rivers State	150,000	Not Applicable	1985	1989	A consortium of JGC Corporation & Marubeni Corporation of Japan and Spie Batignolles of France	$850 M ($2.195B in 2021)	Built to create adequate local capacity which also paved room for export capacity which was achieved for only two years (1991 to 1993). It was short-lived due to production cuts arising from Warri and Kaduna refineries.
						Total (2021 est. val.)	**$7.551B**	

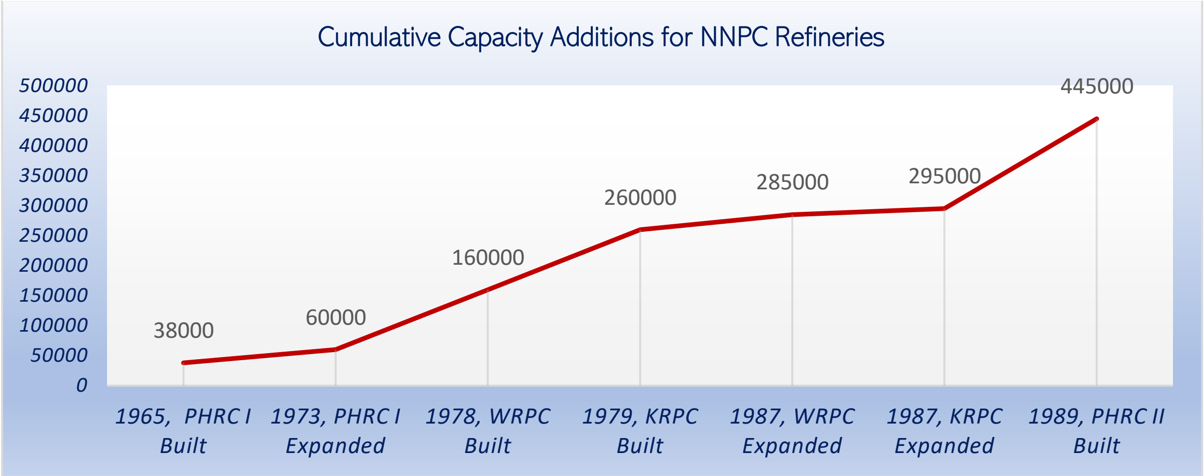
*Source: Author generated, combined from data from Turner, 1977 and Wapner 2017 * Inflation calculated using Bank of England rates*

It can be observed (Table 9) that none of the construction companies that built these refineries are of Nigerian origin. This reflects the apparent lack of technical skills for the construction of refineries in Nigeria. Although no Nigerian company presently has the technology to build refineries, the operations of NNPC refineries over the years has led to the acquisition of the operational know-how for running refineries by Nigerians. Consequently, all NNPC refineries are currently run by Nigerian engineers, technicians and administrators trained by expatriates both locally and internationally (Chima et al., 2002; Wapner, 2017; Turner, 1977). It may be difficult to benchmark the level of expertise of Nigerian engineers to their established western operators regarding refinery operations. This is mainly due to the fact that the NNPC refineries still run on relatively outdated technology compared to most European and American refineries with significant technology upgrades (Wapner, 2017 and UKPIA, 2018).

As such, it is important to note that although, Nigerians are yet to fully develop the capability to completely and independently man their oil and gas operations from upstream to downstream, much knowledge has been acquired by the locals over the years through the various local content development policies initiated by the government, in which international oil companies (IOCs) are mandated to train and employ the locals in certain technical areas of the industry (Heum et al., 2003 and Balouga, 2012). In addition, Wapner (2017) and Chima et al., (2002) acknowledged that more Nigerians have also received training through government-sponsored programs such as the Petroleum Technology Development Fund (PTDF), Niger Delta Development Commission (NDDC) and others, in which the best talents from the universities are regularly sent abroad on scholarships to receive trainings in technical fields for subsequent employment in Nigeria’s oil and gas sector.

Clearly, the foregoing brings some major observations to notice. After the construction of the first Port Harcourt refinery (PHRC-I), the government built additional refineries successively from 1978 to 1989 to meet the growing need for domestic supply of RPPs. During this time PHRC-I was essentially nationalised, and this raised the cumulative capacity of NNPC refineries over the 24-year period to 445,000bpsd (Fig. 13).

Figure 13: Cumulative capacity additions for NNPC refineries, 1965 - 1989



Source: Author generated

This capacity has remained the same from 1989 till date without further additions, despite growing demand. Although, Nigeria's indigenous private organisations have begun to make strides to boost local capacity, Iheukwumere et al. (2020) note that these efforts have met significant challenges, which have delayed their progress.

The challenges faced by the NNPC refineries have been well documented by various scholars. Turner (1977) outlines the implications of technological know-how and government ownership on refinery operations; Iwayemi (2008) documents the policy issues that underlie the poor performance of Nigeria's downstream sector. Eti et al. (2006) examined the implications of poor maintenance culture across the NNPC refineries. Badmus et al. (2012) investigated the efficiency of energy consumption profile for PHRC against recommended standards. Ogbuigwe (2018) outlines the challenges and prospects of NNPC refineries. Ikelegbe (2015) examined the impact of youth restiveness and struggles for resource control in the Niger Delta on oil infrastructure in the area as well as on the national economy. The outcomes of these studies, as indicated in Sections 2.9 are found to touch on political, economic, social, technical, environmental, and legal (PESTEL) issues.

In the context of this study, political factors (P) imply the various forms of government interventions, applicable national legislations, expert regional projections, and outlook as well as identified political factors from published sources, which directly or indirectly impact on the refineries. Economic factors (E) involve the macroeconomic conditions, such as project costs and expectations, competing factors for government resources and their implications on the refineries' performance. Social factors (S) include the various social, cultural, behavioural, and other demographic factors of the external environment which bear direct or indirect consequences on the refineries' performance. While technical factors (T) refer to the various technologically related activities, infrastructures, training, skills, including gaps in local capacity, which present challenges to the refineries' operations. Environmental factors (E) involve the various environmental impacts that result directly from the operations of the refineries, including associated activities of illegal/artisanal refineries encouraged by the sub-optimal performance of NNPC refineries. Legal factors (L) refer to the various legislative frameworks that apply to the refineries' operations. Some of these legal factors interweave with the political factors but efforts are made in this study to avoid their overlap with the identified political factors**.**

Further justification for the adoption of PESTEL framework to categorise these challenges and how it connects to the conceptual framework for this study is presented in Chapter 3 (Section 3.9).

2.4 Challenges faced by the refineries.

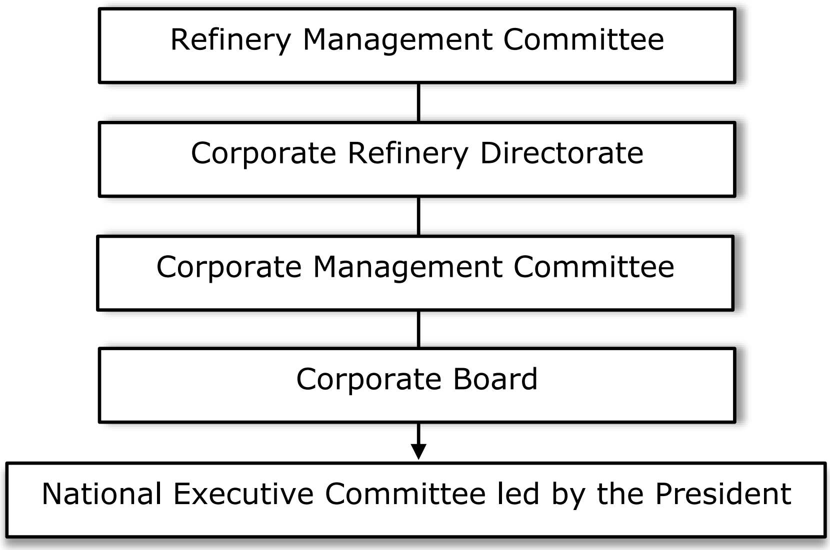
The possible challenges faced by the NNPC refineries can therefore be categorised under the following sections.

2.4.1 Political factors

The political challenges confronting the NNPC refineries stem from the management structure of the NNPC Group, which controls the affairs of the refineries. Ogbuigwe (2018), notes that there has been a significant shift from the initial management structure of the NNPC refineries to what it is presently. According to Ogbuigwe (2018), the refineries were initially set up to have full autonomy, which enabled them to run profitably and efficiently under the then Ministry of Finance Incorporated (MOFI) - an investment arm of the government. This arrangement appeared to have worked well as the refineries were able to manage their own affairs under the governance of a Board comprising professionals and a government representative all appointed by the federal government.

However, this situation suddenly changed in the early 1990s when the then Nigerian military government forced the NNPC to close its accounts in commercial banks and transfer them to the Central Bank. This marked a turning point in the management of the refineries as funding control was transferred to the government officials, giving room for corruption. Consequently, the refineries lost their autonomy and became subjected to the political interference of inexperienced government officials. Other scholars have noted that this change impacted on funding for maintenance and subjected the refineries to political indecisions stemming from unclear government policies from politicians who apparently lack the will to fix the refineries (Chima et al., 2002; Ambituuni et al., 2014 and Chikwem, 2016). In addition, Wapner (2017) and Ogbuigwe (2018) report that there exists a multi-layer of bureaucracy sometimes requiring the approval of up to 27 signatures within the NNPC Group and the federal government to sign off for a major maintenance operation across the refineries. These bureaucratic layers compound issues and unnecessarily prolong intervention times to respond to critical emergencies at the refineries. Figure 14 illustrates the management layers required to be navigated before an approval can be issued to carry out a major maintenance on the refineries.

Figure 14: Approval Committees for the NNPC refineries



Source: Author generated, inspired from Ogbuigwe, 2018

From Figure 14, it can be observed that the Refinery Management Committee must first weigh any requests for carrying out a maintenance for the refineries before passing it on to the Corporate Refineries' Directorate. This second body weighs the issues and sends it to the Corporate Management Committee who after giving a nod, passes it on to the Corporate Board before it gets to the National Executive Committee, where the final approval will be given by Nigeria's President. Otherwise, only smaller issues not exceeding N5m (USD13,000 in 2021), enough to replace a few valves and minor components, may be authorised by the refinery management (Interviewee number 2 (PHC-2), April 2019). Clearly, this condition is potentially one of the main factors limiting the performance of the refineries. As such, these factors were included on the research questionnaire for investigation.

Further literature search reveals, however, that this condition does not stand alone in limiting the performance of the refineries as they operate together with other factors to drive inefficiency. These discussions are developed further in the following sections (Sections 2.4.2 – 2.4.6).

2.4.2 Economic factors

The NNPC refineries are major economic investments of the government, intended to make profits and maximise the economic benefits from Nigeria's petroleum resources. Unfortunately, the poor performance of these refineries over the years have made it difficult for the government to reap its expected returns from these assets.

Gary et al., (2007) opine that building refineries is a capital-intensive undertaking, of considerable expense to its project sponsors. To understand the cost of NNPC refineries to the Nigerian government, it would be necessary to attempt presenting the cost of the projects in their present values. Although, the Nelson-Farrar cost index would have served a better means of estimating these figures, however, the inability to obtain the full components of the refinery equipment, makes it difficult to use this index. In place of this, an estimate of the present equivalent cost of the four refineries built from 1965 to 1989, is calculated using the Bank of England inflation calculator from each of the project award year to 2021 (Table 7). The cost sums up to be approximately US $7.5 billion. Even though, this figure appears to be much smaller than the overall cost of building such refineries today, it does provide an appreciation of the total expenditure of building such assets, thereby justifying the need to ensure the refineries do not become economic drains.

Ideally, operating the NNPC refineries on a profitable basis would necessitate selling the refined petroleum products (RPPs) in a free market environment, where prices would be determined by natural market forces. Unfortunately, the Nigerian downstream sector has long been under full government regulation, such that prices of RPPs are fixed by the government while the differentials are covered by oil subsidies (Akinola, 2018).

Ordinarily, this arrangement should present a variable cost for the government given that the cost of the differentials could either increase or decrease with time. Unfortunately, this is not the case as subsidy costs to the Nigerian government have consistently been on the increase growing from N349bn (US $918mn) in 2011 to N750bn (US $1.97bn) in 2019 (Mark, 2012; and Osae-Brown and Clowes, 2021). Chikwem (2016) opine that this increase is exacerbated by corruption, which encourages the responsible cabals to ensure that government efforts to revitalize the refineries continue to fail. Obviously, it would be difficult for government to continue to operate the NNPC refineries profitably under such conditions. Akinola (2018) and Wapner (2017) argue that subsidy issues in Nigeria also contribute to the erosion of profit margins across Nigeria's refining sector. Context discussions of petroleum subsidy in Nigeria and its impact on the downstream sector was presented in Chapter One – *Section 1.2.3*.

Other economic factors impacting on the performance of the refineries include poor exchange rates between the Nigerian Naira (N) and the dollar due to the disadvantage that Nigeria incurs from selling its RPPs at local currency (Naira) while it purchases its crude oil and related equipment in foreign currency (USD) (Akinola, 2018). Hence, small shocks in the local exchange rates exposes the refineries to more financial losses. For instance, the Nigerian Naira fell more than 25,000% from 0.77 Naira to the dollar in 1982 to 199 Naira per dollar in 2015 and more than 91% to 381 Naira per dollar as of December 2020 and has continued to depreciate even further since then (Wapner, 2017 and CBN, 2020). In addition, the operating capital for the refineries is on the increase (Iheukwumere et al., 2021), being compounded by other social problems such as pipeline vandalization as will be discussed in the subsequent section.

2.4.3 Social Factors

The social factors affecting the performance of NNPC refineries have multiple dimensions. These factors comprise the large-scale forces operating within cultures and societies, influencing people's feelings and patterns of behaviour (Marmot and Wilkinson, 2006). NNPC refinery operations in Nigeria have often been confronted with problems associated with social issues. Such problems include the regular attacks on crude oil pipelines conveying products to and from the refineries. The disruption caused by this incidence to the supply chain logistics of the refineries is estimated to be responsible for 53% of the refinery shutdowns as compared to 47% due to equipment breakdown (McKinsey, 2009). The scale of these attacks can sometimes lead to the total shut down of an entire refinery for a considerable length of time. For example, in 2001, NNPC GMD announced the temporary closure of Warri and Kaduna refineries for weeks pending the rehabilitation of the pipelines feeding the facilities as a result of a bomb explosion by militants on the trunk lines connecting the refineries (Oil and Gas Journal, 2001).

The fundamental causes of such hostilities have been widely debated. Okolo and Etekpe (2010) opine that unmet expectations of the indigenes of the Niger Delta from the companies operating in their environment, often fuel hostilities towards oil installations. This submission is consistent with the views of Edoho (2009) and Ekhator (2014) that despite the presence of some corporate social responsibility (CSR) projects in the Niger Delta, such as hospitals, markets, and school buildings; the impacts of such projects has fallen below the expectations of the host communities and therefore breeds tension in those communities. Whether it is the poor performance of the oil companies with regards to developing their host communities or the government that fails to hold up to their own bargain, remains an ongoing debate. However, there is evidence to suggest that corruption plays a huge role in this menace. For example, Akinola (2018) reports that some of the security personnel charged with the duty of protecting the oil and gas installations sometimes collude with the militants to perpetuate these crimes.

Another form of corruption that appears to compound social issues in the downstream sector is the reported collusion of some NNPC and State officials with corrupt agents in the private sector towards the hoarding and diversion of refined petroleum products (Akinola, 2018; Ehinomen and Adeleke, 2012). A policy change from the government targeted at the stakeholders involved in these practices would be necessary to achieve true reforms in this area. Such policies must also encourage transparency and accountability across the activities of the NNPC to be effective.

2.4.4 Technical factors

The complexity of an oil refinery makes its technical aspect very paramount. Studies show that technical issues constitute one of the most fundamental challenges of NNPC refineries (Iwayemi, 2008; Turner, 1977; Eti et al., 2006; and Chima et al., 2002). Eti, Ogaji and Probert (2006) suggest that the performance of NNPC refineries have been on the decline for years due to poor maintenance culture. The study reports that a reactive maintenance (to breakdowns) culture is prevalent across Nigerian industries, including the refineries. Similarly, Wapner (2017) acknowledged that poor maintenances practices contribute to the refineries' sub-optimal performance. Ideally, refineries are required to undergo scheduled turnaround maintenance (TAM) every 24 to 36 months of continuous operation (Duffuaa and Ben-Daya, 2004). TAM is a planned periodic shutdown of plants or machinery which may either be total or partial, for the purposes of repairs, overhaul, and maintenance operations (Obiajunwa, 2013). According to Duffuaa and Ben-Daya (2004), TAM is an essential component of the process industry, which provides the opportunity for repairs and services that rejuvenate declining equipment and precludes them from further disrepair and deterioration.

Historically, turn around maintenance (TAM) in Nigerian refineries has often been caught in the web of politics and corruption (Wapner, 2017; Bush, 2008; and Iwayemi, 2008). The last refinery in Nigeria (PHRC-II) built in 1989, only had its first TAM on schedule in 1991, the second TAM was done a year late in 1994 and the third, even three years late in 2000 (Wapner, 2017). Since then, there has not been any major TAMs until the ongoing pre-inspection for maintenance exercise commenced since 2019 across all the refineries. The same case was applicable to the Kaduna refinery, which had its first TAM in 1992, which ran over budget and was never satisfactorily completed. According to Busch (2008), the last TAM at the Kaduna refinery was commenced in 1998 and was also not completed.

For the Warri refinery, available TAM records are incomplete as the records show that the last full turnaround maintenance (TAM) at this plant was done in 1994. No other record of a completed or partial TAM for this facility can be obtained at the time of this write up. The other problem with the TAMs of these refineries is that the project must be sanctioned by the federal government, thereby denying the refinery authorities the autonomy to embark on these activities as they see fit. In addition, Busch (2008) reported that such projects are often awarded without being carried out. In Nigeria, such cases are common for government-owned organisations - as can be seen in the Power sector, railways, and steel complexes - all of which have received fixes that failed (Iwayemi, 2008; Eti, Ogaji and Probert, 2006; and Bamisaye and Obiyan, 2006). Furthermore, as noted in Section 2.4.4, the quality of training for local Nigerian engineers and technicians who work in the refineries needs to be reviewed with the aim of scaling up the programs from a mere operational level to a more technical level that imbues the competence to fully troubleshoot, replace or rectify faults with major components.

It is important to note that the maintenance culture for other organisations in Nigeria with optimum performance standards is remarkably different to that for the refineries. For example, the Nigerian Liquefied Natural Gas Company (NLNG) has managed to maintain an optimum performance standard across all their Trains 1 – 7 (LNG liquefaction facilities) since 1999 when production started at its first plant in Train 1. According to Iheukwumere et al. (2021a), the NLNG facility has detailed maintenance programs scheduled for the plants up to 10 years ahead! More importantly, there is an ongoing support from the original equipment manufacturers (OEMs) who monitor the status of each plant using digital twins (offsite electronic replica of onsite equipment) to determine when any production unit may require intervention long before an impact occurs (Iheukwumere et al., 2021a).

One of the fundamental differences between the NLNG and the NNPC refineries is the structure of their contractual agreements with their original equipment manufacturers (OEMs). This is because while the NNPC's contract with their OEMs are more transactional in nature through a turnkey arrangement, that of the NLNG embraces elements of ongoing partnership and support from the various OEMs for the entire asset life. This support from the OEMs, which has proven effective for the NLNG may hold a lesson for the refinery authorities.

2.4.5 Environmental factors

The impact of refinery activities on the environment constitutes one of the interesting topics of the modern environmental debate (Bevilacqua and Braglia, 2002; Otokunefor & Obiukwu, 2005 and Mirkouei, et al., 2016). The environmental factors that affect the performance of NNPC refineries have both social and cultural ramifications. Although this study could not obtain any records of carbon emissions and air pollution from NNPC refineries, the impact of the effluents released into the atmosphere due to refinery operations generally have the potential to cause environmental and health hazards (Wake, 2005 and Concawe, 2004). In addition, the incidence of oil spillage arising from pipeline vandalization of NNPC refineries (see Section 2.4.3) degrades the ecological environment (Nwilo et al, 2006 and Agunobi et al., 2014). Ragothaman and Anderson

(2017) opine that there has been growing concern for refineries in developed economies over emissions as well as the general quality of refined products. The requirement by the International Maritime Organisation (IMO) to limit the sulphur content of marine fuels to 0.5% in 2020 had a costly impact on the operations of refineries due to requirements for technical adjustments to their desulphurisation techniques (Van et al., 2019). Although these standards have been hardly experienced across refineries in Africa due to their poor performance, local authorities still require certain compliance to emission standards (Otokunefor and Obiukwu, 2005). In addition, refineries can face large financial loses through legal suits brought by host communities over claims for compensation on damages to the environment (Watts, 2006). Similar developments can also elicit anger from communities against refinery installations or attacks on refinery workers, especially when such compensations are not paid. These facts inform risk assessment while planning the development of oil refineries, especially in African countries. Particularly, in Nigeria, community grievances as a result of environmental degradation, which have a higher likelihood than elsewhere in the developed countries, may result in higher insurance premiums for new refinery projects and consequently increase the cost of operations (Cruz and Krausmann, 2013).

The foregoing indicates that it is much easier to establish the impact of oil refineries on the environment than it is to state their claim over refineries' operational performance. As such, it is not clear how environmental factors affect the performance of Nigerian refineries. Wapner (2017) indicates that the performance of NNPC refineries is impacted upon environmentally through health and safety issues. For example, the occurrence of frequent fires at NNPC refineries due to accidents usually increases the risk of loss of lives and property, including damage to oil installations and the environment.

2.4.6 Legal factors

The Nigerian oil industry has numerous pieces of legislations governing its activities. Particularly, in the downstream sector, there are four applicable laws relating to the building and operation of refineries. They include: The Petroleum Act (1969), the Hydrocarbon and Oil Refineries Act (1965), the Petroleum Refineries Regulation (1974), and the Department of Petroleum Resources (DPR) guidelines for the establishment of hydrocarbon processing plants (2008). The first three pieces of legislations establish the legal basis for a refinery to operate in Nigeria but have mostly become outdated and unfit for purpose (DPR, 2017). Hence, the introduction of the newer DPR guidelines for private refinery construction in 2008.

Unfortunately, Iheukwumere et al. (2020) observed that the new DPR guidelines also created some technical difficulties through the requirements of its three-stage licensing framework. Also, the absence of strong vetting systems in this licensing scheme in addition to the unclear path for transition from one tier of licensing to another, has seen not more than 3 companies out of 41 progress to the final licensing stage in more than 10 years.

The main legislation which is supposed to harmonise all the activities of the Nigerian petroleum industry, promoting transparency, while stimulating growth in the sector, is the Petroleum Industry Bill (PIB). Unfortunately, this bill spent about 17 years in Nigeria's parliament without passing into law. However, in 2018, the bill was broken down into four different segments, namely: Petroleum Industry Governance Bill, Fiscal Regime Bill, Upstream and Midstream Administration Bill, and Petroleum Host Communities Bill. Eventually, the Petroleum Industry Governance Bill (PIGB) progressed through the parliament and was sent to the President for assent (Reuters, 2018a). Unfortunately, the Presidency rejected this bill on the grounds that the new version of the bill whittles down Presidential powers on governance in the petroleum industry (Reuters, 2018b and Okon-Ekong & James, 2018). This development was perceived as unfortunate by many observers, who note that such a conflict of interest usually hinders progress in Nigeria's downstream sector (Udo, 2018).

A situation, where a head of government sees their right to exercise their powers over mineral resources at the expense of transparency and accountability is not only considered selfish but also dangerous for national development. According to Ernst & Young (2021), a reworked version of the bill was presented to the national assembly in late 2020 and has finally been passed and signed into law in August 2021.

Table 9 shows the summary of the identified PESTEL factors that needs to be evaluated for the performance challenges of the NNPC refineries.

Table 10: A summary of the PESTEL factors to be evaluated for NNPC refineries' poor performance.

FACTORS	REFERENCES
Political Factors	
Govt interference	Ogbuigwe, 2018; Akinola, 2018; Wapner, 2017; and Sayne, Gillies, and Katsouris, 2015
Funding issues	Chima, Owioduokit, and Ogoh, 2002; and Ambituuni et al., 2014
Political indecision	Chikwem, 2016;
Political will	Iwayemi, 2008; PwC, 2017
Managerial appointments	Sancino, Sicilia, & Grossi, 2018
Economic Factors	
Cost of spare parts	Kennedy-Darling et al., 2008
Subsidy issues	Akinola, 2018; Iwayemi, 2008; Ambituuni et al., 2014,
Operating capital	Eti et al., 2004
Exchange rates	Wapner, 2017 and Gary et al., 2007
Profit margins	Gary et al., 2007
Social Factors	
Theft/attacks on pipelines	Siddig et al., 2014; Iwayemi, 2008; Wapner, 2017 and Onuoha, 2008
Illegal refining	Ikelegbe, 2005; and Boris, 2015
Security issues	Boris, 2015
Compensations	Izere, 2010
Collusion and sabotage	Akinola, 2018; Siddig et al., 2014; Brazilian and Onyeji, 2012; Wapner, 2017
Grievances and community disputes	Ikelegbe, 2005; and Obi, 2009/2010.
Technical Factors	
Maintenance issues	Iwayemi, 2008, Bazilian and Onyeji, 2012, Siddig et al, 2014
Ageing facilities	Iwayemi, 2008; Ambituuni et al., 2014; Eti et al., 2004
Facility design	Eti et al., 2006, Turner, 1977
Crude oil/Feedstock supply	Eti et al., 2006
Staff training	Chima et al., 2002, Turner, 1977
Staff competence	Chima et al., 2002
Environmental Factors	
Pollution (air, land and water)	Van et al., 2019, and Bevilacqua & Braglia, 2002.
Health and safety issues	Wapner, 2017
Penalties & Fines	Lynch et al., 2004
Legal Factors	
Petroleum Industry Bill issues	Okoye, 2012
Legal actions	Lynch et al. 2004b
Regulatory procurement issues	Kallestrup et al., 2014
Regulatory limitations on emissions	Van et al., 2019

A discussion on how PESTEL can be combined with other methodological frameworks (both qualitative and quantitative) is presented in more detail in Chapter 3 (Section 3.9).

However, in the following sections, a review of previous efforts undertaken by the Nigerian government to address the identified problems of the refineries is presented.

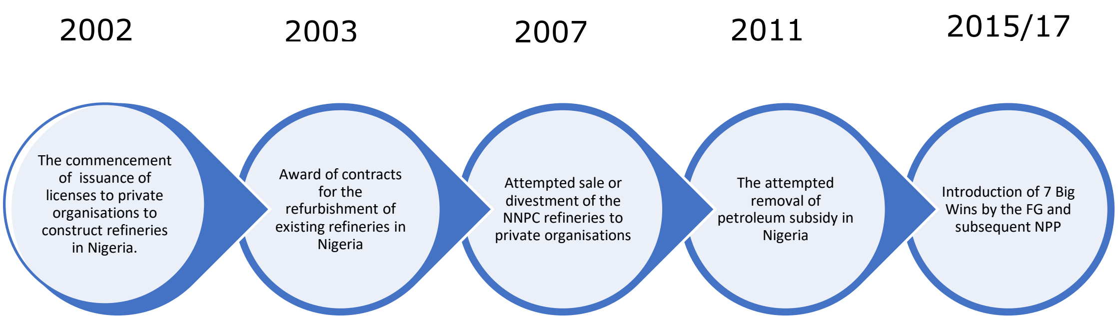
2.5 Previous remedial government efforts to address the refining sector problems.

Over the years, the Nigerian government has made some efforts to address the problems of the refining sector to ensure the steady availability of petroleum products in the country. Unfortunately, these efforts which involve several strategies by multiple administrations have not yet proven effective. Iheukwumere et al., (2020) identifies the most important of these steps as:

- The commencement of issuance of licenses in 2002 to private organisations to construct refineries in Nigeria.
- Awards of contracts for the refurbishment of existing refineries in Nigeria in 2003
- Attempted sale or divestment of the NNPC refineries to private organisations in 2007
- The attempted removal of petroleum subsidy in Nigeria in 2011
- The introduction of the 7 big wins by the Federal Government in 2015 as well as the enactment of the National Petroleum Policy (NPP) in 2017.

The schematic structure of these steps is as shown in Fig 15.

Figure 15: Schematic of government remedial efforts



Source: Iheukwumere et al., 2020

2.5.1 Commencement of licensing for private refinery construction in Nigeria

The creation of a licensing framework that seeks to encourage private sector participation in the downstream sector was re-initiated after Nigeria's transition to democratic governance in 1999. According to Ross (2013) this was done to encourage a more sustainable growth in the oil and gas sector through the involvement of indigenous private companies to achieve more prosperity through local content development. Unfortunately, this measure has not yielded its expected benefits as not more than three companies (Niger Delta Petroleum Resources, Dangote Oil Refinery and Waltersmith Refinery) out of 41 issued licenses have made any significant progress in new refinery construction. Iheukwumere et al. (2020) identified some of these challenges to include unstructured refinery licensing scheme, poor vetting processes for licensing indigenous companies, shortage of local skills in refinery construction, and barriers for accessing sufficient capital.

2.5.2 Award of contracts for the refurbishment of existing refineries in Nigeria

Since 1999, there has been several announcements in the Nigerian news media of NNPC awarding contracts to fix the refineries. Unfortunately, as mentioned in Section 2.4.4, Busch (2008) opines that most of such awards either did not take place or were not completed. This claim is buttressed by the former NNPC Group Managing Director (GMD), Funso Kupolokun, who stated that not less than US $1bn was committed to the turnaround maintenance of NNPC refineries between 1999 to 2007 without achieving any results (Oluwagbemi, 2016). To this end, Faboyede (2010) notes that such practices are primarily driven by corruption, which involves multiple actors within both the NNPC and the federal government.

2.5.3 Attempted sale of the NNPC refineries to private organisations

In 2007, the outgoing Obasanjo administration engaged in a last-minute privatisation exercise to sell the Port Harcourt refinery to a consortium of Blue Star Energy owned by a handful of Nigerian billionaires (Oluwagbemi, 2016). This development led to a massive outcry by the Nigerian public through pressures mounted by the civil society groups on the government. Eventually, this action led to the overturn of the decision by the new Yar'Adua administration (Vanguard, 2015). Consequently, the refineries were returned to their original State-ownership status. Iheukwumere et al. (2021) notes that as at September 2020, there were discussions within the management of NNPC to give up a controlling stake for the refineries in exchange for partnership with private foreign and local investors.

2.5.4 Attempted removal of petroleum subsidy in Nigeria.

The Jonathan administration in 2011 attempted to remove petroleum subsidy in a bid to eliminate the burden of subsidy costs on the government and also free the country of much needed funds to improve the refineries. This announcement drove the pump price of petrol from N65 (US $0.17) to N140 (US $0.37) - an increment of 115% (BBC, 2012). The development once again led to a public protest by the Nigerian Trade Unions, which eventually forced a partial reversal of the policy to a new price of N97 per litre of PMS, a 49% increment from the previous figure. The recurrent inability of the government to tinker with the pump price of RPPs suggest a need for an alternative approach.

Although, experts believe a radical change is necessary to turn around the performance of these assets, unfortunately, there appears to be a public distrust with the way the government has attempted to carry out these initiatives. This is especially the case for the attempted privatisation of the refineries, which generated a lot of controversy about the national assets being converted to the private property of a handful of wealthy individuals to the detriment of the general public (Ahemba, 2007). Meanwhile, the Nigerian government now promises to remove the petroleum subsidy in 2022 following a downturn in the industry, and the economic impact arising from the COVID-19 pandemic (Udo, 2020c). How this development will unfold and any reactions it might elicit over time is yet to be seen.

2.5.5 Government's introduction of 7 Big Wins initiative in 2015 and approval of the National Petroleum Policy (NPP) in 2017

The 7 Big Wins initiative targets the reinvigoration of the refining sector through the complete rehabilitation of the local refineries to enhance their utilisation rates. It also incorporates the setting up of co-located modular refineries to enhance the supply and distribution of refined petroleum products around the country (Omoregie, 2019). Essentially, this strategy is targeted at transforming the country from a net importer of RPPs to a net exporter, such that the benefits of Nigeria's oil resources can be maximised through GDP growth and employment generation.

On the other hand, the National Petroleum Policy (NPP) introduced in 2017 also restates the importance of a commercially viable and significant refining sector through the creation of additional value. The NPP hopes to achieve this through increased processing of oil into finished products. It also seeks to divest the refineries from the dominant control of government to a private sector-led control such that the necessary technical, commercial, and financial capabilities would be infused into the sector (KPMG, 2017). Experts suggest that achieving any of these objectives, would require a strong political will and a coherent strategy that will provide a reliable framework for its implementation (KPMG, 2017). This submission reflects the true state of Nigeria's situation given the country's notable weakness with policy implementation. Awuzie (2014), Makinde (2005), and Okoroma (2006), all agree that the lack of political will, corruption, and discontinuity in government programs consistently lead to policy implementation failures in Nigeria. This condition often constitutes a major barrier to the realisation of laudable government plans and objectives.

It would be useful for the Nigerian government to adopt a means of measuring policy implementation at stage gates. This will help uncover key lessons for the success or failure of implemented policies which can benefit subsequent government programs. For instance, it should be noted that since 2001, there has been no government review of failed policies within the refining sector to understand the barriers to their success.

Considering these difficulties, it may be worth evaluating a three-step approach to revive the declining downstream sector in Nigeria.

2.6 Potential approaches for corrective action for the Nigerian refining sector

Although this is not the actual focus of this study, a corrective action can be potentially achieved through strategic investment in the refining industry in Nigeria to restore its performance and optimise the benefits. The three approaches that can be evaluated include:

- Investing to revamp the existing refining infrastructure and restoring them to their full operational capacity.
- Investing to increase the installed processing capacity of the existing refineries.
- Investing to build new refining capacity in Nigeria.

Implementing the first level approach would, in theory, restore the capacity utilisation of the existing refining infrastructure up to their installed nameplate capacity. However, with the estimated current demand for RPPs at about 700,000bpd, this capacity alone will not be sufficient and would require additional importation of about 35% – 40% of RPPs to augment the local capacity (Ogbuigwe, 2018).

A second level approach would be to increase the capacity of the existing refining infrastructure above their current level to accommodate the growing demand for RPPs in Nigeria. As a second step to the first, more capacity would be achieved, especially if performance is maintained. However, the addition of refining capacity by NNPC should be borne out of four main considerations, namely:

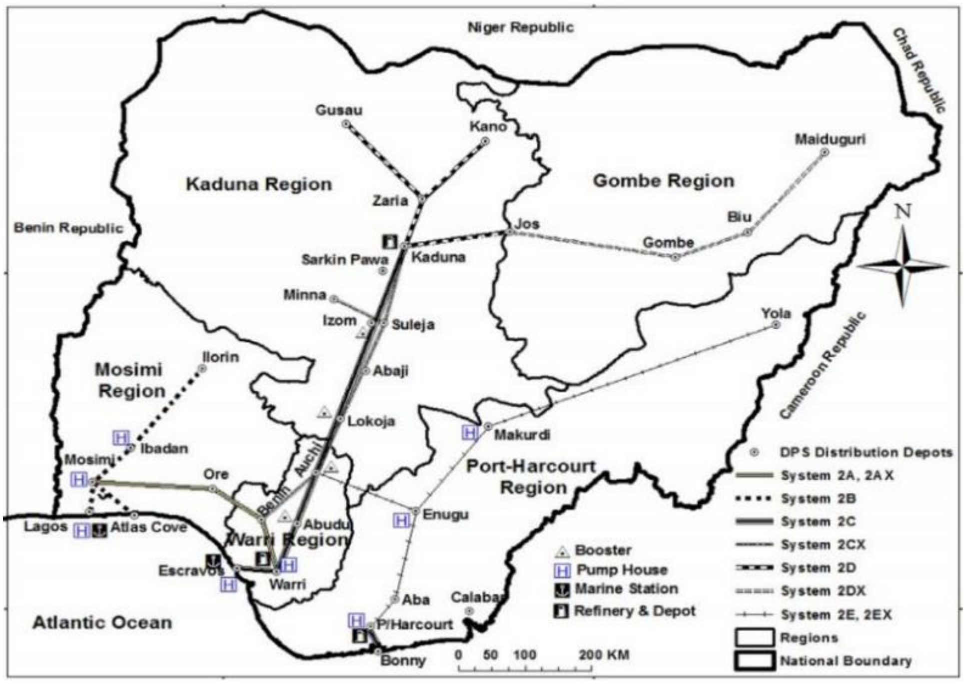
- The percentage annual demand growth for RPPs in Nigeria
- The potential growing addition of spare capacity from private refineries in Nigeria
- The growing desire of other neighbouring African nations to compete and supply their own domestic fuel, and
- The future potential departure in world energy consumption from fossil fuels to green renewable energy.

Balancing these variables will not be an easy undertaking, as some will be hard to predict. For example, the progress rate for neighbouring countries to acquire their own refining capacity and its impact on Nigeria's export capacity, the growth rate of Nigeria's private refining sector, and the adoption rate of African economies for green energy and its corresponding impact (reduction) in fossil energy demand. There is a need for a careful determination of any capacity expansion by the NNPC as a careless approach to such a strategy would potentially lead to a market glut. Maples (2000), Gary et al. (2007) and Cross et al. (2013) all agree that growing competition between refiners in an already saturating global market further erodes the margins for many refiners and has contributed to the closure of many refineries in Europe and North America.

2.7 Nigerian Petroleum Distribution Network

Nigeria has 5,001km length of oil pipeline that distributes petroleum products - PMS, AGO and DPK – in the country. These pipelines are owned by the NNPC through its subsidiary, the Pipeline and Products Marketing Company (PPMC) (Ambitunni et al., 2015). Figure 16 is a map of Nigeria showing the network of petroleum pipeline infrastructure for oil distribution in Nigeria.

Figure 16: Petroleum pipeline distribution network in Nigeria.



Source: Ambituuni et al., 2015

According to Akpogomeh et al., (2006) and Aronsayin (2005) most of Nigeria's oil pipeline network are buried about 3ft deep on an 11.5ft (3.5-metre) wide Right of Way (ROW) to avoid accidental contacts. The pipelines are made up of steel with diameters in the range of 6 to 24 inches. These pipelines link the four refineries and import-receiving jetties to 21 oil storage depots nationwide. Overall, pipeline transport makes up about 70% of the refined petroleum products transported from the refineries to the depots. The other means of transport are by road through trucks and formerly by rail and marine jetties in minor quantities (Akpogomeh et al., 2006). Unfortunately, due to the dilapidation of Nigeria's rail infrastructure, as well as the Jetties at Warri, Calabar, Apapa, Atlas Cove and Okrika, the rail and jetty means of transport for RPPs are mostly moribund at present (2021). The state of pipeline and other distribution infrastructure for RPPs are important to refining operations as regular inflow and outflow of products contribute to the success of refinery operations.

Available data indicates that across the NNPC refineries, pipeline transport for RPPs vary in percentages. For example, in 1988, only 36% of products from Port Harcourt refinery was transported by pipelines, while the figures for WRPC and KRPC were 47% and 49% respectively for the same year (Akpogomeh et al., 2006). Unfortunately, accurate present figures for pipeline transport for RPPs to each of the refineries cannot be obtained at the time of this write up, but Ogbuigwe (2018) suggests that the recurring incidence of pipeline vandalization in the Niger Delta region has compromised pipeline transport as a reliable means of product movement in the region and has caused some of the refineries to switch to alternative ways of shipping crudes to their plants at higher costs. For example, the incessant vandalism experienced along Escravos-Warri pipeline route has led NNPC to switch to the use of vessels to send crude oil to Warri refinery at an additional cost of US $4.20 per barrel – a contract that amounts to over US $7m per month and constitutes an additional burden to the refineries' operating costs (Ogbuigwe, 2018).

Aside from the significant cost of repairs that goes into pipeline damage, the associated loss of oil revenue can be as substantial. For instance, Akinola (2018) reports that between 2009 – 2011, it cost US $5bn to repair damaged oil pipelines caused by militancy and another US $10.9bn of losses in oil revenue. It suffices, therefore, to say that the cost of breaches to pipeline transport in Nigeria has multiple implications – loss of revenue due to product losses, associated cost of repairs & maintenance as well as contamination of the environment due to oil spillage. It would be difficult for the NNPC refineries to scale profitably alongside improved performance under such mounting social and financial challenges, especially for an industrial sector that already suffers from low profit margins (Cross et al., 2013 and Maples 2000). Confronting the challenges around the safety and reliability of petroleum pipeline infrastructure in Nigeria would, therefore, be crucial for the sustainable operations of the refineries.

According to PwC (2017) improving Nigeria's oil refining and supporting infrastructure can be achieved through private sector led partnerships. Public Private Partnership (PPP) is a known mechanism that can provide a pathway for the attainment of such goals by governments.

2.8 Public private partnership (PPP)

Public Private Partnership (PPP) has been suggested by both experts and scholars alike as a viable means of building Nigeria's infrastructure, including the downstream assets such as refineries (PWC, 2017; Iheukwumere et al., 2020; and Unya, 2015). According to Vining et al. (2008) and Yescombe (2011), PPPs are partnership arrangements between a public sector entity and a private sector entity, which are created for the development and management of public infrastructure or assets for a specified period based on agreed commercial terms. PPPs essentially, represent a form of shared service delivery between the public and private sector, in which the private sector supports a public sector project through financing, construction, or management of the asset in return for a stream of income from the government or indirectly from the users (Boardman *et al*., 2005; Vining *et al*., 2008).

There has been concerns over sustainable use of PPPs in Nigeria, mainly due to a lack of trust for government's contribution and possible expropriation by future administrations (Akanfe *et al*., 2014; PWC, 2017). Hodge and Greve (2016) also report that the assessment of the success of a PPP is often hampered by the lack of a shared understanding of what a PPP is, as well as the secrecy surrounding their financial details. However, studies have shown that PPPs, when carefully designed and managed can yield better economic outcomes, and thereby help a country such as Nigeria develop its critical infrastructure like its oil refineries (Akanfe *et al.*, 2014).

Considering that the construction of oil refineries is usually capital intensive (PwC, 2017), governments are often confronted with the challenge of raising sufficient capital to undertake such projects, especially in the face of other competing projects, such as the provision of healthcare facilities, schools, roads, and bridges. PPPs typically play significant roles towards providing the needed capital, as well as the managerial competence to actualise such projects (Wang et al., 2020). For this reason, the adoption of PPPs by the Nigerian government to procure or refurbish its oil refineries would be a reasonable alternative to consider.

It should be noted, however, that the sustainability of any built infrastructure project relies on proper management of the built assets. One of the ways to ensure the proper management and efficient performance of an oil refinery is by adopting measurable key performance indicators (KPIs). Such KPIs provide a reliable basis for assessing the operating efficiency of an asset.

2.9 Assessment of performance challenges of Nigeria's refineries and Key Performance Indicators (KPIs)

There is hardly any consensus in relevant literature on any set of universal KPIs for measuring the efficiency of an oil refinery. As each refinery is unique in their configuration, so are their modes of operations. Moreover, it appears that efficiency KPIs across oil refineries vary between studies. While some studies focus more on energy utilisation efficiency, others prioritise throughputs, operational costs, or a combination of other factors (Azadeh et al. 2015; Francisco et al., 2012 and Li et al., 2017). Unfortunately, previous studies across Nigeria's refineries have assessed the performance of these facilities as isolated cases from the lens of a particular background of study. As such, there has not been a single study assessing all the refineries and their challenges from a holistic viewpoint. For example, Badmus et al. (2012) appraised the performance of government-owned refineries in Nigeria using exergy analysis. Their study revealed that energy consumption patterns of the NNPC refineries fall below international benchmarks. Jesuleye et al., (2007) replicated this study using Port Harcourt refinery as a case study. He observed that for over the 16-year study period, the yearly energy demand level of the refinery far exceeded the stipulated refinery standard.

Ngwu (2014) carried out extant analyses of Nigeria's downstream oil sector and observed that the drivers of its underdevelopment were inefficiency, corruption, mismanagement, excessive subsidising, and bureaucratic bottlenecks. Ogbuigwe (2018) took a different perspective and examined the history, challenges, and prospects of the NNPC refineries and recommended a full rehabilitation of the refineries and a transfer of their management to a fully commercial governance structure. Akinola (2018) reviewed the implications of globalisation and oil sector reform in Nigeria and recommended effective deregulation of the Nigerian oil industry. Iwayemi (2008) examined the challenges of Nigeria's dual energy problems along policy lines. He observed that Nigeria's dismal energy standards negatively impact on its local population and recommends a radical reform of the sector to eliminate corruption and achieve transparency. Igboanugo et al. (2016) carried out a study to identify some of the important factors affecting the operations of the Warri refinery. He observed that a correlation exists amongst the multifaceted variables such as equipment reliability, safety issues, technology limitations, turnaround maintenance and political uncertainties.

A thorough review of these studies showed that none attempted to show any causalities or interrelationships amongst these factors. This study attempts to bridge this gap by examining all identified causal factors from a holistic viewpoint. However, to achieve this evaluation requires an appropriate selection of relevant KPIs to assess the performance of this industry.

Technically, the measurement of efficiency was established by the work of Farrell (1957), which considered the ratio of input to output in organisations. However, Farrell's work has been extended over time by other scholars to incorporate different measures based on the priority of the organisation under study (Charnes et al., 1978). Atris (2020) synthesised numerous methodologies employed by various scholars who assessed refinery efficiency using several input and output measures. Table 11 presents a summary of the relevant studies and their themes.

Table 11: Synthesized efficiency KPIs

Authors	Description	Inputs	Outputs	Key themes
Azadeh et al. (2015)	This study presented a combined approach for evaluating the performance of 5 gas refineries in Iran over the period 2005–2009.	Number of personnel Total costs (except the cost of goods sold (COGS)) Personnel education cost R&D cost Fixed non-current assets Stock turnover Asset turnover ratio Current assets turnover ratio Amount of refinery' s fuel consumption/amount of received sour or sweet gas	• Return on sales • Operating earnings • Net income • Return on assets • Capital return • The amount of gas sent to the torch/the amount of received sour or sweet gas • Operating capacity divided by nominal capacity • Operating capacity of each LPG production unit divided by design capacity of each LPG production • Operating capacity of each refrigeration and dew point control unit divided by design capacity of each refrigeration and dew point control unit • Operating capacity of each sulphur production unit divided by design capacity of each sulphur production unit • Operating capacity of each liquid's stabilization unit divided by design capacity of each liquid's stabilization unit Operating capacity of each dehydration unit divided by design capacity of each dehydration unit.	Profitability Capacity utilisation

Authors	Description	Inputs	Outputs	Key themes
Francisco et al. (2012)	This study assessed the environmental efficiency for 10 oil refineries in the public sector in Brazil in 2004	Idleness percentage of the operating plant The amount of water consumed	Desirable: (refinery production volume) Undesirable: (generated effluents)	Downtime Effective productivity
Li et al. (2017)	This study examined the sustainable performance for 15 refineries in China	Asset-liability ratio Comprehensive energy consumption per unit of output Entire cost per unit Solid waste emissions per unit of output Wastewater emissions per unit of output Waste gas emissions per unit of output Employee turnover rate	Return on assets Asset turnover Investment intensity in science and technology R&A personnel Comprehensive commodity rate Environmental protection cost per 10 thousand Yuan of output “three wastes” disposal rates social contribution rate income per capital.	Profitability
Song and Zhang (2009)	This study presented a method for evaluating and predicting oil refineries performance, using two different techniques.	Manpower cost index Operation cost index	Return on average capital employed Operation cost added value index Manpower cost added value index	Operating cost

Authors	Description	Inputs	Outputs	Key themes
			Assets added value index	
Mekaroonreung and Johnson (2010)	This study Investigated the technical efficiency of 113 US oil refineries in operation over two years, 2006–2007. They found that domestic refineries could improve efficiencies regardless of the different DEA assumptions. Further, environmental regulations reduced the amount of potentially desirable outputs produced by some facilities.	Equivalent distillation as a proxy of capital Energy Crude oil	Gasoline Distillate Toxic release	Utilisation capacity

Source: Adapted from Atris (2020)

From Table 11, some key themes that unify most of the input/output variables can be observed. These themes are capacity utilisation, operating costs, and downtimes. Given that these measures are consistent with the established problem statement of this study (see Chapter One – Section 1.2), this research adopted these three indices as the main criteria to assess the performance of the NNPC refineries. These criteria shall be presented alongside the Analytical Hierarchy Process (AHP) as part of the research methodology in Chapter Four.

2.10 Chapter Conclusion

This chapter established the context relevant to provide an understanding of the problems of Nigeria's downstream sector. To this end, it illustrated Nigeria's oil sector across the energy supply chain as comprising the *upstream sector* (exploration and production; *midstream sector* (oil storage, processing, and transportation); and *downstream sector* (oil refining, marketing, and distribution). It further described the economic importance of crude oil to the Nigerian government as the mainstay of the nation's economy. Secondly, it reviewed the various challenges of the downstream oil sector in Nigeria and identified that these issues cut across a wide range of factors. This includes political, economic, social, technical, environmental, and legal factors. These factors, which would be evaluated by this study, were summarised in Table 10 (Section 2.4). Thirdly, a review of relevant Key Performance Indicators (KPIs) for measuring the performance of oil refineries was carried out in this chapter. As a result, the main KPIs adopted by this study to assess the performance of the NNPC refineries are capacity utilisation, operating costs, and operating runtime/downtime.

Finally, the chapter reviewed the previous measures undertaken by the Nigerian government to address the challenges of the refining sector. As such, it noted these measures to include the issuance of licenses to private indigenous companies to construct refineries, the award of contracts to refurbish existing refineries, the attempted sale of the refineries to private investors, the removal of petroleum subsidy to unburden the government and free public capital to fund the refineries, and the enactment of National Petroleum Policy (NPP) to divest the refineries from government control. This study argues that the failure of the implementation of these initiatives is mainly due to the fact that these approaches were attempted from isolated standpoints rather than from a coherent holistic viewpoint. As such, it proposed the adoption of a holistic approach to understand the causal interrelationships amongst the factors that lead to inefficiency.

The next chapter discusses the concept of systems thinking as an underpinning theory with a holistic approach for dealing with complex organisational problems.

CHAPTER THREE: UNDERPINNING THEORY AND CONCEPTUAL FRAMEWORK

3.1 Introduction

This chapter connects the previous literature and the underpinning theory for this study, thereby establishing its conceptual framework.

The chapter also aims to identify the optimal methods within the constraints of the study to explain the causal interrelationships amongst the multiple factors leading to the performance challenges across the NNPC refineries. Lastly, the overall conceptual framework evaluated through systems thinking covering political, economic, social, technical, environmental, and legal (PESTEL) factors, is presented.

3.2 From systems to systems thinking

According to Sherwood (2011), there were two pioneering works that laid the foundations for systems to be studied as their own subject: Weiner (1948) with his publications on cybernetics, which examined the basis of control with respect to information flow; and Forrester (1961) with his industrial dynamics, in which he examined complex commercial and managerial systems to infer better decision-making in organisations. However, more recently, other notable works in the field such as Limits to Growth by Meadows et al. (1972), and Fifth Discipline by Senge (1990) appear to have made as much impact.

Meadows (2008) defines a system as an interconnected set of elements that is coherently organised in a way that achieves something. This definition aligns with the view of Kim (1990), who defined a system as a group of interacting, interrelated and interdependent parts that form a unified complex whole with a specific purpose. This compares well with the definition of a system in the Oxford dictionary, which defines a system as *a set of things working together as parts of a mechanism or an interconnecting network, a complex whole*. From these definitions, it appears that *elements* (things) are being *interconnected* with some *purpose.* Building on this concept, Meadows (2008) illustrated some examples of systems sharing these attributes, as shown Table 12.

Table 12: Some examples of systems and their attributes

System	Elements	Interconnectedness	Purpose
A football team	Players, coach, referee, field etc	The rule of the game, players communication, coach's strategy etc	To score and win, have fun, exercise, make money.
An organisation	Workers, managers, cleaners, buildings etc	Communication amongst employees, cooperation, management of work and team, policies and procedures	Make money (profits) and grow, serve the community.
A digestive system	Teeth, oesophagus, intestines, enzymes etc	Communication and exchange between the constituent parts	Break down food and nourish the body.
A forest	Trees, bushes, animals	Trees provide food and shade for some animals; animal dungs provide manure for some trees.	Survival
A school	Students, teachers, classrooms etc	Teaching, examinations, admissions, graduation	Discover and pass knowledge across and award recognised certificates

Source: Meadows, 2008, amended by author.

However, before assigning the label "system" to things, Meadows (2008) calls for caution as not everything can be regarded as a system. For example, a new apartment building with different people that are not communicating or working towards any common goal is not yet a system until such a purpose and interactions emerges. Similarly, a dead body is no longer a system as the functionalities within the living parts of the body ceases even though the body can constitute an addition to the wider ecological system in terms of manure generation. This submission appears to be consistent with the views of Ackoff (1994) who also acknowledged that a system as a whole is one that cannot be divided into independent parts, such that its performance can never be equated to the sum of the actions of the parts taken separately. Just like a disassembled human body loses its overall essence when divided into separate parts, a system must depend on the interactions of its component parts to satisfy its purpose.

Meadows (2008) argues that systems can change, adapt, goal-seek, and even respond to events. They can be resilient, evolutionary, and self-organising. Systems can be embedded in systems, which can also embed other systems. This implies that systems can sometimes be organised in hierarchies to incorporate other sub-systems. Examples include a tree in a forest, the earth in the solar system, a department within an organisation, the digestive system in a human body, a ministry within a Federal Government and a refining sector within a wider industry segment.

Foster-Fishman et al. (2007) suggests that changes in system parts (elements) can alter the characteristics of the system as much as changes to its interconnections and purpose. A football team, a university or a national assembly of a country will essentially remain a system even though their parts (members) change from time to time. If their purpose and interconnections essentially remain the same, systems may still retain their name.

3.3 Systems Thinking - Origins and Foundations

Sherwood (2011) reports that the earliest reference to the concept of systems thinking is credited to Aristotle some 2,300 years ago. In his *Metaphysics,* Aristotle is quoted as stating:

"Now anything that has a plurality of parts but is not just the sum of these, like a heap, but exists as a whole beyond its parts, invariably has a cause".

This description appears to be the first in literature to convey the general idea of a system. However, since the 20th century, systems ideas appear to have developed as a field of inquiry and practice extending from various disciplines such as biology (Bertalanffy, 1946/1968), anthropology (Ashby, 1961; and Bateson, 1972), mathematics (Weiner, 1948), computer science (Forrester, 1968). and management (Checkland, 1981; Senge 1990; and Ackoff, 2003). Peters (2014) and Arnold & Wade (2015) seem to agree that the term *systems thinking* can be credited to Barry Richmond, who in 1987 proposed a common language and framework for sharing specialised knowledge, expertise, and experience. Since then, the term has been defined by various scholars in different ways but along what appears to echo unifying themes: wholeness, interconnectedness, and complexity.

Senge (1990) described systems thinking as a discipline for seeing wholes rather than parts, for observing patterns of change rather than static snapshots, and for understanding the subtle interconnectedness that give systems their unique character.

Goodman (1997) defined it as a holistic approach to analysis that focuses on how the constituent parts of a system interrelate and act over time within the context of larger systems. Cabrera (2006) observed that systems thinking is interdisciplinary and bridges the physical, natural, and social sciences. They argued that the concept of systems thinking has gained in popularity because of its promise to conceptualise issues and solve complex problems. Monat and Gannon (2015) synthesised the definition of systems thinking using over thirty key publications on the subject. They opine that systems thinking appears to encompass three main themes: perspective, language, and a set of tools.

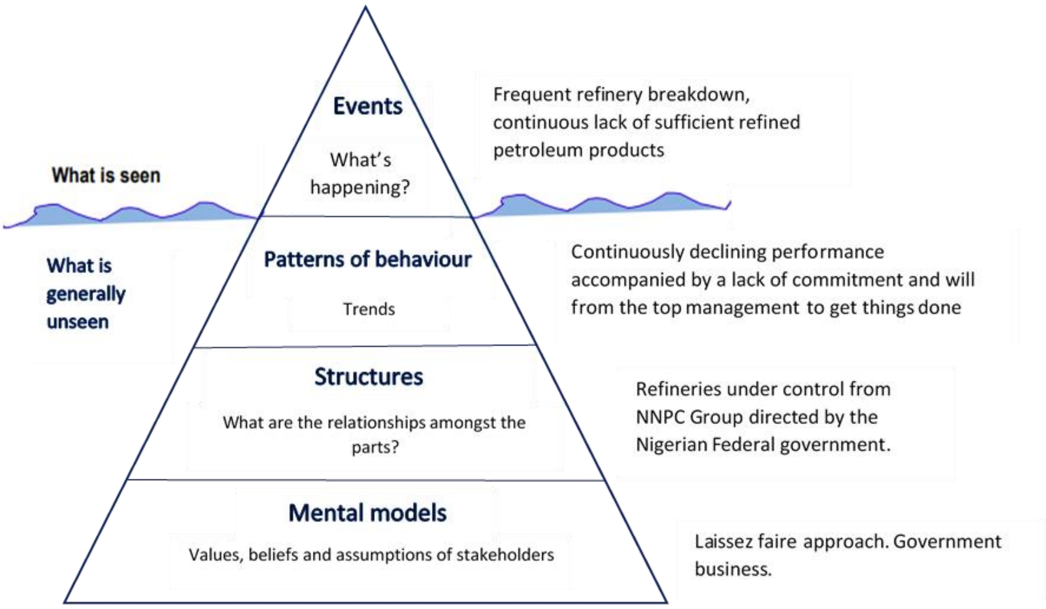
3.3.1 Systems thinking as a Perspective:

Monat and Gannon (2015) observed that systems thinking is opposite to traditional linear thinking and focuses on relationships amongst components of a system rather than the components themselves. In addition, aside from the fact that systems thinking allows for the 'breaking up' of larger systems into sub-systems for analytical purposes, Monat and Gannon (2015) argue that systems thinking differs from "dissective" scientific thinking and attempts to study systems holistically. This approach requires a vision of the future and an understanding of the past. As a perspective, the researchers acknowledged that systems are dynamic and are subject to forces of feedback mechanisms, some of which are reinforcing while others are de-stabilizing. According to Goodman (2002), to view systems thinking in perspective, a linkage to the Iceberg Model would be beneficial.

The Iceberg Model explains that *events* and *patterns* which are observed in organisations normally develop from hidden systemic structures, which in turn are derivable from people's mental models. Just like an iceberg in the ocean, the model argues that while *events* and *patterns* are observable (above water level), *systemic structures* and *mental models* are not as obvious (below water level) (Lisa et al, 2012). A clearer explanation for this is offered by the works of Blokland and Reniers (2020), who present the Iceberg Model as four levels of thinking. In their submission, the first level of the iceberg model is concerned with the basic information or data for *what happened*, *where, how*, and *when*, which are all observable or collectable data from the *Event*. The second level is then built on the richer picture which can be drawn from a deeper level when the data is collected for a longer time frame to reveal *Patterns* and

Trends. The causes behind these patterns and trends can then be drawn from a much deeper level of thinking that shows how the interplay of factors bring about these observable outcomes. At this level, Blokland and Reniers (2020) argue that it is critical to understand how the factors interact due to how the systems are structured (*Systemic structures*). And yet the deepest level of thinking of the iceberg model that hardly comes to the surface are referred to as the *Mental models.* This is the reflection of the views, attitudes, and values of the individuals within the system (organisation) and the overall influence of the organisation on how things should or should not work. Figure 17 depicts the iceberg model and mirrors it on the Nigerian refining sector.

Figure 17: The Iceberg model as compared to the Nigerian refining sector.



Source: Author generated, inspired from Goodman, 2002.

Figure 17 indicates that each level of the iceberg model is important and helps provide critical answers to the underlying situation of the Nigerian refining sector. Table 13 presents a summary explanation of the iceberg model.

Table 13: The iceberg model explained.

Iceberg Concept	**Relationship to Nigeria's Refining Sector**	**Perceptibility**	**Water level**
Events	Lack of sufficient locally refined petroleum products in the country	Can be observed (Obvious)	Above Water
Patterns	Continuous lack of adequate locally refined petroleum products occasioned by frequent refinery breakdowns. Product shortage continuously being filled by imports.	Not obvious	Below Water
Systemic structures	What drives the sub-optimal performance of the Nigerian refineries? Organisation structure of NNPC Group? Govt control?	Not obvious	
Mental models	What are the thoughts of the stakeholders of the Nigerian refining industry? How are things perceived in this industry by the people who run the affairs and the people whose lives are affected by the outcome?	Not obvious	

3.3.2 Systems thinking as a language:

As a language, Monat, and Ganot (2015) identifies several key terminologies of systems thinking which incorporates the concept of the iceberg model such as events, patterns, systemic structures, and mental models; and those of other system properties such as self-organization, emergence, feedback, and unintended consequences. They further argued that systems thinking tools such as causal loop diagrams and stock & flow diagrams constitute effective systems thinking language for communicating inter-relationships amongst components.

Table 14 provides a summary definition of some of the key systems thinking terms essential for understanding systems knowledge.

Table 14: Systems thinking terms and definitions

Systems Thinking Terms	***Definitions***
Boundary	The borders of the system, determined by the observer, which determines where control action can be taken.
Emergence	This is the property of a system which is developed as a result of the combined interrelationships from its various components (sub-systems), which are not possessed by the constituent components (sub-systems) on their own. Essentially, these are properties which emerge as a result of the assembly of sub-systems e.g., the concept of countries from regional or state governments, schools of fishes, the murmuration of (starling) birds etc.
Feedback	The return of information or response about the status of a process.
Environment	The context or space outside the system boundary which may affect the behaviour of the system.
Perspective	A way of experiencing in a cognitive way, that which is shaped by our unique personal and social histories.
Hierarchy	Layered structures about a system forming a continuum of levels in organisation.
Complexity	The characteristic of a system having many components and the different ways in which these components interact.
Unintended consequences	Results of actions that were neither planned nor foreseen arising due to a lack of systems thinking.
Self-organisation	The tendency of systems to develop patterns or structures without the intervention of a designer or central plan.
Leverage point	An area where a small change can yield a large improvement in a system.
Events	Things that happen which we can see or observe
Patterns	Sets of recurring and consistent observable events
Systemic structures	The underlying inter-relationships that drive the components of the system
Mental models	Paradigms or belief structures that attempt to interpret or simplify the world in which we live.

Source: Monat and Gannon (2015)

These systems thinking terms enrich the language for communicating complexities and interdependencies. Goodman (1991) infers that systems-thinking, as a language, also possesses certain qualities useful for discussing and analysing complex issues. Such qualities include: its focus on closed interdependencies, its ability to provide visual diagrams using some of its tools, such as causal loop diagrams (CLDs), and its power to force mental models into visible pictures.

3.3.3 Systems thinking as a tool:

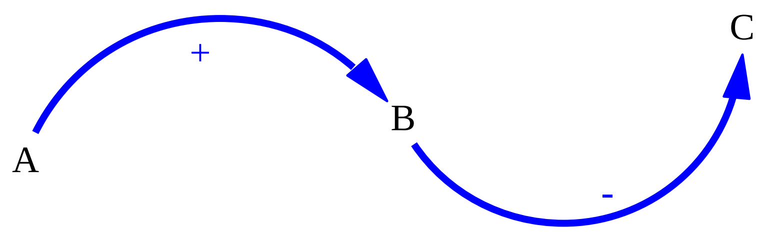
As a tool, Monat, and Gannon (2015) mapped out five distinct criteria to identify the tools fundamental to systems thinking. They explain that these tools must be widely applicable to most systems, must be well described in systems thinking literature, must be easy to use and understand, must address one of the concepts of systems thinking and must focus on the understanding of existing systems. As such, they outlined the following tools as basic to systems thinking: systems archetypes, behaviour over time graphs, causal loop diagrams (CLD) with feedback and delays, systemigrams, stock and flow diagrams, system dynamics/computer modelling, root cause analysis (RCA) and interpretive structural modelling (ISM).

The foregoing essentially suggests that systems thinking promotes the understanding that the world is made up of interconnected and hierarchical social and technical entities, which are organised to produce unique behaviours that are not often likely to be predicted from observing the parts of the systems in isolation. As such, the fundamental tenet of systems thinking is that real and complex problems can best be interpreted as networks of interconnected feedback loops (Sherwood, 2011). This network of interconnected feedback loops is represented as causal loop diagrams, which form the backbone of systems thinking modelling.

3.3.3.1 Causal Loop Diagrams (CLDs)

Videira et al. (2014) and Sterman (2010) note that causal loop diagrams are systems thinking tools for showing interrelationships between causal variables within a system. CLDs are used to demonstrate the behaviour of cause and effect by mapping relationships between variables in a system and also identify their feedback loops. CLDs normally interconnect variables in a system in given directions using positive or negative sign notations accordingly (Iheukwumere, et al., 2021b). A simple CLD network in which an increment in variable A leads to an increment in variable B is considered to be moving in the same direction and is represented by a curly arrow from A to B with a positive sign notation (+). While a network in which an increment in variable B leads to a decrease in variable C is considered to be moving in opposite direction and is represented by a curly arrow from B to C with a negative sign notation (-). This convention is illustrated by Figure 18 as shown.

Figure 18: Causal loop diagram

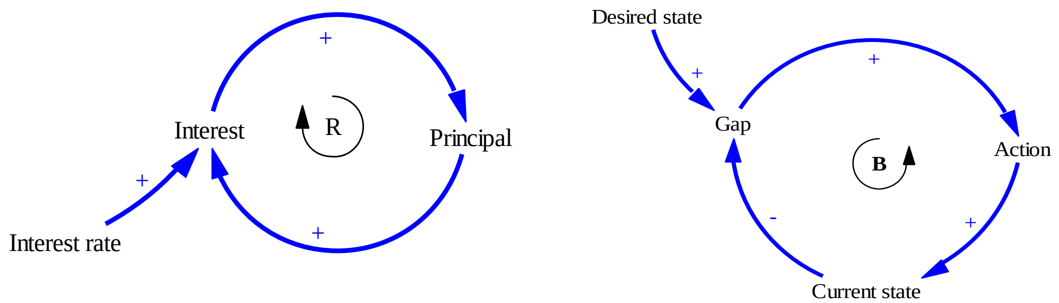


According to Sterman (2010) and Sherwood (2011), CLDs are usually drawn using the most important (significant) variables in the system to express more relevant relationships that keep system diagrams simpler.

It is important to note that two kinds of loops are distinguished in causal loop diagrams – a reinforcing and a balancing feedback loop (Sherwood, 2011; Sterman, 2010 and Meadows, 2008).

A reinforcing loop (denoted by R with a clockwise arrow) is considered a positive feedback loop in which an action from a variable within a system produces a change in the system, which furthers more of the same action leading to further increase or decrease in the system property (Iheukwumere et al., 2021b). As implied by its name, reinforcing loops re-enforce the behaviour expressed by the system property producing further growth or decay in the system (Sterman, 2011). These loops are determined in a system with arrows bearing all positive sign notations in a loop or by arrows bearing all positive sign notations with an even number of negative sign notations in a loop (Meadows, 2008 and Kim, 1992). A simple example of a reinforcing loop can be illustrated by the effect of an interest rate on a principal deposit over time (Figure 19).

Figure 19: Reinforcing and balancing loops



Conversely, a balancing feedback loop (denoted by B with a counter-clockwise arrow) is considered a negative feedback loop and is expressed in a system, where an action through a variable produces a counteracting force to oppose further growth or decay in the system property. Balancing loops are characterised by an odd number of negative sign-bearing arrows in a loop, which may be interconnected with some positive sign arrows. These loops are goal-seeking in nature by acting to move the system from one state to a desired state by closing the gaps between the two states. These examples are illustrated as shown in Figure 19.

3.4 Hard and Soft Systems approaches

Hard and soft systems approaches are systemic viewpoints introduced by Checkland in the 1970s. According to Checkland (1978/1981), soft systems approach or soft systems methodology (SSM) is a strategy for analysing complex systemic problems with a view of identifying acceptable improvements to the system. SSM acknowledges systems as epistemological constructs rather than real world entities as different stakeholders interpret the problems of the systems differently (Checkland and Scholes, 1990). Hasan (2011) opine that to achieve an improvement in a system, SSM utilises information gathering techniques such as qualitative and quantitative methods of enquiry, including observations to build a model consistent with the various viewpoints drawn from data gathering. Checkland (1981) observes that human organisational problems are typically representative of soft systems approach as the problems appear messy and less defined. Therefore, SSM requires a creative and intuitive approach to a solution that is geared towards an organisational improvement through learning and better understanding rather than a defined solution.

On the contrary, hard systems thinking assumes that systems have a clear purpose and well-defined goals (Hasan, 2011). It is ideal for problems which can be modelled with precise objectives having solutions expressed in precise quantitative mathematical models. Examples of hard systems include engineering systems and operations research models requiring a scientific approach to problem solving to provide a precise solution. Hard systems approach represents the traditional way of viewing systems in computer science. It requires rigid techniques and procedures to provide unambiguous solutions to data processing problems (Cairns, undated).

This implies that while the problems relating to the complex engineering and technical systems at the refineries may benefit from a hard systems approach; the management issues which form the focus of this study will benefit from a soft systems approach.

3.5 Systems Thinking in Engineering and Management

The fields of systems engineering, and management present some overlap. According to the International Council on Systems Engineering, INCOSE (2019), the systems engineering (SE) perspective is based on systems thinking. As such, SE may be described as an interdisciplinary field that encompasses engineering and management in a manner that focuses on approaches to design, integrate, and manage complex systems over their life cycles. Some studies further demonstrate the usefulness of systems thinking in Engineering and Management studies. For example, Chan (2015) used systems thinking to present a set of useful concepts in the design and operation of engineering systems. Monat and Gannon (2018) used systems thinking concepts to show how catastrophic failures can be avoided in complex engineering designs.

However, Mingers and Leroy (2010) opine that the importance of systems thinking in management sciences was first recognised by Ackoff (1962) and Churchman (1968). Similar studies imply that systems thinking may be leveraged by organisational management through policy and strategy to lower costs, improve performance and staff motivation and increase customer satisfaction (Forrester, 1997; and Duggan, 2016). These findings further buttress the importance of systems thinking and its suitability for adoption by this study.

Before developing a framework for this study, it is essential to review some of the key systems theories that underpin systems thinking applications.

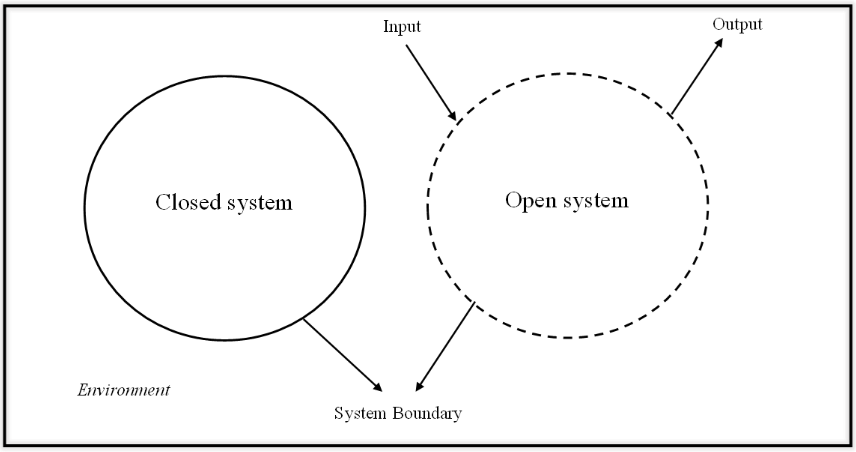
3.6 Systems theories

Systems theory incorporates the views that organisations as social systems interact with their environment to survive. It encompasses the key concepts and ideas drawn from general systems theory, cybernetics, chaos theory, and complexity theory, which are essential for management and organisation studies (Schmitz, 2012; and Montuori, 2011).

3.6.1 General Systems Theory (GST)

GST originated in the 1940s with the works of the biologist Ludwig von Bertalanffy, who sought a new approach to the study of living things. Bertalanffy (1948/1968) envisioned GST as a way to address the increasing complexity of the world's problems. According to Montuori (2011), GST later emerged as an alternative to the then dominant form of reductionist enquiry, by rejecting its inability to address wholes, interdependence, and complexity. GST argued that by studying parts of a larger system in isolation, reductionism is unable to account for the emergent property of systems, which is a consequence of the ability of its parts to produce a much greater function working together rather than working separately. Walonick (1993), writing on general systems theory, asserts that systems can be controlled (cybernetic) or uncontrolled. GST further introduced the concept of closed and open systems, recognising the role and importance of context and environment for systems (Montuori, 2011). This is because systems comprise a complex set of interacting elements that are open to and interact with their environment (Bertalanffy, 1968). As such, an open system may possess the capability of taking an input from the external environment and produce an output, while a closed system may not possess any of such capabilities as illustrated in Figure 20.

Figure 20: Open versus Closed Systems



Amagoh (2008) and Jaafari (2003) also suggest that open systems possess intelligence and can therefore respond to change, whereas closed systems do not.

As will be shown later in Section 3.8, the Nigerian refining sector (as constituting the 4 refineries) is an open system in theory that interacts with its environment.

3.6.2 Cybernetics

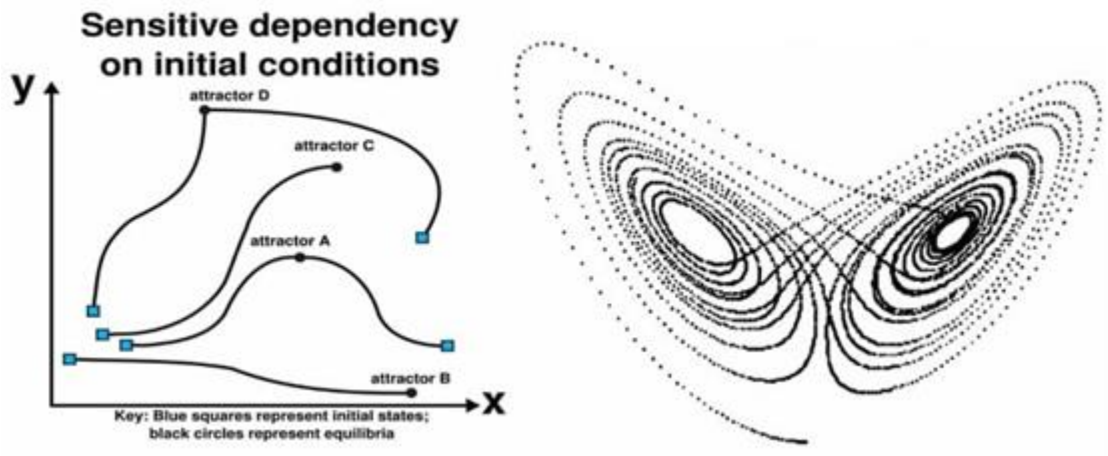
DeYoung and Krueger (2018) opine that cybernetics or control theory is a trans-disciplinary approach to the study of principles for exploring regulatory and purposive systems, including their structures, constraints, and possibilities. Cybernetics mainly involves communication and control with a focus on how information flows through a system, including how the system uses that information for self-regulation (Ashby, 1961). In other words, the information that an organisation receives can influence the way it responds to its environment.

Using the concept of circular causality or feedback loops, cybernetics traces outcomes of actions of a system back as input for further actions. Deriving its origins from the fields of control systems, electrical network theory, anthropology, and psychology in the 1940s, cybernetics has evolved, broadening in scope to include works in management and organisation studies (Scholte, 2020). Beer (1985) applied the seminal principles of cybernetics to management and operations research. He argued that the principles of cybernetics would help all kinds of organisations understand the nature of internal interactions within the organisations and thereby lead to increased operational efficiency. As such, it can be argued that the flow of relevant information within an organisation is as crucial as the ability of the organisation to correctly utilise that information for their own benefit. To this end, NNPC refineries can learn from the information resulting from other refineries with similar technologies with better operating efficiency and use same for their own benefit.

3.6.3 Chaos Theory

Emerging from a branch of mathematics, chaos theory has become an interdisciplinary theory that suggests the presence of interconnected underlying patterns residing within random and chaotic complex systems. These underlying patterns may embody feedback loops which may be repetitive, producing self-similarity, fractals, and self-organisation (Thietart, 1995 and Williams, 1997). Chaotic theory takes root from the concept of Sensitive Dependence on Initial Conditions (SDIC) propounded by Maxwell (1876), which he described as physical axioms that violate flow-like consequences. The principle is related to the *butterfly effect* in which small changes in a deterministic nonlinear system may produce large changes in a later state (Figure 21). Metaphorically, it implies that a butterfly flapping its wing in Scotland might produce a hurricane in Nepal two weeks later. That is, small errors or disturbances within a system might result to an explosive growth within the system's physical behaviour. Maxwell (1876) argued that such phenomena was typically present in systems with sufficiently large number of variables, and which possesses high levels of complexity. However, Poincare (1913) later observed that such behaviour could be recognized in systems with small number of variables possessing very complicated behaviour.

Figure 21: The butterfly effect with sensitive dependence on initial conditions



Source: SCM Globe (2021).

Chaotic behaviour is prevalent in natural systems, especially in fluid flows, weather & climate, stock market, population biology, economics, social psychology, and road traffic congestions (Bishop, 2017 and Adewumi et al., 2016).

In addition to exhibiting sensitive dependence, Smith (2007) opined that chaotic systems possess two other important properties: deterministic and nonlinear properties. Deterministic properties are not related to predictability and refer to systems exhibiting chaotic behaviour while experiencing unique evolution, whereas nonlinearity accounts for any disproportionality in response to small changes in a system's variable.

Considering NNPC refineries as a social system, chaotic behaviour may be observed by the repercussions which wrong decision-making, such as a delay in maintenance operation, might set off on the entire plant.

3.6.4 Complexity theory

Complexity theory is widely applied in the field of strategic management and organisational studies (Houchin and MaClean, 2005; Lewin, 1999; and Anderson, 1999). It examines complexity and non-linearity and emphasizes interactions and their associated feedback loops that constantly change systems (Grobman, 2005). Complexity is characterised by a system with multiple parts interacting in multiple ways, producing a higher order of emergence greater than the sum of its parts. It is important to note that the definition of complexity can be nuanced, in that, what one organisation may consider as complex, another may see as simple.

Weaver (1948/1991) posited the existence of two forms of complexity: organised complexity and disorganised complexity. Organised complexity is embodied by the non-random or correlated interactions between parts, which create differentiated structures that can interact with other systems. This coordinated system’s linkages create properties not carried by the individual system parts – emergence. A system with organised complexity can be understood by modelling and simulations. An example of organised complexity is a city neighbourhood with its people as the system parts, a university system with its students and faculty members, and an organisation such as NNPC refineries. Disorganised complexity, on the other hand, is manifested by the random interaction of a system with large number of parts. The properties of a disorganised complex system can be understood by probability or statistical methods. A typical disorganised complex system is a gas stored in a container with the molecules as its parts.

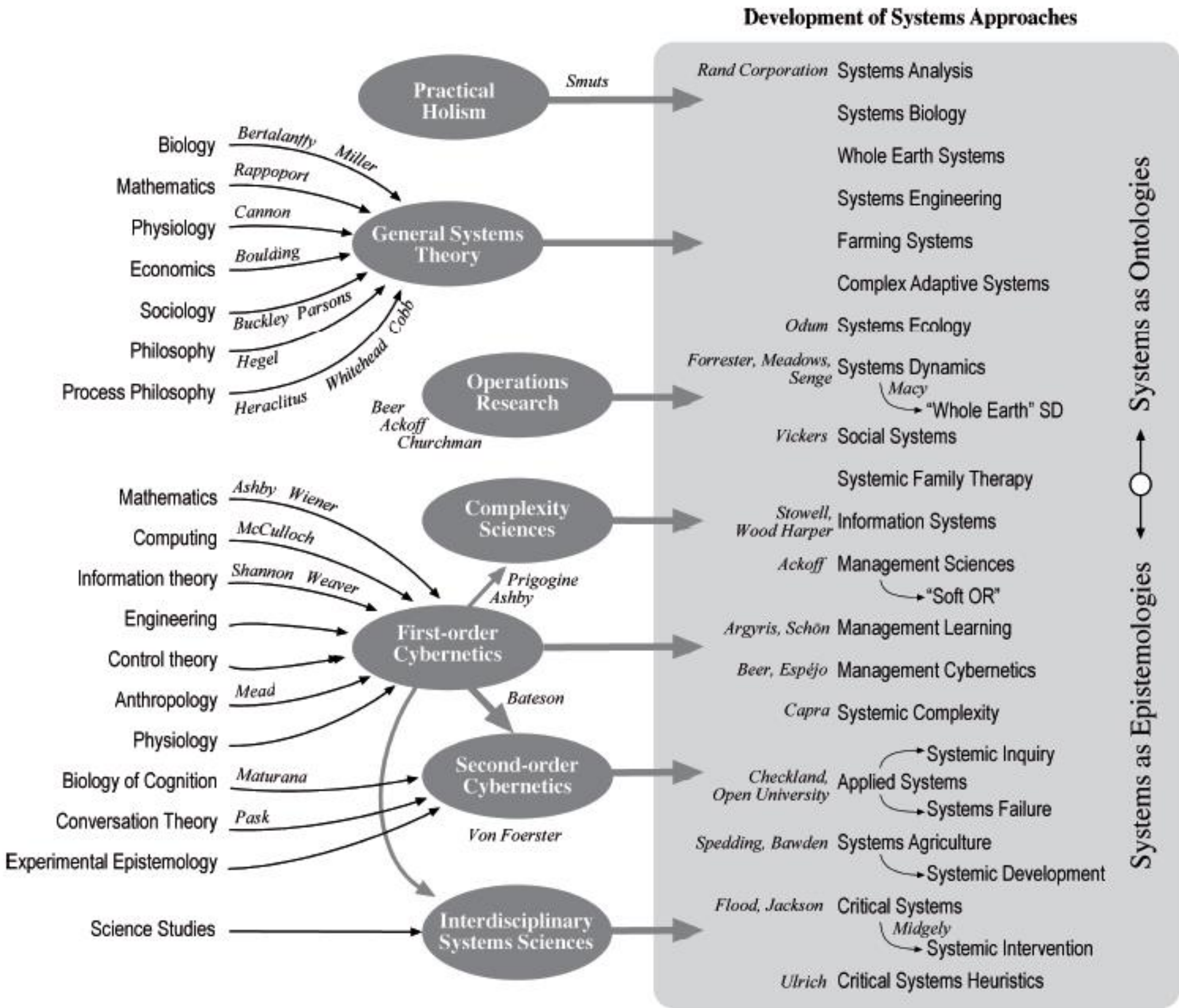
Complexity theory in general tends to explore how organisations adapt to their environment and cope with uncertainties. The multiple interactions within the Nigerian refining sector, which produces an undesirable sub-optimal performance may possibly be understood by viewing it from the lens of a complex system. Table 15 summarises how the various systems theories can be related to the NNPC refineries.

Table 15: Relationship of system theories to the Nigerian refineries.

Systems Theory	**Adaptation to the NNPC Refineries**
General Systems Theory (GST)	GST helps explain how the Nigerian refining sector as an open system interacts with its environment to function in the society.
Cybernetics	The principles of cybernetics enhance the understanding in this study that NNPC refineries can learn from the internal interactions and feedbacks of the factors that inform their sub-optimal performance. As such, this provides opportunities for observing potential leverage points through these interdependencies to address their operational inefficiencies.
Chaos Theory	Considering NNPC refineries as a social system, chaotic behaviour may be observed by the repercussions which wrong decision-making such as a delay in maintenance operation, might set off on the entire refinery plant.
Complexity Theory	Complexity theory can be beneficial for explaining the interrelationships amongst the variables that lead to inefficiency across the NNPC refineries. As the refineries can be classed as a social system with organised complexity, modelling and simulations can be applied to understudy the relationships of the elements operating within the system.

Table 15 shows that the NNPC refineries as a social system can benefit from the four system theories to understand their operational relationships with their internal and external factors. In addition, the influences that have shaped contemporary systems theories, approaches, and the linkages from which they have emerged is as shown in Fig 22.

Figure 22: Contemporary systems theories and approaches



Source|: Adapted from the Open University, 2017

3.7 Justification for systems thinking applications for the Nigerian refining sector.

Systems thinking has been successfully applied to multiple problem-solving areas ranging from local to global levels. Ulrich (1988), Forrester (1994), Meadows et al. (1972), including the OECD in Ramos and Hynes (2019) have all applied the concept of systems thinking for policy analysis, both at national and international levels. Paul and Stroh (1999) applied it to life management and parenting issues. Cole (2019) also applied systems thinking to project management to improve project success. Systems thinking has been equally applied across diverse areas to help conceptualise and analyse issues regarding global warming (Ballew et al., 2019), food security (Roggio, 2019), violence and terrorism (Monat and Gannon, 2015b), and public health (Leischow et al., 2008). Similarly, Ackoff (2008), Senge (1990), Boardman & Sauser (2008), and

Sherwood (2011) have used it to analyse strategic organizational management issues. There is, therefore, a preponderance of evidence that systems thinking can be successfully applied to analyse strategic management issues across Nigeria's NNPC to evaluate the performance challenges across its refining sector.

The relationships that drive systems-thinking transcend traditional linear thinking and requires application of a non-linear holistic approach that enhances deeper understanding of any patterns contributing to the problem under study. Given that the issue of Nigeria's refining sector has lingered for more than two decades, evading all implementation measures as a solution, a holistic approach to understanding all the possible interconnections in the problem is only reasonable. According to Goodman (1997), a problem requires a systems-thinking approach when the issue is important, chronic (not a one-time event), has a known history, and has evaded previous attempts for a solution. Clearly a study on the performance improvement of the Nigerian refineries is a perfect match for this description.

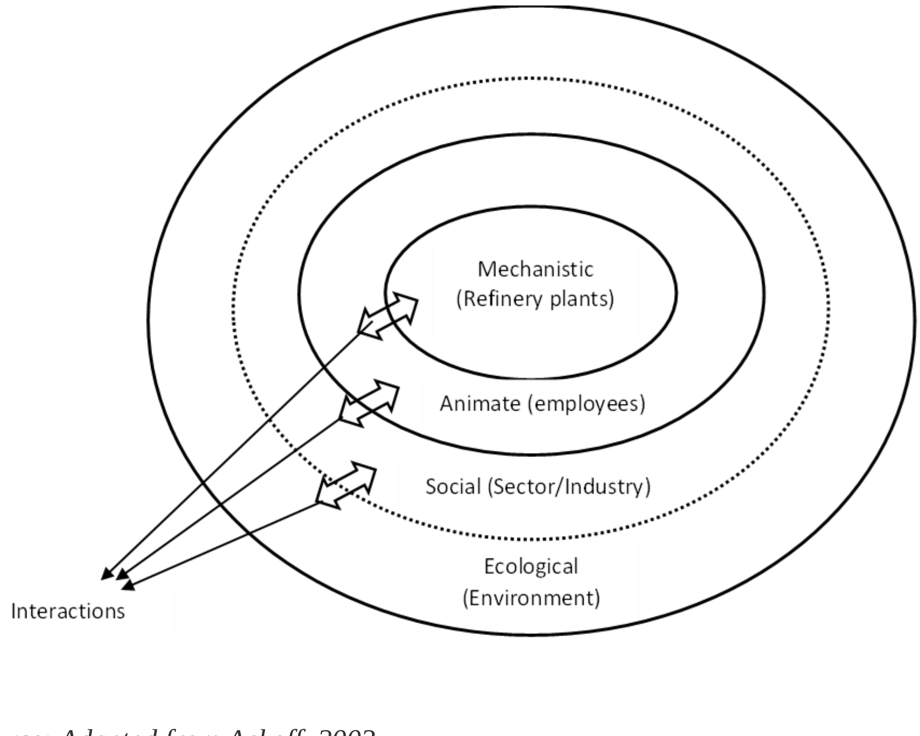
3.8 The Nigerian refining sector as a system

Ackoff (1994) initially proposed three kinds of systems, namely: mechanical, organismic, and social systems. However, in Ackoff (2003), this was updated to four kinds of systems: a *mechanistic system* e.g., machines; an *animate system* e.g., humans; a *social system* e.g., corporations; and an *ecological system* e.g., nature. These systems are claimed to have hierarchies and possess the capacity to incorporate one another according to their levels. They also may or may not have their own purposes. When broken down further, the levels of hierarchy in Ackoff's systems can be related to the Nigerian refining sector as explained below.

Mechanistic Systems: These have no purposes of their own but their parts work together in a systemic manner to produce a functioning of the whole. Examples are clocks, machines, or *a refinery plant*, in this case. On the other hand, *Animate Systems* can be conceived as purposeful systems. Although the parts have no purpose of their own, the whole has one essential purpose – survival. Animate systems are living systems that are necessarily open, in the sense that they must interact with and respond to their environment to survive. Examples include the human body, plants, and animals or in this case, *people who work in the refinery plant.*

On the other hand, according to Merriam-Webster dictionary, *Social Systems* can be defined as patterns/networks of relationships that constitute a coherent whole which exist between individuals, groups, and institutions. Ackoff (2003) identified three characteristics for social systems as: (1) they have purposes of their own, (2) they consist of parts, some of which are animate, hence have purposes of their own too, and (3) are usually part of one or more larger containing systems, which may have purposes of their own too. Examples of social systems include an organisation e.g., *the NNPC refineries*, an institution, or even a national government. *Ecological Systems* comprise of parts, some of which are purposeful, but the whole is not. For example, the earth is an ecological system, which has no purpose of its own but comprises of social and animate systems that do, and mechanistic systems that do not. In the context of this study, ecological systems can be affected by the activities within their sub-systems. For example, the operation of oil refineries can impact on the ecological environment through pollution. Figure 23 shows the map of Nigeria's refining sector according to Ackoff's System Classes.

Figure 23: Map of Nigeria's refining sector based on Ackoff's system classification.



Source: *Adapted from Ackoff, 2003.*

Figure 23 implies that the Nigerian refining sector can be considered as a social system with sub-systems comprising humans (animate) working towards serving the wider economy through the operations of plants and machinery (mechanistic). The entire social system is surrounded by a boundary which is open and continuously interacts with the larger external environment (ecological). This system can be conceptualised through the lens of a framework to help visualise how it interfaces with the challenges operating within its macro-environment.

3.9 Justification for PESTEL framework

Srdjevic et al. (2012) identified SWOT (Strengths Weaknesses Opportunities and Threats) and PESTEL (Political, Economic, Social, Technical, Environmental and Legal) as the two most popular frameworks available for strategic planning and analysis of an organisation's business environment, which are also mostly used in management studies. Both SWOT and PESTEL take into consideration the external and internal factors of an organisation's business environment.

Introduced in the 1960s by Albert Humphrey, the SWOT model was originally proposed to reinforce an organisation's business strategy by assessing its strengths and weaknesses, including its opportunities and threats (Jain, 2015; and Helms & Nixon, 2010). Presently, the use of the SWOT model has been extended to include the identification of strategic options by linking the internal and external factors that influence an organisation's performance within its business environment (Srdjevic et al., 2012). However, SWOT has been criticised over its vagueness and over-simplification of complex business situations, thereby requiring the search for a more robust and effective alternative model such as PESTEL (Teoli et al., 2019 and Helms and Nixon, 2010).

The PESTEL framework evolved from PEST (Political, Economic, Social and Technical) factors, initially introduced in the 1980s by Fahey and Narayanan (1986) for the analysis of an organisation's business environment from a macroeconomic perspective. Over time, the framework has been used in various forms. Richardson (2006) used it as STEPE to account for the constraints limiting the development of Turkmenistan's information economy. Boateng et al. (2015) used it as STEEP to analyse the construction risks of the Edinburgh Tram project. Pan et al. (2019) used PESTEL to examine the constraints within the construction industries of Singapore, Hong Kong, and the United Kingdom.

PESTEL provides a multi-faceted approach for assessing the entire perspective of forces necessary to understand an organisation's business position (Song et al., 2017). According to Yuksel (2012), the environment in which an organisation operates has two components – the internal and external environment. While the internal environment deals with the resources and capabilities of the organisation, the external environment involves factors beyond the organisation's physical control, which nevertheless affects its operations (Fleisher and Bensoussan, 2003). An organisation's external environment comprises the macro environment and sectoral environment. Ulgen and Mirze (2007) noted that the sectoral environment comprises where the organisation procures its inputs, sells its products, and services, and also competes with its rivals. The macro environment, on the other hand, comprises the political, economic, social, technical, environmental, and legal (PESTEL) factors that directly or indirectly affects the organisation's operations. It is this attribute that makes PESTEL suitable for the analysis of the NNPC refineries to understand the extent of the effect of these factors and their sub-factors on the performance of the refineries.

PESTEL is reported to have some limitations to the depth of analysis it can provide an organisation. For example, Yuksel (2012) asserts that PESTEL's qualitative structure typically favours the qualitative method over the quantitative. It is important to note that even though the structure of PESTEL prescribes a holistic approach, previous studies have mostly used it to evaluate each of the factors independently (Katko, 2006; Shilei & Yong, 2009).

However, these shortcomings are overcome by PESTEL's ability to integrate other analytical frameworks for investigation. In other words, PESTEL has the flexibility and effectiveness to integrate both the quantitative and the qualitative methods for analysis. For example, Tsangas et al. (2019) integrated PESTEL-SWOT analyses with the Analytical Hierarchy Process (AHP) to assess the hydrocarbon sectors in Cyprus. Quiceno et al. (2019) also combined PESTEL and SWOT analyses in a case study of the Colombian electricity industry for scenario development and strategic design, while Yuksel (2012) combined the PESTEL framework with AHP to develop a multi-criteria decision model for a Turkish based organisation.

Given the effectiveness of PESTEL for evaluating an organisation's multifaceted problems as evidenced from the foregoing, this study adopted the PESTEL framework to evaluate the problems of the NNPC refineries.

Table 16 summarises the key differences between PESTEL and SWOT for the analysis of an organisation's performance factors.

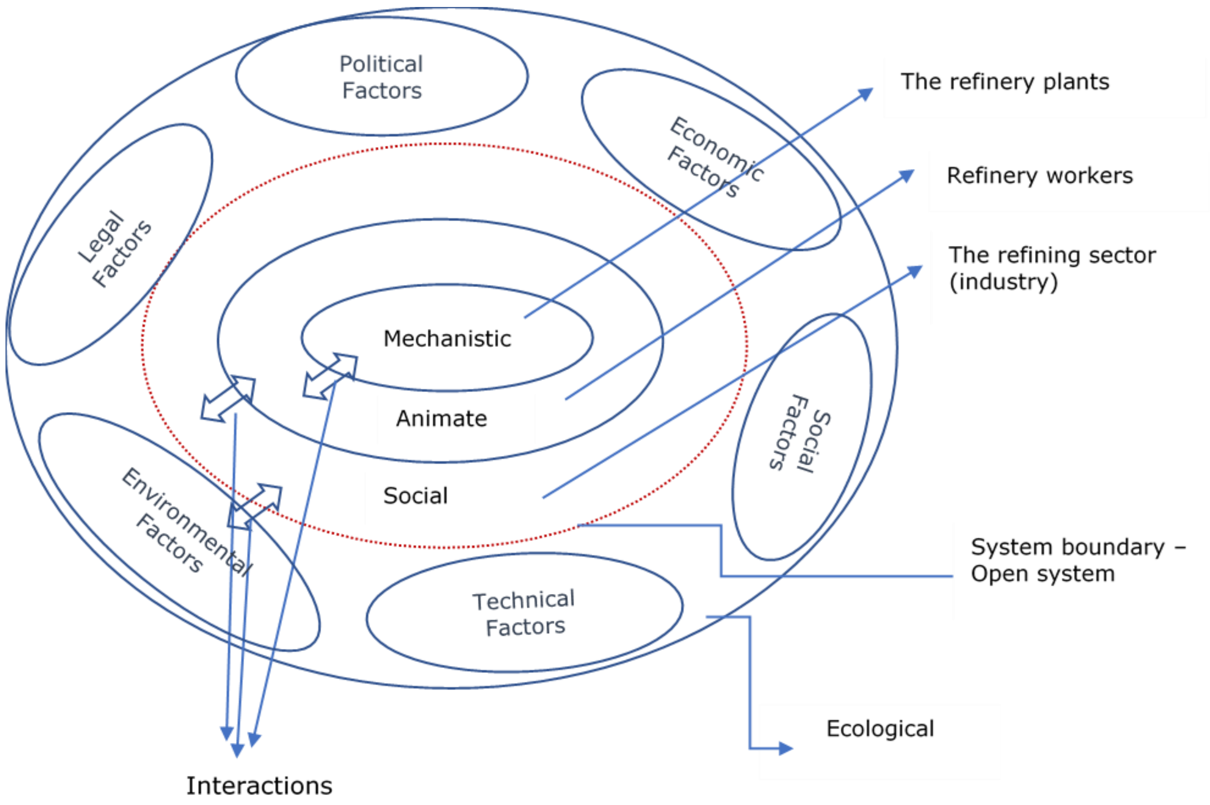
Table 16: A summarised comparison between SWOT and PESTEL framework

Technique/ model	Strengths	Weaknesses	Reason for Adoption/Rejection
SWOT	Favours a quick yes or no decision usually within a small group (Srdjevic et al., 2012). Helps to identify an organisation's strengths, weaknesses as well as opportunities and threats.	Vague and over-simplifies complex business situations. Not suitable for critical reflection by a collective group (Teoli et al., 2019).	Will not offer opportunity for multiple actors over a variety of criteria for complex decision-making processes.
PESTLE	Accounts for all the multi-factors affecting the performance of an organisation from a macroeconomic perspective (Song et al., 2017)	May require efforts and time to identify all the significant factors and analyse their relative strengths (Yuksel, 2012).	Suitable to account for all the multiple factors identified across the refineries.

Table 16 indicates that SWOT is too simplified and lacks the detail required to account for all the multiple factors affecting the NNPC refineries. On the other hand, PESTEL accounts for all the factors and is sufficiently equipped to handle the analysis of the NNPC refineries.

A richer context of the conceptual framework for visualising the challenges of the refineries through the established PESTEL framework may be represented by Figure 24.

Figure 24: A conceptual model of the Nigerian refining sector based on Ackoff (2003)



Source: Author generated, inspired from Ackoff (2003).

Figure 24 shows how the Nigerian refineries visualised as a social system can be understood through the lens of the PESTEL framework.

3.10 Chapter Conclusion

This chapter presented the theoretical and conceptual framework of this study based on systems thinking. It demonstrated that Nigeria's refining industry can be likened to a social system as described by Ackoff's (2003) four classes of systems. As such, it argued that, as a social system, a continuous interaction of the NNPC organisation with its internal and external environment is essential for its continuous operations. To this end, it proposed the suitability of systems thinking tools such as causal loop diagrams (CLDs) as capable of building predictive models to understand and address the issues of the system.

In addition, a justification for the adoption of a PESTEL framework to the analysis of the refinery challenges, was shown to derive from the effectiveness of PESTEL for dealing with the complexities of the identified issues as opposed to SWOT's high level and unsuitable technique for the problems. Therefore, the challenging factors presented within their PESTEL categories will suitably provide a focused context beneficial for policymaking towards resolving the issues.

The next chapter will present the methodology adopted by this study to link these concepts through data collection and subsequent analysis.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.0 Introduction

Having established the conceptual and theoretical framework for this study (Chapter Three), this chapter focused on the research methodology adopted with respect to its philosophical views, approaches, and strategies. An evaluation of different research methods regarding appropriate techniques for data collection and analysis for the study was also presented.

4.1 Research methodology

A research methodology provides the underpinning justification for the choice of philosophies, strategies, and approaches for a research study (Bryman, 2012; Goddard and Melville, 2004). Essentially, the methodology of a research comprises the procedures and techniques employed by the researcher to identify, select, and analyse their research data to achieve the aims and objectives of their study (Leavy, 2017, and Creswell and Creswell, 2017).

Walliman (2015) and Wilkinson & Birmingham (2003) note that there are various research methods available to fulfil different research objectives. While there are multiple research methods, there is hardly any method par excellence (Ormston et al. 2014; Schultze and Miller, 2004). On the contrary, some methods are more appropriate for specific cases than others. According to Conway & Lance (2010) and Descombe (2003), it is important for a research method to be reasonable, explicit, and appropriate for lack of such attributes can lead to doubts and criticisms.

To maintain some structure for this Chapter, the key steps adopted for this research design may be represented as shown in Figure 25. The grid as shown in Figure 25 was made by author from the various steps for research design as outlined by Saunders et al. 2019.

Figure 25: Steps for research design

Philosophy	*Positivism*	*Critical Realism*	*Interpretivism*	*Post-modernism*	*Pragmatism*
Approach to theory development	*Deduction*		*Abduction*		*Induction*
Methodological Choice	*Qualitative*		*Quantitative*		*Mixed methods*
Strategies	*Experimental*		*Case study*		*Action research*
Data collection and analysis	*Semi-structured Interviews*		*Online self-completed questionnaires*		

Direction of progression

Author generated from Saunders et al. 2019

4.2 Research Philosophy

According to Saunders et al. (2016) a research philosophy refers to a system of beliefs and assumptions regarding the development of knowledge. Johnson and Clark (2006) also note that researchers must not only possess the ability to carry out their study within their philosophical preference but must also be able to justify the choice of their philosophies amidst other alternatives. Although philosophical ideas may remain largely hidden in research works, they still influence research practice and need to be clearly identified (Creswell, 2003). As such, research projects are usually guided by basic philosophical worldviews or paradigms (Lincoln, Lynham, & Guba, 2011). According to Saunders et al., (2019), the main philosophical paradigms commonly adopted in management studies include positivism, critical realism, interpretivism, post-modernism and pragmatism as described in Table 17.

Positivism imitates the natural sciences and ultimately relies on meanings derived by sensory experiences and interpreted by reason as authentic knowledge (Bryman, 2012; and Crotty, 1998). As such, it does not accommodate imperfections arising from the complexities inherent in the study of social phenomena within organisations. Critical realism, on the other hand, considers reality as independent and external to the researcher and cannot be accessed by observation and knowledge (Saunders et al.

2016/2019 and Sayer, 2004). As such, critical realism tends to undermine the researcher's knowledge and abilities to interpret the social realities regarding their study. Interpretivism recognises the differences in social realities and acknowledges that humans are capable of creating meanings from social phenomena (Saunders et al. 2019). Unfortunately, interpretivists overly rely on interpretations of social realities with little or no recognition for the value of objective measurements as true knowledge (Lincoln et al. 2011; Guba and Lincoln, 1994). Post-modernism focuses on language to recognise limitations and bias inherent in social order (Chia, 2003). Post-modernists' lack of belief in any right or wrong way to describe the world makes it opaque and inherently flawed to offer any philosophical viewpoint (Willower, 1998).

Table 17: Various research philosophies.

Philosophies	**Definitions and characteristics**
Positivism	Positivism embraces the view that genuine knowledge can be exclusively derived by imitating the natural sciences, whereby only the meanings derived from sensory experiences and interpreted by reason and logic may be regarded as authentic knowledge (Bryman, 2012 and Crotty, 1998)
Critical realism	Critical realism, on the other hand, holds the view that reality is independent and external, but not directly accessible through observation and knowledge (Saunders et al., 2016/2019; and Bhaskar, 1989). In other words, critical realists believe that as social phenomena are produced by mechanisms that are real, they cannot be accessed by direct observation but can only be discerned through their effects (Wynn and Williams, 2012).
Interpretivism	Interpretivism recognises differences in social realities and emphasizes that humans are different from physical phenomena as they create meanings (Saunders et al., 2016). Interpretivists are critical of the positivists' attempt to make definitive universal law-like generalisations and rather argues that a richer and contextual understanding of the social world can be drawn from the interpretations of different meanings of different people (Guba and Lincoln, 1994).

Post-modernism	Post-modernism focuses on the role of language and power relations and seeks to challenge conventional ways of thinking. Post-modernists recognise the inadequacy and bias of language to account for social order (Chia, 2003). In other words, post-modernism believes that as there is no order in the social world beyond that ascribed to it by language, there is then no absolute way of determining the right or wrong way to describe the world (Saunders et al., 2016).
pragmatism	In contrast, pragmatism strives to reconcile facts and values with accurate and rigorous knowledge using different contextualised experiences (Saunders et al., 2016; and Creswell, 2003). Creswell (2003) and Bryman (2012) also note that pragmatists are rather more concerned with what works and aims to provide practical solutions to research problems. Consequently, instead of focusing on methods, pragmatic researchers emphasize the research problems and use all available approaches to understand the problem.

Source: Author adapted from various literature as indicated in the Table.

On the other hand, pragmatism values the meanings and opinions captured in research data as facts that can be accessed through the examination of their practical consequences (Kelly and Cordeiro, 2020). Although pragmatism has been criticised over its approach of adopting a soft stance for what works for a researcher (Denzin, 2010 and Heis-Beiber, 2015), the lack of logic to determine who decides what works has been questioned (Teddlie and Tashakkori, 2003). In addition, Patton (2005) and Kelly & Cordeiro (2020) argue that pragmatism epistemologically steers clear of the metaphysical debates of the nature of truth and reality and focuses on the practical understanding of concrete real-world issues. Feilzer (2010) and Biesta (2010), also note that pragmatism provides the philosophical underpinning for mixed methods in social science research and provides informed solutions to guide future practice. For these reasons, pragmatism was considered most suitable for this study as it could afford the researcher an opportunity to apply the relevant research methods to uncover as much detail as necessary from the NNPC refineries.

4.2.1 Philosophical Assumptions

The philosophical assumptions of this study were based on the views of Creswell & Poth (2018) and Saunders et al. (2019) that researchers consciously or unconsciously make three main kinds of assumptions regarding realities while developing knowledge. These assumptions include ontological assumptions (the nature of entities/knowledge), epistemological assumptions (what counts as knowledge) and axiological assumptions (the role of values in research). These assumptions essentially shape a researcher's understanding of their research questions, choice of methods, and interpretation of findings.

4.2.1.1 Ontology

Ontology deals with the classification and explanation of entities (Bryman, 2012). A researcher's ontological assumptions shapes the way they see and study their research objects (Saunders et al., 2016; and Creswell and Poth, 2018). Such objects may include organisations, management, events, and artefacts. In social sciences, ontology considers whether social entities can be regarded as objective entities with a reality external to social actors (objectivism); or should be regarded as social constructs built from the perceptions of social actors (constructionism) (Bahari, 2010).

In a social context, the ontological emphasis on the interactive nature of an organisation becomes more significant when viewed through the lens of systems thinking. This is because humans can be regarded as active agents within an organisation with behaviours conditioned by ongoing processes of perceptions, interpretations, and creation of meanings (Hammond, 2005). This paradigm appears to support the interpretivist theory, which can be helpful for drawing out meanings while interpreting the relationships amongst the causal factors affecting the performance of Nigeria's refining industry. This is because interpretivist researchers believe that access to reality can be gained through social constructions such as language, instruments, consciousness, and shared meanings (Myers, 2008). As such, it is important for a researcher to appreciate the differences between people and their perspectives (Saunders et al., 2016).

4.2.1.2 Epistemology

Epistemology is concerned with the assumptions about knowledge and what constitutes acceptable and valid knowledge, including how knowledge can be communicated to others (Burrell & Morgan, 1979; and Saunders et al., 2016). The multi-disciplinary nature of some backgrounds, especially management studies, makes different kinds of knowledge e.g., numerical data, textual data, audio-visual data, narratives, stories, facts, and their interpretations acceptably legitimate (Saunders et al., 2016). By implication, different epistemological assumptions can provide a researcher with different choice of methods requiring different forms of data collection. This is because, while the positivist assumption may prefer objective facts as the best form of evidence and thereby favour the quantitative method, the interpretivist view may argue that a richer and more complex view of organisational realities can be accounted for through the qualitative method.

Under a systems viewpoint, epistemological consideration of knowledge highlights the dynamic and dialectical nature of knowledge, which emerges out of the complex web of relationships linking the researcher and their object of study (Eilam and Reisfeld, 2017 and Verhoeff et al., 2018). Hammond (2005) argues that the nature of systems is a continuing perception and deception, requiring continuous review of the world and whole systems and their components. As such, systemic knowledge encourages effective communication, the asking of meaningful questions and the discovery of alternative points of view, which promotes participatory decision-making. The knowledge derived from this approach, which supports the qualitative method, will arguably lead to a more effective management for the refineries. The *asking of meaningful questions and the discovery of alternative points of view,* can be drawn from interviews. The information obtained through interviews can also be useful for validating facts uncovered through literature reviews and quantitative surveys (Naes, 2018 and Pehrson et al., 2017).

4.2.1.3 Axiology

Axiology considers the role of a researcher's personal values and ethics, including those of the research subjects in the research process (Saunders et al., 2016). Hebron (1996) opines that a researcher's axiological skills must enable them to articulate their values as a basis for making judgments regarding their research methods. In other words, a researcher's axiology influences their choice of philosophy and data collection techniques. Table 18 synthesized the various methodological assumptions relevant to this study alongside different paradigms.

Table 18 A synthesis of the five main Philosophies in Management

Ontology (The nature of reality)	**Epistemology** (What constitutes acceptable knowledge)	**Axiology** (Role of values)	**Typical Methods**	**Weaknesses and reason(s) for acceptance/rejection in the study**
		Positivism		
Real, external, and independent of the researcher. Granular and ordered	Based on the scientific method using observable and measurable facts to produce law-like generalisations. Uses causal explanations to make predictions as contributions.	Researcher is detached maintaining a neutral and independent mindset from what is researched.	Mainly deductive and highly structured. Employing measurements in typically quantitative methods of analysis, although can incorporate a range of data.	Inflexible and disregards human behaviour which may appeal to a researcher's emotion influencing their objective judgement (Carr, 1994). For this reason, this philosophy is not considered suitable as it would not allow for a comprehensive validation of data through the qualitative method.
		Critical Realism		
Stratified and layered across the empirical, the actual and the real ontological frameworks. External and independent. Makes use of objective structures and observes causal mechanisms.	Adopts relativism in its epistemological stance. Knowledge is historically situated and transient.	Research is value laden. Bias is acknowledged by researcher by world views, cultural experience, and upbringing. Researcher, however, tries to minimise bias	Research is *retroductive* and in-depth making use of historically situated analysis of pre-existing structures and emerging agency. It also employs a range of methods and data types to fit the subject matter.	Although this philosophy can be quite useful for a systems-thinking approach for the Nigerian refining industry given its recognition of the fact that the problems surrounding the sector is historical and relies mainly on pre-existing systemic structures. However, because it encourages bias in a researcher and due to the fact, that the researcher has a common

Ontology (The nature of reality)	**Epistemology** (What constitutes acceptable knowledge)	**Axiology** (Role of values)	**Typical Methods**	**Weaknesses and reason(s) for acceptance/rejection in the study**
		and remain objective as much as possible.		popular knowledge of how things "supposedly work" in NNPC Nigeria, it is rejected as it would not allow the researcher to detach himself from those cultural opinions.
		Interpretivism		
Ontologically, this type of study is complex, rich, and socially constructed through culture and language. It can involve multiple meanings, interpretations, realities, experiences, and flux of processes.	Epistemologically, its theories and concepts are too simplistic. It focuses mainly on narratives, stories and perceptions, and interpretations. It brings new understandings and world views as its contributions.	This is value-bound research in which the researcher is part of what he is researching. Mainly subjective. The interpretation of the researcher is key to their contribution.	Typically, inductive. Making in-depth investigation of small samples through qualitative method. The researcher is reflexive in the process.	Interpretivism has been criticised for its susceptibility to interview bias. It is also difficult to replicate such studies as the effect of time on long term observations can be quite significant (Saunders et al., 2016). For this reason, this philosophy is considered unsuitable for this study.
		Pragmatism		

Ontology (The nature of reality)	**Epistemology** (What constitutes acceptable knowledge)	**Axiology** (Role of values)	**Typical Methods**	**Weaknesses and reason(s) for acceptance/rejection in the study**
Rich, complex and external in its ontological assumption. It believes "reality" is the practical consequence of ideas. It involves flux of processes, experiences, and practices.	The practical meaning of knowledge is placed in specific contexts. Focuses on problems, practices, and relevance; with a view that "true" theories are those that enable successful actions. Its contribution comes from problem solving and informed future practice.	Axiologically, research is value-driven, initiated, and sustained by researcher's doubts and beliefs. Researcher remains reflexive during the entire process.	Typically employs a range of multiple methods, especially mixed methods involving quantitative and qualitative methods. Many a times action research with emphasis on practical solution and outcomes.	This philosophy, which allows flexibility in adopting a range of methods to fit the subject matter, has been criticised as a possible escape route for a researcher from the challenge of understanding the other research philosophies (Sanders et al., 2016; and Bryman, 2012). However, it is considered the most suitable for this study given that the Nigerian oil and gas environment is sometimes difficult to access due to unwillingness to share information (Badmus et al., 2013). As such, a flexible approach that allows the validation of data obtained from one method of inquiry, especially interviews with that from another form, such as questionnaires, will prove more reliable. In addition, since the development of any decision-making model will require the validation of industry experts, this approach will allow such continuous

Ontology (The nature of reality)	**Epistemology** (What constitutes acceptable knowledge)	**Axiology** (Role of values)	**Typical Methods**	**Weaknesses and reason(s) for acceptance/rejection in the study**
				interactions between researcher and industry practitioners, which will help to accurately establish relationships across all the identified factors.
		Post-modernism		
Research is ontologically nominal, rich, complex, and socially constructed through power relations. It believes some meanings, interpretations and realities are dominated and overshadowed by others. It involves flux of processes, experiences, and practices.	Epistemologically, it views what counts as knowledge is decided by dominant ideologies. It focuses on silences and repressed ideologies and tends to give voice to oppressed meanings. It contributes to knowledge by challenging dominant views and power relations.	Research is value-constituted. The researcher and the research are embedded in power relations believing that some narratives are repressed and silenced by others. The researcher is radically reflexive.	It is typically deconstructive – involving reading texts and realities against themselves. It makes in-depth investigation of anomalies, realities, and silences. It usually employs qualitative method of analysis using a range of data types.	This philosophy is considered quite untypical for a systems thinking study due to its unusual challenge of established methods of reliable knowledge. This philosophy is also prone to a lack of coherence and has been criticised for obscurantism and resistance to reliable knowledge (Callinicos, 1990 and McGowan, 1991).

Source: Adapted from Saunders et al., (2016/2019).

From the critical review of the various philosophical paradigms shown in Table 18, pragmatism (highlighted in green borders) emerged as the most suitable paradigm for this study. This is because pragmatism allows the researcher to adopt different methods of inquiry necessary to answer the research questions posed by the study (see Section 4.2). Table 18 further indicates that the ontological, epistemological, and axiological assumptions of pragmatism allow for the adoption of case studies incorporating both quantitative and qualitative approach for investigating the problems of the NNPC refineries. As such, both objective and subjective points of view from different data collection techniques are valued.

4.3 Approach to theory development

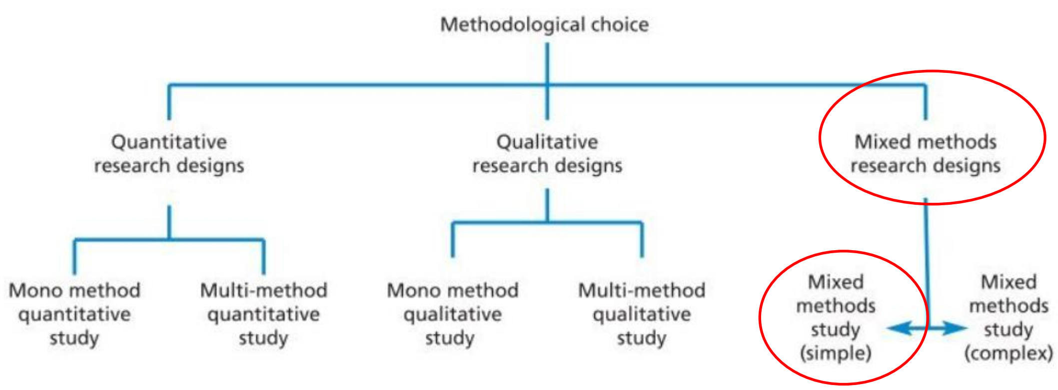
Most researchers identify three main approaches to theory development, namely: induction, deduction, and abduction (Reichertz, 2004; and Douven, 2021). According to Saunders et al. (2019), a deductive approach to theory development involves a researcher beginning with a theory arising from a literature search and progressing to research design to test the validity of such theories. In contrast, an inductive approach involves a researcher commencing with data collection designed to explore a phenomenon to generate or build a theory, usually in the form of a conceptual framework. Whereas an abductive approach involves a researcher collecting data to explore a phenomenon, identify themes and explain patterns such that a new theory can be formulated or an existing one modified, which will further be tested and validated through additional data collection.

To achieve the research objectives of this study as earlier stated (Chapter One, Section 1.3), an abductive approach to theory development is adopted. This is because this study commenced from a literature review to identify the challenges of the NNPC refineries and culminated in the formulation of a theoretical framework based on systems thinking. In addition, the research was designed to validate its findings through additional data collection through interviews from relevant experts within the industry and academia. As such, abduction will be used to prove and validate the theory that systems thinking can be used to explain the causal interrelationships that drive sub-optimal performance across the NNPC refineries. It is important to note that this abductive approach has been shown to be consistent with the pragmatic paradigm already established in this study (Behfar and Okhuysen, 2018 and Saunders et al., 2016).

4.4 Methodological Choice

Creswell and Creswell (2017) identified three main choices of research methods for management and social sciences, namely: qualitative, quantitative, and mixed methods. A qualitative method emphasises words rather than numbers in its data collection and analysis techniques. These techniques include interviews, focus groups, and participant observation to generate non-numerical data for in-depth insights into a problem (Denzin & Lincoln, 2011). It typically leans towards the interpretivist and inductive approach to make sense of its data. A quantitative method, on the other hand, focuses on objective measurements for its data collection and analysis techniques. It utilises techniques such as questionnaires, surveys, polls, and systematic observations to generate numerical data for its analysis. Quantitative methods generally lean towards empiricist and positivist views with a deductive approach to test or shape its theories (Proctor and Capaldi, 2006). Whereas a mixed methods research integrates both the use of quantitative and qualitative data collection and analysis techniques into a single research study. This method helps the researcher triangulate or corroborate the findings of one research method with another. As indicated earlier in Table 18, a mixed methods research is adopted by this study as depicted in Fig 26.

Figure 26: Methodological choice of study



Source: Adapted from Saunders et al. (2016)

According to Creswell &Creswell (2017), and Sanders et al. (2016), while mixed methods is not inherently superior to other research methods, in practice, it can be useful for complementing the results of one method with another and thereby provide better detail and clarity for answers. Mixed methods can be used in parallel such that both quantitative and qualitative data are collected at the same time, or in sequence whereby one method precedes the other (Schoonenboom and Johnson, 2017). Although some researchers have argued that mixed methods may be more time-consuming and may present tremendous challenges to a new researcher, especially when managing both approaches simultaneously (Saunders et al, 2019), mixed methods research has been found to provide broader opportunities to help answer research questions in more elaborate ways than any one method can afford. In that context, a mixed methods approach was considered most suitable for answering the research questions proposed in Chapter 1 (Section 1.2). This is because as stated earlier in Table 18, more reliable information about the NNPC refineries can be uncovered by validating one method of enquiry with another.

It is important to note, however, that this is not to undermine the effectiveness of either the qualitative or the quantitative methods as a single method, but rather a recognition of the fact that NNPC and its subsidiary companies have a known history of unwillingness to release vital information (Jesuleye et al., 2007 and Badmus et al., 2013), and as such would require a flexible approach to access relevant data for this study.

4.5 Research strategy

Research strategies refer to how a researcher proposes to answer their research questions and implement their methodology. In other words, it is a general orientation of how to conduct a research (Creswell and Creswell, 2017; and Bryman, 2012). Denzin and Lincoln (2011) report that a research strategy serves as a methodological link that can ebb and flow between a researcher's philosophy and their choice of methods for data collection and analysis. According to Saunders et al. (2016/2019), some notable research strategies in management sciences include experiments, action research, case studies, archival research, surveys, ethnography, and grounded theory.

The following section briefly examines these strategies with a view of selecting the most suitable research strategy for this study. It should be noted, however, that the suitability of any research strategy should be based on its effectiveness for answering the research questions and achieving the research objectives, including the coherence with which it links to the research philosophy and approach (Saunders et al., 2016).

4.5.1 Experimental research

Experimental research strategy takes its root from the natural sciences and is mostly carried out in controlled environments such as laboratories and requires a high level of precision to determine the effects of a change in one variable against another (Brown, 1992, and Lipsey, 1990). Although experiments are also conducted in the fields of psychology and social sciences, they are more suited for research incorporating predictive hypotheses in which a researcher can control the variables involved rather than in open research questions, where such control is non-existent (Ross and Morrison, 2004; Bryman, 2012 and Saunders et al., 2016). As this study did not involve the experimental research of its subjects in any predictive hypothesis, experimental design was not considered suitable for this study.

4.5.2 Archival research

Archival or documentary research strategies involve the use of a range of archival or documentary materials accessed via online, journals, books, museums, and other sources to carry out their investigations. Such materials are usually one of their kind and may be in the form of audio, visual, and textual formats which provide reliable sources of information (Lee, 2012). Archival research typically presents some problems with data reliability and validity as well as inconsistencies and missing gaps, especially considering their rarity. As such, this kind of research is often combined with other forms of inquiry to complement their findings (Schmidt, 2010). In this study, part of the information used to develop the historical background of some of the refineries were gleaned from NNPC diaries, which are forms of archives.

4.5.3 Action research

Action research can take a variety of forms and usually involves the researcher collaborating with members of a social setting to diagnose a problem and develop a solution (Clark et al., 2020). By implication, action research requires the participation of the researcher within an organisational setting in an iterative manner of enquiry to diagnose issues with a view of proffering solutions to organisational problems (Greenwood and Levin, 2007). Action research is similar to ethnographic research in the sense that both involve participatory activities to understand the phenomena of their investigation. However, Passos et al. (2012) opine that action research differs from ethnography as it focuses more on process and practices that will improve future practice or the creation of new knowledge in organisations. Whereas ethnography focuses more on culture and values and leads to an in-depth understanding of a group's way of life.

Action research strategy could have been ideal for understanding the detailed causal interrelationships between the identified challenging factors for the NNPC refineries. However, as action research requires a high level of cooperation and collaboration between members of the organisation and the researcher, it was difficult to adopt this strategy given distance, time, resource, and access constraints.

4.5.4 Surveys

Surveys are popular in business and management research and are suitable for answering research questions involving "what", "where", "who", "how much" and "how many" questions (Saunders et al., 2019). Survey research strategies usually use questionnaires to collect standardised data from a large sample of respondents, thereby allowing statistical inferences to be made from the analyses of such results (Fowler, 2013). Additionally, structured observations and structured interviews are other forms of data collection techniques employed by survey research (Schatz, 2012). It is important to note that surveys are often incorporated in other forms of research such as case studies (Gable, 1994; and Saunders et al., 2019). In this respect, questionnaire surveys were considered useful for this study. This is because Buckingham and Saunders (2004) note that questionnaire surveys provide effective techniques for gathering statistical information regarding the attributes, attitudes, and actions of research populations. To this end, the opinions of the NNPC workers can be reliably captured through the use of survey questionnaires.

4.5.5 Case studies

According to Yin (2009), a case study research is an in-depth investigation into a phenomenon or topic of interest (which may be a person, a community, or an organisation) within its real-life setting. Bryman (2012) further notes that the goal of case studies is to basically understand how something works. This understanding can be achieved by examining the interactions between a phenomenon and its context (Dubois and Gadde, 2002). Case studies have been criticised by some researchers over their potential inability to produce generalisable and reliable contribution to knowledge (Flyvberg, 2011). Other studies have countered these claims affirming case studies as robust research strategies capable of drawing from both quantitative and qualitative data from a range of sources to fully understand the dynamics of the case (Buchanan and Bryman, 2012; and Saunders, et al., 2016). It is therefore logical to argue that the dynamic interactions between the PESTEL factors within the NNPC refineries (PHRC, KRPC and WRPC) will be well understood through a case study strategy. As such, case study research strategy will form part of this study.

To define a case for a case study strategy, Yazan (2015) recommends that researchers should view their case as "a bounded system" and inquire into it "as an object rather than a process". Stake (1995) also opines that some of the attributes of a case study involve conceptualisations in which a case is "a specific, complex, functioning thing," or more specifically "an integrated system" which "has a boundary and working parts" and is purposive. In this context, the Nigerian refineries can be treated as multiple cases (one per refinery) under a social system.

4.5.6 Types of Case Studies

Yin (2018) uses two discrete dimensions to distinguish four kinds of case studies.

- Holistic versus embedded case studies, and
- Single case versus multiple case studies

A holistic case study deals mainly with the unit of analysis where the researcher may focus wholly on an organisation, while an embedded case study may involve multiple units of analysis within the same organisation investigating different departments or phenomena.

On the other hand, a single case study refers to the representation of a critical or unique case usually selected purposively to typify the case or phenomena under investigation, whereas a multiple case study incorporates more than one case with the rationale for potential replicability across the cases. Saunders et al. (2019) note that adopting a multiple case study approach is not simply related to producing more evidence than in single case studies. In other words, using a multiple case study approach does not necessarily result in more volumes of data or information to justify the case. As a multiple case study approach is usually chosen to allow for replication, it was considered suitable for the research questions posed in this study, which sought to investigate the significant factors affecting the efficiency of all the NNPC refineries (PHRC, KRPC, and WRPC).

To use Case studies, Yin (2003/2009) identified three criteria that should be considered.

1. The type of research questions posed by the researcher.
2. The researcher's extent of control over behavioural events, and
3. The degree of focus on contemporary issues

According to Yin (2009) the typical research questions suitable for the use of case studies are the "what", "how" and "why" questions. From Section 1.2, the research questions posed in this study were clearly preceded with these words. As for the second condition regarding the degree of control, Rashid et al. (2019) opines that case studies are more suitable for conditions where the researcher has no control over behavioural events under investigation. In this study, the researcher did not have any control over behavioural events affecting the performance of NNPC refineries. The researcher merely surveyed the opinions of the experts and was clearly outside the case without any abilities to manipulate the behaviour of events therein. Thirdly, the issues being investigated were quite contemporary and concerns determining the effects of PESTEL factors on the performance of the refineries.

In summary, the rationale for adopting a case study in this research was based on the following:

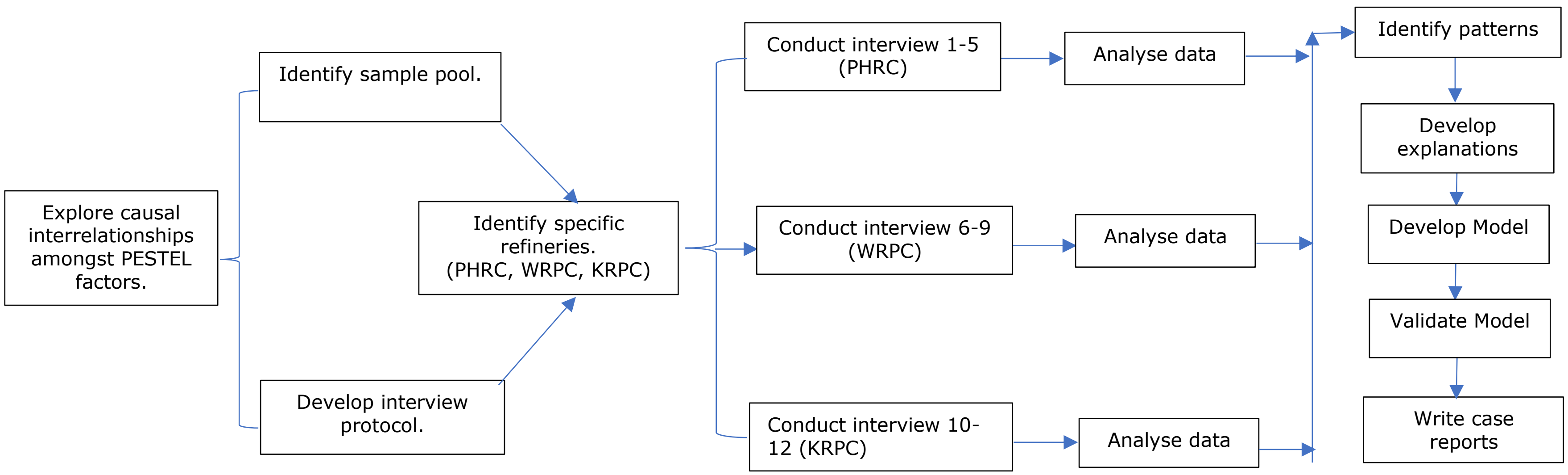
1. Case studies enable a researcher to make an in-depth analysis of one or more units of the selected cases in study (Bryman, 2012). A study on performance challenges across Nigeria's state-owned refineries can be investigated by examining the refineries on how the PESTEL factors impact on their performance. This approach will help provide sufficient detail to identify any policies that may be useful for managing the refineries.
2. Case studies are concerned with the complexity and particular nature of the case in question (Stake, 1995). This study was designed to examine the complexity of the nature of the three cases across the refineries to see if there is a common pattern that can uncover leverage points that will inform good decision-making by government policy makers.
3. According to Yin (2009), Case studies are suitable for answering "What", "How" and "Why" research questions like the ones in this study (see Section 1.2).

4.5.7 Multiple Case Study design

A multiple case study design allows a researcher to explore the phenomenon under investigation by replication strategy. Replication is carried out by selecting cases to explore and confirm or disprove identified patterns observed in the initial case (Zach, 2006). Eisenhardt (1991) and Zach (2006) suggest that if this model produces a situation where all or most of the cases are of similar results, then this could lead to the development of a preliminary theory to describe the phenomenon. Alternatively, a multiple case study may commence with a theory and proceed to case selections accompanied by data collection protocol (Yin, 2009).

This may then be followed by conducting the individual case studies and writing their case reports, which leads to cross-case conclusions and theory modifications. This procedure is as shown in Figure 27.

Figure 27: Multiple Case study procedure.



Source: Adapted from Zach (2006) and Yin (2013).

This study adopted a multiple case study under its qualitative approach to investigate the causal interrelationships amongst the PESTEL factors affecting the performance of NNPC refineries. This is done with a view of confirming or disproving the findings of the questionnaire regarding the performance challenges of the refineries.

4.6 Ethical Considerations

In conducting this study, some important ethical considerations were made as required by a research process. Smith and Quelch (1992) note that ethical standards are designed to ensure that abuse of information and conflict of interest are avoided by a researcher through compliance to certain principles and obligations. As such, all research students at Robert Gordon University are obliged to observe the highest standards of professional conduct in this regard. Prior to the commencement of this study, the researcher sought and obtained permission from Robert Gordon Research Ethics Committee to proceed on this study.

Subsequently, the researcher took steps through a series of measures to ensure compliance to all ethical guidelines. Firstly, the researcher ensured confidentiality and anonymity of the research subjects by ensuring that the participants are not exposed to harm through exposure of their personal information, or any information obtained in the research process. Secondly, the researcher ensured voluntary participation was complied with as research subjects were made aware of their freedom to withdraw or refuse to answer any questions that they may not feel comfortable answering. Thirdly, the researcher adopted a free mindset, maintaining an open mind throughout the research process to mitigate personal biases. In addition, the researcher ensured that the privacy of respondents is respected by asking only professional and logical questions devoid of personal probing. Lastly, the researcher ensured that plagiarism was avoided throughout the research process by making sure that all materials used in this thesis from other works were appropriately cited and referenced (Saunders et al., 2019).

4.7 Method of Data Collection and Analysis

As stated earlier, in their performance appraisal on the government-owned refineries, Badmus et al. (2013), acknowledged the challenge encountered by Jesuleye et al. (2007) in obtaining data from Port Harcourt refinery. Considering the nature of this study, which seeks to understand the causal interrelationships that drive sub-optimal performance across the NNPC refineries, a mixed methods approach that will allow the flexibility to obtain relevant information for this study was adopted. This was also to ensure the quality and reliability of information for this research. Bryman (2012), and Johnson & Onwuegbuzie (2004) suggest that a mixed methods approach complements the strengths of both the qualitative and the quantitative methods of enquiry. As such, this study employed the use of questionnaires and interviews (mixed methods) for data collection and analysis.

4.7.1 Questionnaires

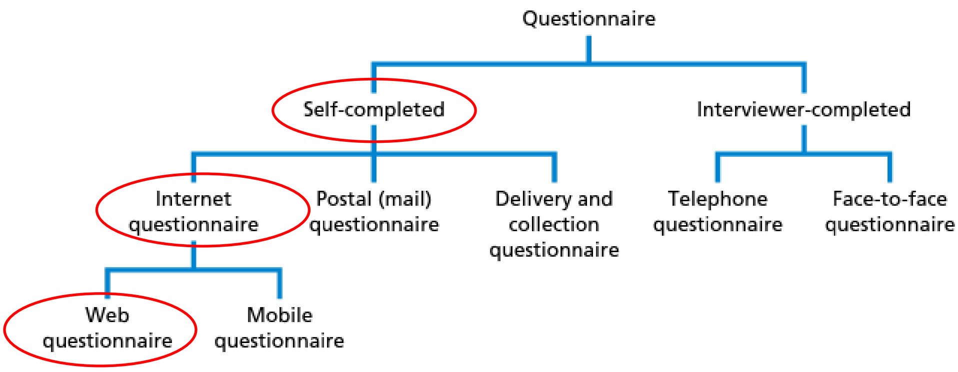
Questionnaires are quantitative research instruments designed to extract measurable and often numerical data from research participants (Krosnick, 2017). Within business and management studies, questionnaires are commonly used with the survey, experimental and case study research strategies (Saunders et al., 2019).

Questionnaires were adopted by this study to obtain the relevant quantitative data from the experts who work across the NNPC refineries. According to Gill and Johnson (2010), questionnaires are particularly helpful for explanatory and descriptive research purposes seeking to identify and describe variability across different phenomena. Thompson (2017) also opines that questionnaires are useful for examining and explaining the cause-and-effect relationships. More appropriately, Boateng et al (2015) and Archaya (2010) demonstrate that questionnaires offer valuable means of quantitative analysis to answer, "*how much", "how many"* as well as ranking research questions, which are useful for determining significance based on the weights of the variables under analysis. This attribute of questionnaires makes them suitable to obtain the more significant factors within a category of research variables. As such, in the context of this research, questionnaires were deployed and quantitatively analysed with proven mathematical techniques to obtain the weightier variables for developing causal loop models for this study. It can be recalled from Section 3.3.3.1 that causal loop models are best developed using the more significant variables to obtain the most relevant interconnections in a system, while keeping the model simple.

The type of questionnaire used in this study was the self-completed, internet-based, questionnaire. The choice of this path for quantitative data collection is based on the fact that the research subjects are experienced enough to answer the research questions for themselves, and as such are not influenced by others in reaching their individual assessments. Secondly, the internet path was chosen for ease of access as the researcher could reliably reach as many participants as possible in a cost-effective manner without having to travel to participant locations. According to Bryman (2012) and Saunders et al. (2016), this approach provides an equally effective means for data collection.

Questionnaires were made accessible to participants via emails and WhatsApp forums containing a hyperlink to a web-based survey form designed with an online tool, *Google forms*. The path for this data collection is highlighted by the red circles in Fig 28, adapted from Saunders et al. (2016).

Figure 28: Questionnaire selection path for the study.



Source: Adapted from Saunders et al. (2016).

The contact details of the research participants were obtained by the help of the researcher's contacts working in these organisations, who also formed part of the research subjects as they fit into the selection criteria. The reason for administering internet-based questionnaires via emails and WhatsApp contacts was to gain a higher level of confidence that the responses came from the right persons and that the process would have little room for collusion and unnecessary duplication (Saunders et al., 2016). This approach was also considered useful to respect the privacy and commercial sensitivity of any information the researcher might obtain as indicated in the ethical considerations for this study (see Section 4.6).

4.7.2 Interviews

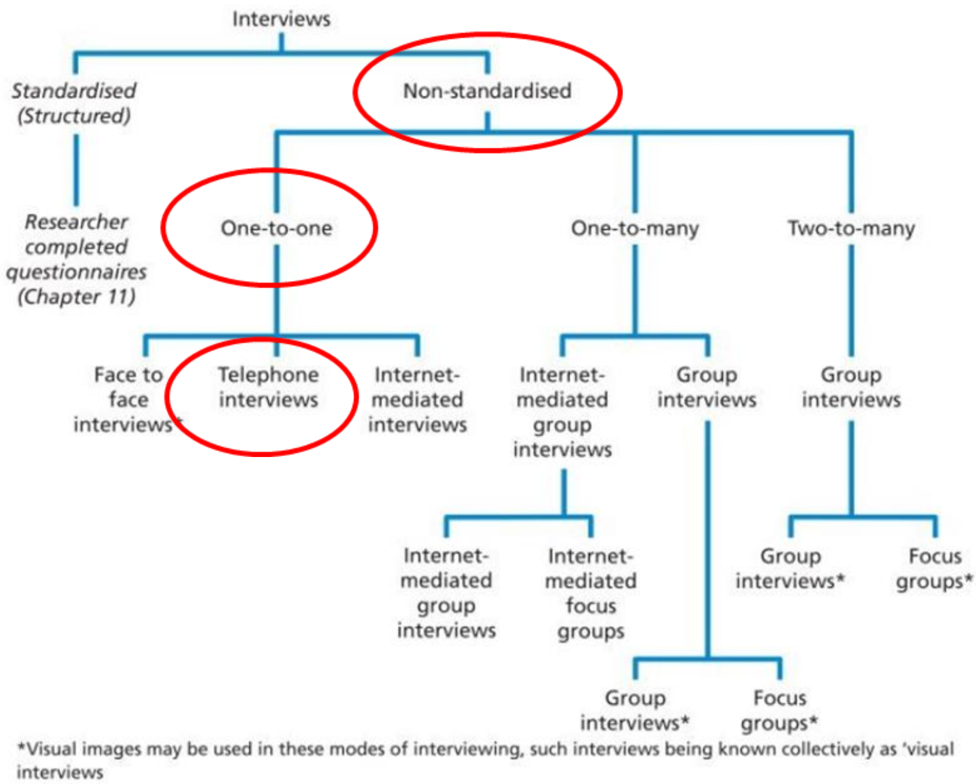
A research interview is a purposeful conversation facilitated by a researcher (interviewer) with research participant (interviewee) to extract useful information that will help answer the research questions (Gillham, 2000). Interviews are useful for capturing the experiences and opinions of research subjects on the phenomena being investigated (Bryman, 2012, Gillham, 2000). Interviews were adopted as the qualitative method of enquiry for this study to explore the interdependencies and causalities of the variables that affect the performance of NNPC refineries.

There are two main kinds of interviews – standardised (structured) and non-standardised interview (Saunders et al., 2016/2019). While the standardised (structured) interview is more applicable for the quantitative method, the non-standard forms of interview are more applicable to the qualitative methods (Bryman, 2012). Since the interviews conducted for this study were to validate the findings of the questionnaire (quantitative method) in a sequential manner, it was logical to adopt the non-standard (semi-structured) route to investigate a selected pool of the questionnaire participants with higher authorities in the organisations on a one-to-one basis. The choice of participants that fit this criteria was determined by a purposive sampling method which targeted respondents with higher years of experience as well as being in some decision-making authority at the refineries. Essentially, the selection took into consideration role-relevance, seniority, authority as well as availability, and willingness to participate in the study. Dawson et al. (1993) acknowledged the importance of choosing interview participants from relevant groups with the highest chances of obtaining more reliable information.

The reason for adopting the semi-structured approach was to allow the researcher some flexibility to further understand how the performance factors in the refineries operationalise based on individual mental models. In addition, a semi-structured interview will enable the researcher to effectively answer some of the research questions (Section 1.2), which comprise of “what”, “how” and “why” questions. Telephone interviews were chosen over face-to-face interviews due to resource and time constraints, as well those imposed by the pandemic. This approach did not affect the effectiveness of the interview as telephone interviews have been proven equally effective in eliciting research responses from research subjects (Musselwhite et al., 2007).

As such, the path for the interview adopted for this study is the non-standard, one-to-one, telephone, semi-structured, in-depth interview as shown in Figure 29.

Figure 29: Path of interview adopted.



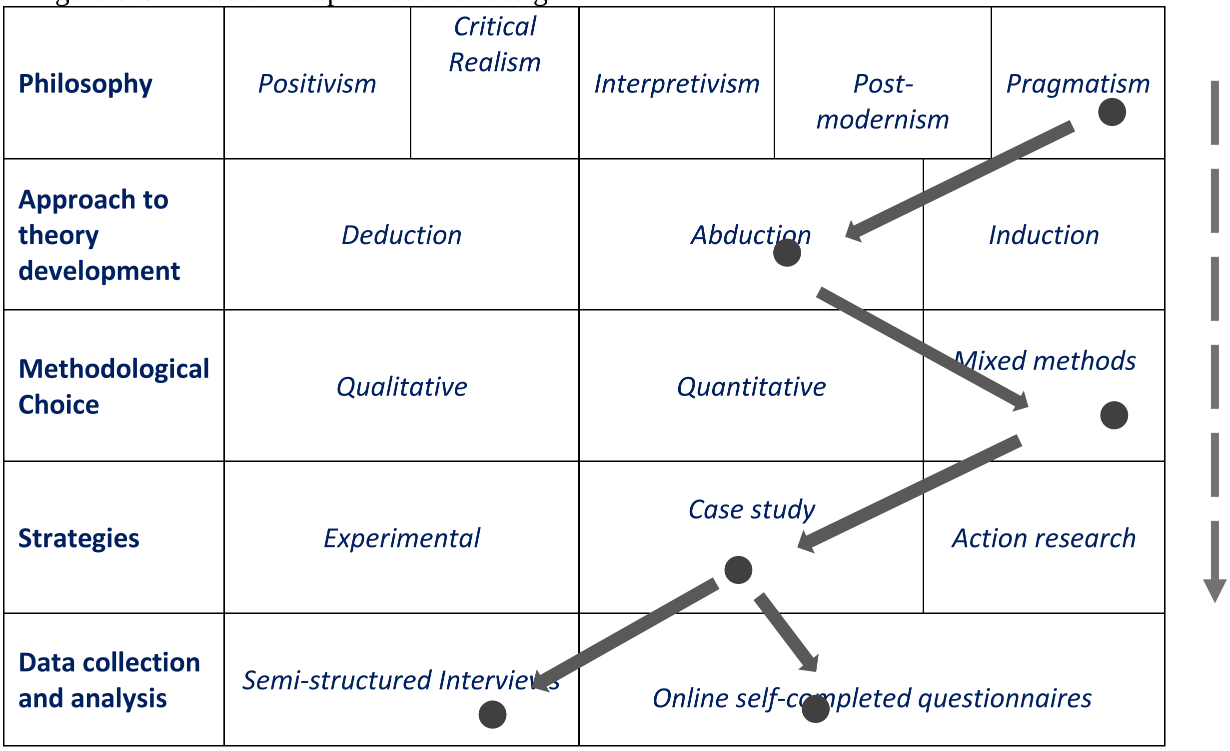
Source: Adapted from Saunders et al. (2019)

The content of the interviews for this study was recorded with an Olympus audio recorder with permission from the respondents. However, some respondents (two respondents) who refused to be recorded, rather preferred to have their words documented as the interview took place. The quality of information recorded in this manner was checked by confirming with the respondents the authenticity of what has been written at the end of each interview.

It is worth noting that access for data collection in this regard was officially facilitated through a request letter from the researcher, which was signed off by the principal supervisor to help gain the cooperation of the refinery authorities (See Appendix 1 and 2)

The overall research design for this study can be logically summarised by the network map as shown in Figure 30.

Figure 30: A network map of research design



Source: Author generated

Figure 30 indicates that this study utilised pragmatism as the philosophy with an abductive approach to its theory development. The Figure further shows that the study adopted a mixed methods approach with a case study research strategy that involves data collection using a semi structured interview and online self-completed questionnaire across the three NNPC refineries. Lor (2011) agrees that a multi-strategy research paradigm can be combined through case studies that collect both quantitative and qualitative data to address the research problems.

Considering the foregoing, it is important to examine how the chosen research methodology for this study connects with the research questions. For example, it can be observed that questionnaires and interviews can be useful for finding the answers to research question 1 (RQ1) - *What are the specific factors that drive the low productivity of the NNPC refineries?* However, for Research Question 2 (RQ2) – *"How can these factors be prioritised such that effective decision making can be inferred?",* it is essential to discuss important strategic decision-making frameworks used for prioritising complex organisational issues.

4.8 Strategic Decision-making Frameworks

Cheng et al. (2010) and Bhushan and Rai (2007) acknowledge the challenges confronting today's business managers and government policymakers amid increasing flux of technological advancement and information overload. As decision-making in big corporations and government agencies usually involve multiple actors, the stakes are often high for errors given the increasing demand for accuracy and reliability. This is because wrong decisions in such organisations can concatenate into disasters with national or international consequences. A typical example of such is the groupthink error that contributed to the United States Space Shuttle Challenger Incident in 1986 (Hughes and White, 2010). Groupthink is a psychological phenomenon which results when the desire for harmony and conformity within a group of decision makers causes them to make irrational decisions that produce negative outcomes (O'Connor, 2002).

The avoidance of similar errors, including those with less magnitude, necessitates the establishment of vital communication links between members of a decision-making group with a view of understanding the syntax and semantics of the underlying issues. Abdulrahman (2015) and Bhushan & Rai (2007) suggest that given the complexity of decision-making requirements which often involve multiple criteria with variables, which may be fuzzy or stochastic, it is essential that organisations adopt comprehensive frameworks for effective decision-making.

Presently, there are structured techniques utilising practical and theoretical advances in the fields of mathematics, artificial intelligence, cybernetics, and operations research to optimise decision-making. Some of these techniques are equipped to deal with conflicting multiple criteria which decision makers may use to either maximise or minimise their combinations to promote the metric of interest within a set of imposed constraints. This is because conflicting criteria are typical for option evaluations. For example, portfolio managers may be confronted by the challenge of balancing the need to bring in high returns while minimising risks, whereas the stocks with the potential of high returns may carry the greatest risks (Andrews et al., 2018 and Sharp, 1991). In the context of this study, while increasing capacity utilisation may be important to NNPC refinery management, ironically, this would require increased spending as well as increased operational downtimes for equipment rehabilitation. It is the need to balance such kinds of objectives that multicriteria decision analysis (MCDA) techniques were created by decision scientists seeking to aid complex decision-making across organisations and government agencies.

4.8.1 Multiple Criteria Decision Analysis (MCDA)

Multiple criteria decision analysis (MCDA) is a complex decision-making tool, which incorporates both quantitative and qualitative factors (Mardani et al. 2015). Wang et al. (2009) opine that MCDA is an operational evaluation and decision support technique suitable for addressing complex problems with high uncertainties, conflicting objectives with multi-interests and perspectives. MCDA belongs to an interdisciplinary field commonly used in the field of operations research, business, and management studies for evaluating multiple conflicting criteria in decision-making. MCDA is profoundly useful for appraising policy options across government and industry. According to Emovon and Oghenenyerovwho (2020), some of the key methods of MCDA include Analytical Hierarchy Process (AHP), Analytical Network Process (ANP), Technique for the Order of Prioritisation by Similarity to Ideal Solution (TOPSIS), Data Envelopment Analysis (DEA), Multi-Attribute Utility Theory (MAUT), Multi-Attribute Value Theory (MAVT), Value Analysis (VA), Decision-Making Trial and Evaluation Laboratory (DEMATEL), Value Engineering (VE), Weighted Product Model (WPM), Weighted Sum Model (WSM), Fuzzy logic, ELECTRE, and VIKOR.

MCDA methods can be used as a single approach or in hybrid combinations for various applications. Stojcic et al. (2019) chronicled the various applications of MCDA methods in single and hybrid forms across civil engineering, supply chain, transport & logistics, and energy sectors. For example, Rashid et al. (2017) combined AHP and TOPSIS to assess the properties of fresh and hardened concrete by varying the amounts of ceramic waste incorporated. Ozcan-Deniz and Zhu (2015) applied ANP for selecting the most environmentally friendly way for highway construction. Zhao and Guo (2014) combined fuzzy entropy and TOPSIS to select the best green supplier in a thermal power project. Klein et al. (2015) employed the WSM technique to compare a wide range of conventional and alternative electricity generation technologies across multiple criteria.

Table 19 Summary of main MCDA techniques commonly applied in management and industrial research

MCDM method	Principle of decision making	Inventor/Year	Merits	Demerits
AHP	Considers the degree of the relative importance of its criteria and alternatives in determining the optimum solution. The problem is generally structured in hierarchical format before a solution is sought.	Thomas Saaty: 1970s	It does not require additional tool for criteria weight determination. It is a tested and proven technique for ranking, prioritisation, and option evaluation.	The technique may become more complicated as criteria and alternatives increases
TOPSIS	Applies the concept of distances to positive and negative solutions to evaluate the optimum alternative.	Hwang and Yoon:1981	The process is quite simple, and the solution procedure does not change irrespective of number of decision criteria and alternatives	The correlation between criteria is not considered in the evaluation of Euclidean distance. In addition, vector normalisation may be required in solving problem that are multi-dimensional.
PROMETHEE	The tool serves as an outranking methodology and solves a decision problem on the basis of comparing alternatives while considering their deviation with reference to a decision criteria.	J. P. Brans and P. Vicke: 1982	The process does not require score normalisation	Criteria weights need to be evaluated with different tools. Additionally, Preference function need to be defined
ELECTRE	The ELECTRE method develops a solution by defining outranking relationships between two alternatives at a time. Some of the variant of the tool are ELECTRE I and II	Benayoun Roy: 1968	The technique can provide solution even when there are missing data	In the absence of software, technique is computationally difficult due to complex evaluation procedures involved
VIKOR	The VIKTOR technique determines optimum solutions by comparing alternatives with respect to measure of closeness to ideal alternative	S. Opricovic: 1990	The approach is an updated variety of TOPSIS	In the face of conflicting scenario, the technique becomes quite challenging to evaluate.

MAUA	The technique offers an avenue for systematic trade-off among decision criteria in order for the best option to emerge from the various alternatives	P.C. Fishburn: 1965, R.L. Keeney: 1969, H.R. Raiffa: 1969	Preference order for alternatives is evaluated simultaneously	Decision attribute outcome is uncertain
WSM	In this approach, the optimal solution is the one with the best value of the weighted sum. For beneficial criteria, the best value is the maximum while for the non-beneficial criteria the best value is the minimum.	L. A. Zadeh: 1963	The calculation is easy and can be implemented without any software	The technique is normally suitable for problems having the same type of criteria. It is either all criteria are beneficial, or all criteria are non-beneficial
WPM	The technique is very similar to WSM. The only difference is instead of using addition operation applied in WSM, a multiplication operation is performed in WPM	Bridgeman: 1922	The evaluation process is simple and can be implemented without software	The approach is generally applicable to decision problems with same type of criteria.

Source: Adapted from Emovon and Oghenenyerovwho (2020)

Dimic et al. (2016) developed a model for strategic transport management by combining DEMATEL, ANP and Fuzzy Delphi.

Table 19 adapted from Emovon and Oghenenyerovwho (2020) shows some of the MCDA methods alongside their strengths and weaknesses based on which the Analytical Hierarchy Process (AHP) is the most suitable technique for answering Research Question 2 (RQ2) given its reliability for ranking and prioritisation.

4.9 The Analytical Hierarchy Process

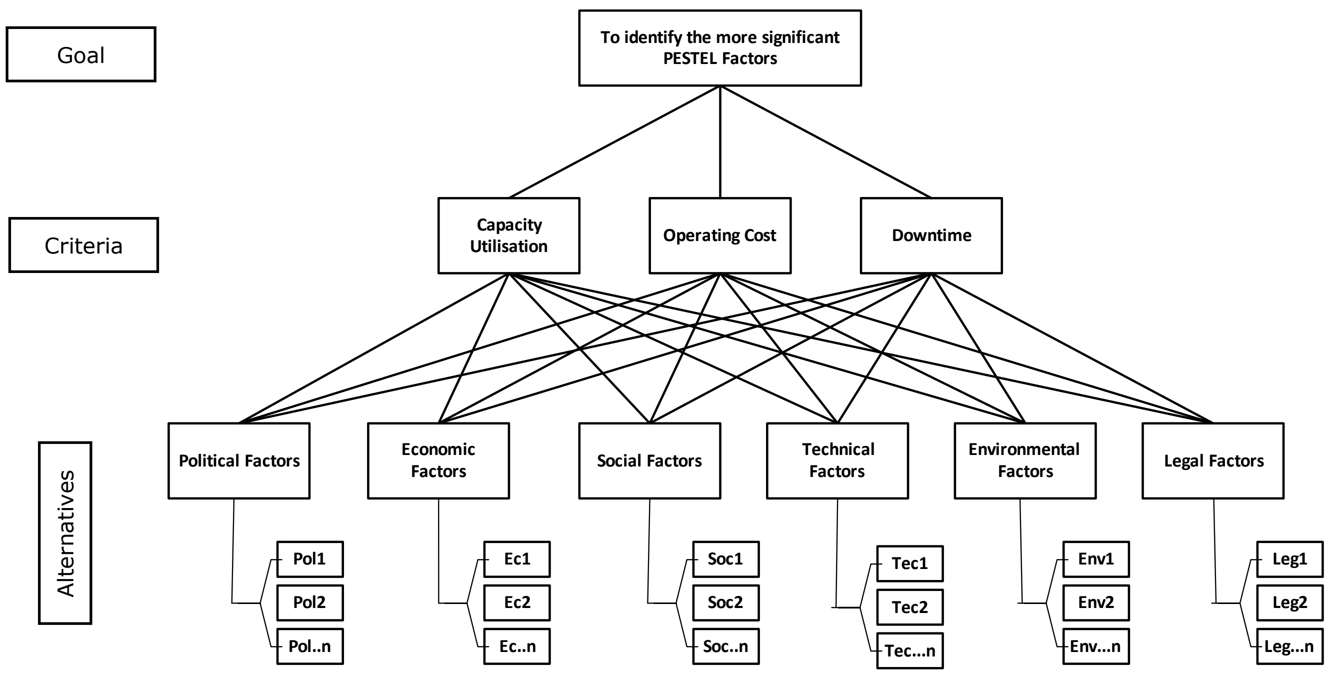
The Analytical Hierarchy Process (AHP) is a structured mathematical model developed by Thomas Saaty in the 1970s in support of decision theory. It is a systematic approach developed to aid complex decision-making based on experience, intuition, and heuristics (Bhushan and Rai, 2004). The technique is recognised as the most popular multi-criteria decision analytical tool for structuring and organising a problem into a decomposed set of hierarchies with prioritised alternatives as outcomes (Mardani et al., 2015). The simple logic employed by AHP, and its ease of use has made it attractive and resourceful for aiding complex decision-making across government, industrial and commercial sectors. For example, AHP has been applied for resource allocation (Ramanathan and Ganesh, 1995; Kwak and Lee, 1998); location allocation (Badri, 1999); planning and development (Nepal et al., 2010); costing implementation (Omotayo et al., 2020); spare parts inventory (Gajpal et al., 1994); and for optimum portfolio selection (Marasovic and Babic, 2011; and Badri, 2001). Vaidya and Kumar (2006) also report that AHP possesses the flexibility to be integrated with other analytical techniques such as Linear Programming, Fuzzy Logic, Quality Function Deployment etc. to develop solutions to complex problems. For example, Gonzalez and Pradenas, (2019) and Stojcic et al. (2019) summarised several papers which combined AHP with other decision support methodologies to solve complex decision-making problems.

AHP uses ratio scales to make pairwise comparisons between the factors under consideration (Saaty, 1977). It starts with the decision maker laying out the overall hierarchy of the decision factors involved. The decision hierarchy includes the overarching goal of the decision, the criteria for consideration and the alternatives.

In the context of this study, the overall goal for using the AHP is to identify the more significant PESTEL factors that affect the performance of the NNPC refineries. The AHP will also help determine the order of priorities for these factors based on the judgement criteria which have previously been established as capacity utilisation, operational cost, and operational downtime (Section 2.9). The alternatives, which represent the expected outcomes are the order in which the political, economic, social, technical, environmental, and legal (PESTEL) factors would be prioritised. The prioritised factors obtained by the AHP would provide the input variables for the causal loop model, which will explore the interrelationships amongst these factors based on systems thinking (see Section 3.3.3.1).

Following the guide provided by Saaty (2004), the structure of the AHP for this study can be represented by Figure 31.

Figure 31: The structure of the Analytical Hierarchy Process



Source: Author generated

Figure 31 shows that AHP is structured according to hierarchies with an overarching goal at the top followed by the decision criteria (and sometimes sub-criteria) at the middle and ending with alternatives at the bottom.

According to Taherdoost (2017) and Bhushan and Rai (2004), the methodology for using AHP is as shown by the following steps:

1. The problem is decomposed into a hierarchy of goal, criteria, sub-criteria, and alternatives (Figure 32).
2. Data are collected from the experts or decision-makers according to the hierarchic structure based on pairwise comparisons. The fundamental ratio scale (Table 20) provides a guide for decision makers for the judgement ratings.

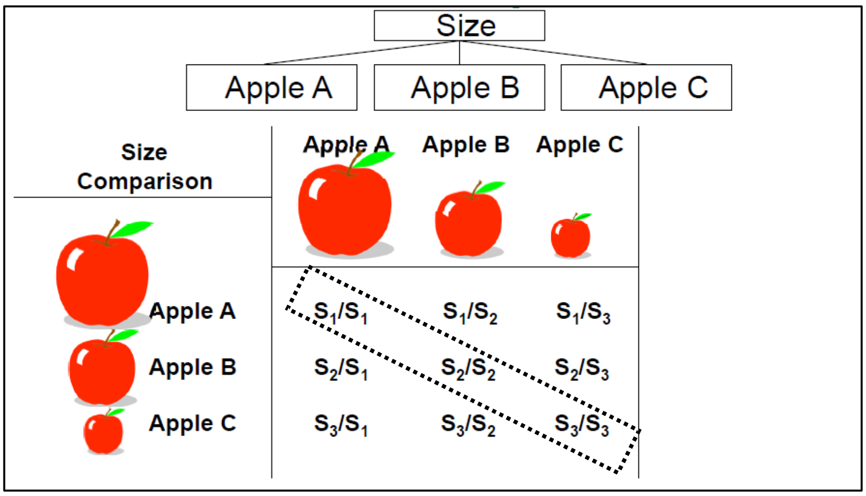
Table 20: Fundamental scale of pairwise comparison and judgement

	Option	Numerical Value
1	Equally preferred	1:1
2	Equally to moderately preferred	2:1,3:2,4:3,5:4,6:5,7:6,8:7,9:8
3	Moderately preferred	3:1,4:2,5:3,6:4,7:5,8:6,9:7
4	Moderately to strongly preferred	4:1,5:2,6:3,7:4,8:5,9:6
5	Strongly preferred	5:1,6:2,7:3,8:4,9:5
6	Strongly to very strongly preferred	6:1,7:2,8:3,9:4
7	Very strongly preferred	7:1,8:2,9:3
8	Very to extremely preferred	8:1,9:2
9	Extremely preferred	9:1

Source: Chen et al., 2011

3. The pairwise comparisons generated in Step 2 are organised into a square matrix to aid calculations that will derive the alternative priorities. The diagonal elements in the square matrix must be 1 as shown in the pictorial matrix (Figure 33), in which *S1/S1*, *S2/S2*, and *S3/S3* would be equal to 1.

Figure 32: Square Matrix of AHP's Pairwise comparison (Saaty, 2004)



To evaluate the matrix for a given element A $_{(i, j)}$, the criterion in the *i*th row is better than the criterion in the *j*th column if the value of the element (*i*,*j*) is more than 1; otherwise the criterion in the *j*th column is better than that in the *i*th row (Saaty, 1980/1977; and Bushan & Rai, 2004). This comparison matrix, A, is as shown by Equation (1).

$$A = \begin{bmatrix} S1/S1 & S1/S2 & S1/S3 \ldots\ldots S1/Sn \\ S2/S1 & S2/S2 & S2/S3 \ldots\ldots S2/Sn \\ S3/S1 & S3/S2 & S3/S3 \ldots\ldots S3/Sn \end{bmatrix} \quad \ldots\ldots\ldots\ldots (1)$$

4. The principal eigenvalue and the corresponding normalised right eigenvector of the comparison matrix give the relative importance of the criteria being compared. The elements of the normalised eigenvector are the weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives.

Using a ratio matrix similar to the one in equation (1), equation 2 is given as follows:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \ldots & 1 \end{bmatrix} \quad \ldots\ldots\ldots (2)$$

To determine the ranking of each element in the ratio matrix, the value of eigenvector, $\lambda_{\max}$ is calculated as shown in equation 3.

$$\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \ldots & 1 \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \lambda_{max} \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} \quad \ldots\ldots\ldots (3)$$

In solving for the rankings, equation (3) can be reduced to the equation (4) as shown:

$$AW = \lambda_{max} W \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where W is the weight of the alternatives in question,

5. The consistency of the matrix of order, *n*, is evaluated according to equation (5) as shown:

$$CI = ((\lambda_{max} - n)/ (n -1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where CI is the Consistency Index, λ_{max} is the maximum eigenvalue of the judgment matrix.

CI is usually compared to that of a random index (RI) to derive the Consistency Ratio (CR) as shown in equation 6:

$$CR = CI/RI \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (6)$$

According to Saaty (1980), CR must be less than 0.1 to satisfy the consistency of the judgment evaluations; otherwise, answers may be re-examined.

According to Saaty (1980), the Random Index Table from where RI values corresponding to the number of elements in the matrix is as show in Table 21:

Table 21: Average Random Index Table

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45

Source: Saaty, 1980

6. The rating of each alternative is multiplied by the weights of the sub-criteria and aggregated to obtain local ratings with respect to each criterion. The local ratings are then multiplied by the weights of the criteria and aggregated to get the global ratings.

From the foregoing, it is logical to conclude that the AHP technique is valid for answering research question 2 (RQ2) in this study (Section 1.2) – "*How can these factors be prioritised such that effective decision making can be inferred*?

At this point, it will be beneficial to review the various research questions relating to this study and how the questionnaire questions will further develop. Table 22 summarises these developments.

Table 22: Summary of research questions and formulation of questionnaire questions

	Research Questions	Issues learned from Literature	Generalised Questionnaire/Interview questions
1	What are the specific factors that drive the low productivity of the NNPC refineries?	The specific factors cut across political, economic, social, technical, environmental, and legal factors. Their sub-category factors are listed in Table 10, Section 2.4	How would you rank the impact of the PESTEL factors and their sub-category factors on the refineries' performance?
2	How can these factors be prioritised such that effective decision making can be inferred?	The AHP has been justified as a reliable technique for prioritisation. Three criteria (capacity utilisation, operational downtime, and operational cost) representing key performance indicators of refineries have been selected for this analysis	How does the PESTEL factors affect the performance of the refineries in terms of the selected criteria?
3	How do the factors significantly interrelate and how can these be modelled?	Systems thinking provides a good framework for modelling interrelationships between causal variables.	How does each of these PESTEL factors influence one another regarding performance of the refineries?
4	How can these analyses produce outcomes that will guide policymakers to inform solutions that will improve future practice in Nigeria's refining industry?	Systems thinking produces causal loop models that can uncover leverage points for policies that can improve organisational performance.	How can policy changes regarding PESTEL factors be used to guide performance improvement?

The questions indicated from Table 22 informed the data collection, the result of which is presented and analysed in Chapter 5.

4.10 Research reliability and validity

Ensuring the reliability and validity of a research study is an important part of an academic research. Hermon and Swartz (2009) opine that research reliability denotes the dependability and consistency of the research data. Reliability also refers to the faith that can be obtained from the research instrument and the degree to which it controls for random error (Mohajan, 2017).

To ensure reliability for this study, the researcher adopted the following measures:

- Carried out an initial pilot-test on the research instrument (questionnaire) with 25 participants representing about 10% of the target population and used the outcome to improve the questionnaire quality before its final deployment across the organisation.
- Carried out a consistency check according to Saaty's (2004) guidelines (Equations 5 and 6) to ensure the responses form the questionnaires were acceptable.
- Carried out a thorough check of the research transcripts during qualitative data analysis to ensure that errors were eliminated
- Carefully coded research themes arising from data collected to match research findings without shifting meanings of research participants to suit researcher's beliefs.

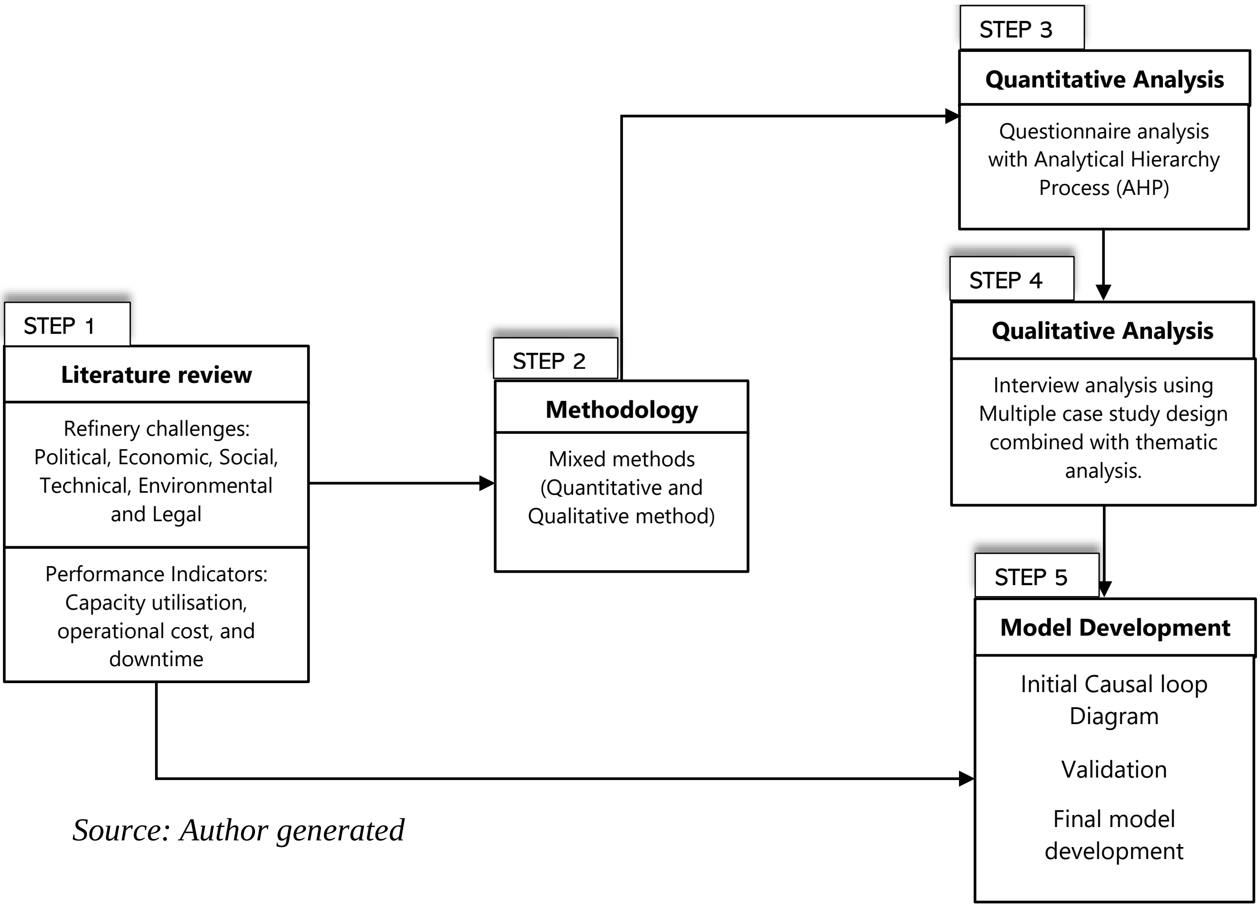
On the other hand, research validity entails the appropriateness of the research design and data collection techniques for answering the research questions (Bryman, 2012). To ensure the validity of this study, the researcher followed the guidelines recommended by Shenton (2004) by adopting the following steps:

- Employing appropriate and well recognised research methods (credibility)
- Provision of adequate background to the study to establish context (transferability)
- Employing overlapping methods through triangulation afforded by the sequential mixed methods approach incorporated to promote repeatability (dependability)

- Admission of researcher beliefs and assumptions and triangulation to reduce researcher bias (confirmability)
- Spending sufficient time in data collection to ensure an in-depth understanding of the phenomenon under study.

The overall research framework developed for this study can be represented by Figure 33 as shown.

Figure 33: Research framework



Source: Author generated

Figure 33 shows that the study commenced with a literature review to identify the various challenges confronting the NNPC refineries using the PESTEL framework. It also established the performance indicators for the refineries, as well as the methodology employed (mixed methods). Finally, the framework shows the method for model development from initial model through validation to final model.

4.11 Chapter Conclusion

This chapter articulated the various methodologies employed by this study, including the rationale behind their selections. It evaluated the effectiveness of the various research strategies and identified a case study research strategy as most suitable for investigating the problems of the NNPC refineries. It further argued that a pragmatic paradigm incorporating a mixed methods approach to data collection was essential to obtain a complete and reliable set of data for the study. This decision was primarily based on literature evidence recounting the experience of previous researchers who encountered difficult challenges with data collection with one method of enquiry while understudying the refineries (Jesuleye, 2007 and Badmus et al., 2013).

Lastly, the chapter justified the adoption of the Analytical Hierarchy Process (AHP) as a proven structured mathematical technique for ranking and prioritisation suitable to obtain the significant challenging factors affecting the refineries.

The next chapter will discuss the techniques for data collection and analysis based on the methodologies selected in this chapter.

CHAPTER FIVE: DATA COLLECTION AND ANALYSIS

5.1 Introduction

Having established the research methodology for this study in Chapter Four, this chapter further validates the details of the data collection and analysis techniques employed. As such, it describes the details of the mixed methods approach to data collection, which was applied in a sequential manner with the questionnaire survey being carried out before progressing to the interviews. In addition, the analyses of data from both methods of enquiry involving the AHP for the quantitative and thematic analysis for the qualitative were presented accordingly.

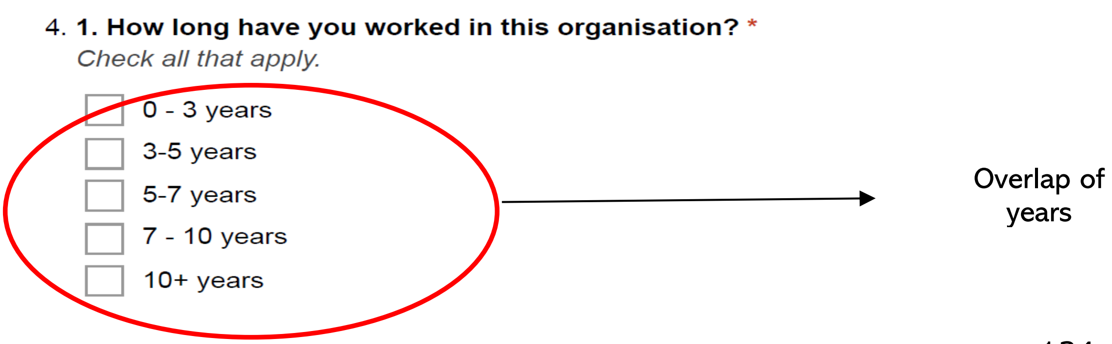
5.2 Pilot Study and Survey Questionnaire Design

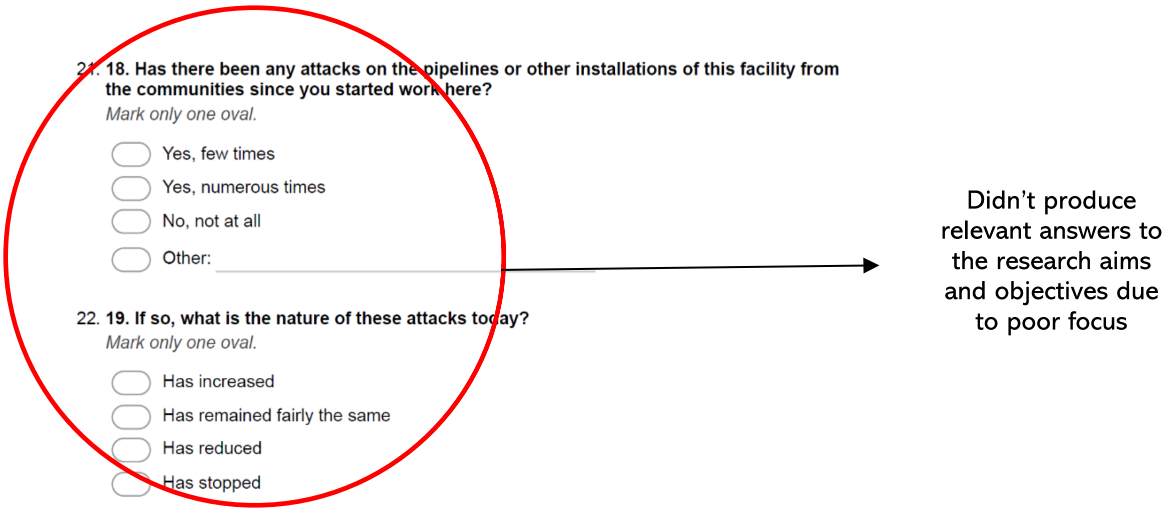
Using the categorised PESTEL factors identified from the literature, a pilot test of 10% of the targeted population of the staff of the refineries was carried out. This is because the study was focused mainly on the employees of the refineries as the study population. The researcher utilised the help of a few of his contacts at the refineries to select willing participants amongst this population on a simple random basis. The pilot was done to ensure that the questions on the questionnaire were clear and unambiguous to the targeted respondents. This practice also afforded the researcher the opportunity to make necessary adjustments to the questionnaire where such issues arose (Krosnick, 2018; and Brace, 2018).

Following the feedback obtained from the initial responses, the questionnaire was slightly modified with some changes on the items on the questionnaire to be more concise, direct and to refocus the questions towards the research objectives. These amendments helped convey clearer meanings to the study participants. Figure 34 shows some of the *before* and *after* sections of the questionnaire as a result of the pilot study.

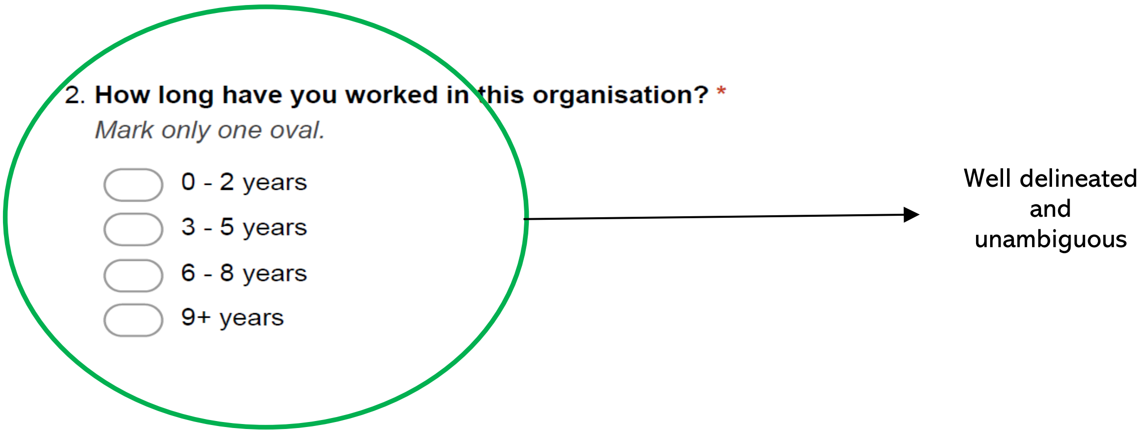
Figure 34: Before and after questions of the pilot study

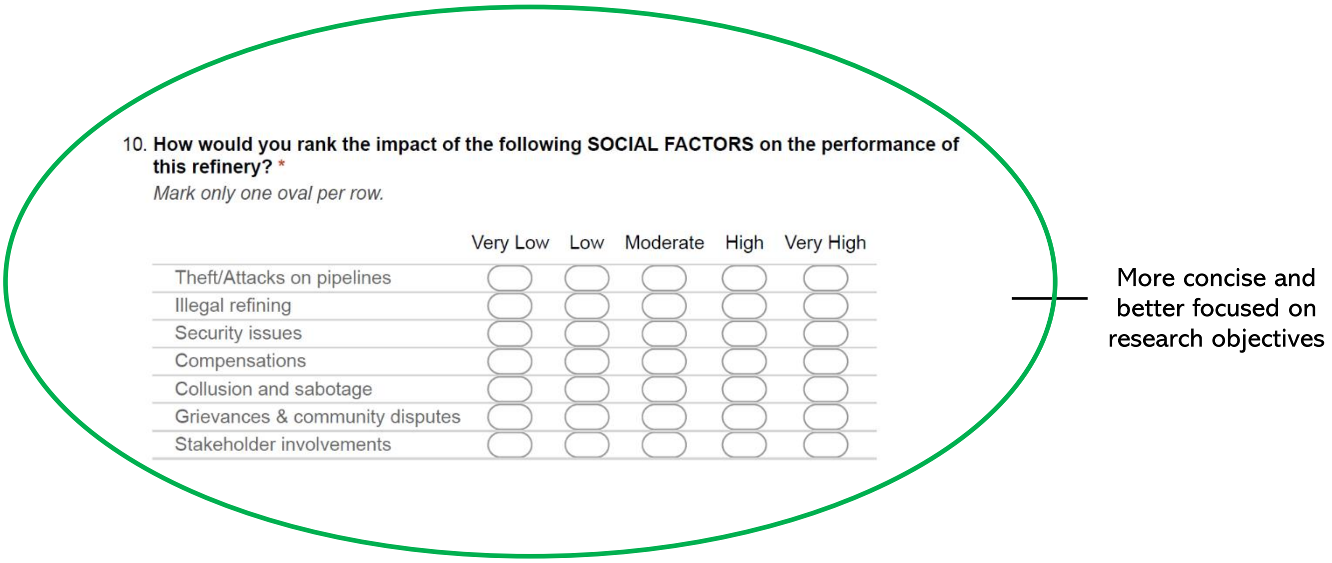
<u>Some of the *before questions* during the pilot study</u>





<u>**Some of the *after questions* of the questionnaire as a result of the pilot study**</u>





Although Bishop and Herron (2015) argue that Likert scales sometimes violate the statistical assumptions required to evaluate them as normally distributed parametric data, Likert-type scale was considered appropriate for this study as it has been proven effective for evaluating the interactive experiences and judgements of respondents in the form of quantified data (Jamieson, 2004; and Kaptein et al., 2010). It is important to note that academic opinions vary on the ideal number of points of scale to choose regarding a Likert-type scales. While Cohen, et al. (2000) recommend the use of a 7-point Likert scale for optimum reliability; Mattel, and Jacoby (1971) argued that the number of scale points on Likert scales does not affect their validity and reliability. However, Ray (1980) determined that adopting a five-point Likert scale increased the internal reliability over a 3-point scale for their results. To this end, a five-point Likert-type scale was adopted for this study to determine the overall assessments of the NNPC workers on various performance issues regarding the refineries.

The targeted population size for the main questionnaires was determined using a 5% margin of error with a 95% confidence level based on the estimated number of direct staff of all the refineries (Bartlett et al., 2001). According to the 2018/2019 released financial statement of the refineries, the number of direct staff who work at the refineries was somewhat evenly spread across the three facilities with a total of 2,023 personnel. Since obtaining responses from all the refinery workers would be practically impossible and not actually required, a 5% margin of error on 2,023 staff members with a 95% confidence level would require 323 interview respondents for the study. See equation 7.

$$\text{Margin of error} = z \times \frac{\sigma}{\sqrt{n}} \qquad \dots\dots\dots\dots\dots\dots\dots (7)$$

Where, n = sample size

σ = population standard deviation

z = z score (the number of standard deviations a given proportion is away from the mean). To find the right z – score, see Appendix 6.

However, after applying the criteria for a minimum of three years' work experience, the number fell to 199 participants. The choice of the three-year work experience was made in addition to the participants' roles within the industry where the participants must be in a field relevant to the refineries operations. This position helped ensure that the participants have some good knowledge of the challenges facing the refineries.

The questionnaire, which explored the level of effectiveness of the various PESTEL factors regarding their impact on the performance of the refineries (See Appendix 5) had a range of 1 – 5 representing *Least impact* to *Highest impact*, respectively. To easily access the survey, an online tool (Google forms) was used to design the questionnaire and cascaded it to appropriate staff of the refineries. The data were collected over a 6-month period from 10 December 2018 to 30 June 2019 as the responses gradually accumulated over time with constant reminders. This timeframe was considered sufficient for all the willing respondents to complete the survey.

For this study, it is important to note that PHRC-I and PHRC-II were treated as one entity (PHRC) as the two refineries are co-located and are essentially run by the same pool of staff as a single company.

The summary of the demographics of the questionnaire participants for this study, which has been cited in a publication carried out as part of this research in Iheukwumere et al. (2021/2021b) is as shown in Table 23.

Table 23: Demographics of questionnaire participants

Participants	**Size**
Targeted Population	200
Respondents	118
Department	
Engineering/Technical	83 (70%)
Administration (HR/Finance/Accounts)	28 (24%)
Managers	7 (6%)
Years of Experience	
3 – 9 years	65 (55%)
10+ years	53 (45%)
Refinery	
PHRC	69 (58%)
KRPC	27 (23%)
WRPC	22 (19%)
Qualifications	
BSC/HND	64 (54%)
MSc	54 (46%)

Table 18 indicates that 118 out of the targeted 199 (59%) participants completed the questionnaire. Although Fowler (2002) argued that there is no standard response rate for research studies, Groves (2006), however, acknowledged that a higher response rate can be indicative of a more reliable survey with better quality allowing limited room for bias. Fincham (2008) opined that a near 60% response rate for a survey questionnaire is not only satisfactory but should be the goal of every researcher. On this basis, the response rate for this study is judged to be satisfactory.

From this data, 83 (70%) of the participants had an engineering/technical background, 24% (28) were from administration, while 7 (6%) have some management positions in the refineries. The spread of the respondents across the refineries were 69 (58%) for PHRC, 27 (23%) for KRPC and 22 (19%) for WRPC. Overall, 65 (55%) of the respondents had 3 – 9 years' experience, while 53 (45%) had 9+ years' experience.

5.2.1 Standardised quantitative results

The questionnaire initially focused on sampling the perception of the refinery professionals on the impact of the PESTEL factors on the performance of the refineries with respect to capacity utilisation, operational cost, and downtime. The respondents ranked their scores from 1 representing *Least impact*, 2 – *Low impact*, 3 – *Moderate impact*, 4 – *High impact* and 5 - *Highest impact*. This was done to provide some insight into how the respondents viewed the effects of each of these factors on the refineries' performance.

These responses were standardised based on participants' years of experience. This was done by multiplying the scores of each participant based on their average years of experience. This approach ensured that professionals with higher years of experience carried higher relative scores compared with their counterparts with lesser years of experience (Boateng et al., 2015). These calculations were tabulated, coded, and summarised in an excel spreadsheet.

Using a weighted quantitative scoring (WQS) method (Equation 7), the relative weights of the three judgement criteria were first determined using the responses to the question: "How would you rank the importance of the following criteria for measuring the performance of this refinery [Capacity utilisation, Operating costs, and Downtime]?"

Based on the WQS method, the Mean Values (MVr) for the relative weights is as expressed by equation 8:

$$MVr = 1/n\left(\sum_{i=1}^{n} \mathrm{Yi(cu, oc, d)}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. (8)$$

Where:

MVr = the value of mean scores of importance for each criteria determined by the WQS

Y = value of each criteria expressed as a percentage of each participant's year of experience multiplied by their score of importance.

I_{cu} = participant's score of importance for criteria on capacity utilisation

I_{oc} = participant's score of importance for criteria on operating cost

I_{d} = participant's score of importance for criteria on downtime

n = total number of research participants (n = 118)

Table 24 is a summary of the standardised participants' score of importance for the three criteria used for pairwise comparisons.

Table 24: Standardised value for criteria

	$1/n\left(\sum_{i=1}^{n} Yi(\mathrm{cu})\right)$ Capacity utilisation	$1/n\left(\sum_{i=1}^{n} Yi(\mathrm{oc})\right)$ Operating costs	$1/n\left(\sum_{i=1}^{n} Yi(d)\right)$ Downtime	Rounded Mean Values (MVr)
Capacity utilisation	3.50			4
Operating costs		3.55		4
Downtime			3.47	3

Having standardised the relative importance of these criteria, the Mean Values for the PESTEL factors against each of the criteria were also standardised as shown in Table 25.

Table 25: Standardised criteria Mean values for the PESTEL factors.

	$1/n\left(\sum_{i=1}^{n} \mathrm{Yi(CU)}\right)$ Capacity utilisation	$1/n\left(\sum_{i=1}^{n} \mathrm{Yi(OC)}\right)$ Operating costs	$1/n\left(\sum_{i=1}^{n} \mathrm{Yi(D)}\right)$ Downtime	Rounded Mean Values (MVr)		
				Capacity utilisation	Operating costs	Downtime
Political	3.54	3.47	3.58	4	3	4
Economic	2.90	3.18	3.07	3	3	3
Social	2.34	2.57	2.50	2	3	3
Technical	3.07	3.15	3.15	3	3	3
Environmental	2.25	2.36	2.31	2	2	2
Legal	2.17	2.20	1.92	2	2	2

CU = Capacity utilisation; OC = Operating cost; and D = Downtime

These standardised set of values (rounded mean values) were used for the pairwise comparisons of the analytical hierarchy process across the three criteria namely: capacity utilisation, operating cost, and downtime. These criteria were used to assess the performance impact of the PESTEL factors on the refineries through ranking. Therefore, using the question: "*How would you rank the impact of the following PESTEL factors with respect to capacity utilisation, cost of operation and downtime on the refineries*?".

The responses of the participants were analysed in a spreadsheet using the AHP equations outlined in equations 1 – 6 (see Section 4.9) and summarised as shown in Table 26.

The steps undertaken to develop Table 26 involved the development of the matrices for pairwise comparison, which helped calculate the priorities, consistency indices and the consistency ratios.

Table 26: Matrix of pairwise comparisons of the PESTEL factors for capacity utilisation, operating cost, and downtime

		MVr	Political	Economic	Social	Technical	Environmental	Legal	Pi	Ranking
Capacity Utilisation	Political	4	1	2	3	2	3	3	0.3268	1
	Economic	3	½	1	2	1	2	2	0.1884	2
λ max = 6.0138	Social	2	1/3	½	1	½	1	1	0.0988	3
CI = 0.0028 RI = 1.25	Technical	3	1/2	1	2	1	2	2	0.1884	2
CR = 0.0022	Environmental	2	1/3	1/2	1	1/2	1	1	0.0988	3
	Legal	2	1/3	1/2	1	1/2	1	1	0.0988	3
	Political	3	1	1	1	1	2	2	0.2000	1
Operating Cost	Economic	3	1	1	1	1	2	2	0.2000	1
λ max = 6.0000	Social	3	1	1	1	1	2	2	0.2000	1
CI = 0.00	Technical	3	1	1	1	1	2	2	0.2000	1
RI = 1.25	Environmental	2	1/2	1/2	1/2	1/2	1	1	0.1000	2
CR = 0.00	Legal	2	1/2	1/2	1/2	1/2	1	1	0.1000	2

		MVr	Political	Economic	Social	Technical	Environmental	Legal	Pi	Ranking
Downtime	Political	4	1	2	2	2	3	3	0.3102	1
	Economic	3	1/2	1	1	1	2	2	0.1703	2
λ max = 6.0138 CI = 0.0028	Social	3	1/2	1	1	1	2	2	0.1703	2
RI = 1.25	Technical	3	1/2	1	1	1	2	2	0.1703	2
CR = 0.0022	Environmental	2	1/3	1/2	1/2	1/2	1	1	0.0895	3
	Legal	2	1/3	1/2	1/2	1/2	1	1	0.0895	3

Legend: *λ max = Maximum eigenvalue, Pi = Priorities, CI = Consistency Index, RI = Random Index, CR = Consistency Ratio (= CI/RI)*

The priorities (Pi) as indicated in Table 26 were calculated using the Row Geometric Mean Method (Ri) with the pairwise *N* x *N* comparison matrix as expressed by equation (9) and standardised as shown by equation (10) (Escobar et al., 2004).

$$Ri = \left(\prod_{i=1}^{N} A\,i,j\right)^{1/N} \quad \text{.......................... (9)}$$

$$Pi = \mathrm{Ri} / \sum_{i=1}^{N} Ri \quad \text{.......................... (10)}$$

Therefore, Tables 27 and 28 can be developed for Factor Weights and Factor Evaluations using the priorities across the three criteria over the PESTEL factors.

Table 27: Factor weights for PESTEL factor

Factor Weights		MVr	Political	Economic	Social	Technical	Environmental	Legal
λ max = 6.0138	Capacity utilisation	4	0.3268	0.1884	0.0988	0.1884	0.0988	0.0988
CI = 0.0028	Operating cost	4	0.2000	0.2000	0.2000	0.2000	0.1000	0.1000
RI = 1.25	Downtime	3	0.3102	0.1703	0.1703	0.1703	0.0895	0.0895
CR = 0.0022								

Table 28: Factor evaluation for the three judgment criteria

Factor Evaluations		MVr	CU	OC	D	Pi
λmax = 3.0	Capacity utilisation (CU)	4	1	1	2	0.4000
CI = 0.00	Operating cost (OC)	4	1	1	2	0.4000
RI = 0.52	Downtime (D)	3	1/2	1/2	1	0.2000
CR = 0.00						

The overall ranking is determined by multiplying the Factor Weights (FWs) by the Factor Evaluations (FEs) for all the PESTEL factors and summing the columns to determine the total priorities. Therefore, combining Tables 27 Table 28, will result in Tables 29 and 30 as shown.

Table 29: Factor weights and factor evaluations

Criteria		**Factor Weights**					
	Factor Evaluations	Political	Economic	Social	Technical	Environmental	Legal
Capacity utilisation	0.4000	0.3268	0.1884	0.0988	0.1884	0.0988	0.0988
Operating cost	0.4000	0.2000	0.2000	0.2000	0.2000	0.1000	0.1000
Downtime	0.2000	0.3102	0.1703	0.1703	0.1703	0.0895	0.0895

Table 30: A product (W) of Factor Weights (FWs) and Factor Evaluations (FEs).

	Political	Economic	Social	Technical	Environmental	Legal
Capacity utilisation	0.13072	0.07536	0.03952	0.07536	0.03952	0.03952
Operating cost	0.0800	0.0800	0.0800	0.0800	0.0400	0.0400
Downtime	0.06204	0.03406	0.03406	0.03406	0.0179	0.0179
$\sum_{j=1}^{n} W$	**0.27276**	**0.18942**	**0.15358**	**0.18942**	**0.09742**	**0.09742**
Ranking	1	2	4	2	5	5

Table30 shows the product (W) of the Factor Weights and Factor Evaluations which determines the final rankings of the PESTEL factors. This implies that across the three judgment criteria, political factors ranked the highest, followed equally by economic and technical factors, then by social factors and lastly by environmental and legal factors, which ranked equally, as summarised in Table 31.

Table 31: Summary of PESTEL Factor rankings

Factors	AHP priorities	AHP Ranking Scores
Political	0.27276	1st
Economic	0.18942	2nd
Technical	0.18942	2nd
Social	0.15358	4th
Environmental	0.09742	5th
Legal	0.09742	5th

As indicated in Section 4.9, using equations (5) and (6), a consistency test was carried out to validate the values obtained from the pairwise comparison matrices. As such, since all the values of the Consistency Ratio (CR) were less than 0.10 in Table 26, it implies that the values obtained were acceptably consistent (Saaty, 1980/1987).

To determine the priorities for the subcategory PESTEL factors, a pairwise comparison matrix was set up as shown in Table 32.

It should be noted that the values in Tables 26 and 32 are mostly a value of one (1) as the variables from the questionnaire had been reduced to their least forms having been converted using Saaty’s fundamental scale of pairwise comparison shown in Table 20.

Table 32: Pairwise comparison matrix for subcategory PESTEL factors

Political factors		MVr	GI	FI	PI	GC	MA	Pi	Ranking
λmax = 5.0	Government interference (GI)	4	1	1	1	1	2	0.2222	1
CI = 0.00	Funding issues (FI)	4	1	1	1	1	2	0.2222	1
RI = 1.11	Political indecision (PI)	4	1	1	1	1	2	0.2222	1
CR = 0.00	Government commitment (GC)	4	1	1	1	1	2	0.2222	1
	Managerial appointments (MA)	3	1/2	1/2	1/2	1/2	1	0.1111	5

Economic factors		MVr	CSP	OC	ER	SI	PM	Pi	Ranking
λmax = 5.0	Cost of spare parts (CSP)	4	1	1	1	2	1	0.2222	1
CI = 0.00	Operating capital (OC)	4	1	1	1	2	1	0.2222	1
RI = 1.11	Exchange rates (ER)	4	1	1	1	2	1	0.2222	1
CR = 0.00	Subsidy issues (SI)	3	1/2	1/2	1/2	1	1/2	0.1111	5
	Profit margins (PM)	4	1	1	1	2	1	0.2222	1

Social factors		MVr	TPA	IR	SI	C	CS	GCD	STI	Pi	Ranking
λmax = 7.0	Theft/pipeline attacks (TPA)	4	1	2	1	2	2	2	2	0.1905	1
CI = 0.00	Illegal refining (IR)	3	1/2	1	1/2	1	1	1	1	0.0952	3
RI = 1.35	Security issues (SI)	4	1	2	1	2	2	2	2	0.1905	1
CR = 0.00	Compensations (C)	3	1/2	1	1/2	1	1	1	1	0.0952	3
	Collusion &Sabotage (CS)	3	1/2	1	1/2	1	1	1	1	0.0952	3
	Grievances & comm disputes (GCD)	3	1/2	1	1/2	1	1	1	1	0.0952	3
	Stakeholder involvements (STI)	3	1/2	1	1/2	1	1	1	1	0.0952	3

Technical factors		MVr	MI	ARP	LPC	FSS	ST	SC	Pi	Ranking
λmax = 6.0	Maintenance issues (MI)	4	1	1	2	1	1	1	0.1818	1
CI = 0.00	Ageing refinery plants (ARP)	4	1	1	2	1	1	1	0.1818	1
RI = 1.25	Limited plant capacity (LPC)	3	1/2	1/2	1	1/2	1/2	1/2	0.0909	6
CR = 0.00	Crude oil/Feedstock supply (CFSS)	4	1	1	2	1	1	1	0.1818	1
	Staff training (ST)	4	1	1	2	1	1	1	0.1818	1
	Staff competence (SC)	4	1	1	2	1	1	1	0.1818	1

Environmental factors		MVr	POL	H&S	P&F	Pi	Ranking
λmax = 3.0	Pollution (Air, land, water) (POL)	3	1	1	1	0.333	1
CI = 0.00	Health & Safety (H&S)	3	1	1	1	0.333	1
RI = 0.52	Penalties and fines (P&F)	3	1	1	1	0.333	1
CR = 0.00							

Legal factors		MVr	UPIB	LA	RPI	RLE	Pi	Ranking
λmax = 4.0	Uncertainties about PIB (UPIB)	4	1	2	2	2	0.4000	1
CI = 0.00	Legal actions (LA)	3	1/2	1	1	1	0.2000	2
RI = 0.89	Regulatory procurement issues (RPI)	3	1/2	1	1	1	0.2000	2
CR = 0.00	Regulatory limitations on emissions (RLE)	3	1/2	1	1	1	0.2000	2

Dropping the variables with the least ranking priorities across each category, results in Table 33 where these variables are highlighted. The significance of these findings was put up for validation through interviews to ascertain their usefulness for building the causal loop models.

Table 33: Overall AHP weights highlighting less significant variables to be dropped

Political Factors *AHP Weight = 0.27276*	*AHP Score (1st)*	**Sub-Factor AHP Ranking**
Government interference (GI)		1
Funding issues (FI)		1
Political indecision (PI)		1
Government commitment (GC)		1
Managerial appointments (MA)		5
Economic Factors *AHP Weight =0.18942*	*AHP Score (2nd)*	
Cost of spare parts (CSP)		1
Operating capital (OC)		1
Exchange rates (ER)		1
Subsidy issues (SI)		5
Profit margins (PM)		1
Technical Factors *AHP Weight = 0.18942*	*AHP Score (2nd)*	
Maintenance issues (MI)		1
Ageing refinery plants (ARP)		1
Limited plant capacity (LPC)		6
Crude oil/Feedstock supply (FSS)		1
Staff training (ST)		1
Staff competence (SC)		1
Social Factors *AHP Weight = 0.15358*	*AHP Score (4th)*	
Theft/pipeline attacks (TPA)		1
Illegal refining (IR)		3
Security issues (SI)		1
Compensations (C)		3
Collusion &Sabotage (CS)		3
Grievances & comm disputes (GCD)		3
Stakeholder involvements (STI)		3
Environmental Factors *AHP Weight* =0.09742	*AHP Score* (5th)	
Pollution (Air, land, water) (POL)		1
Health & Safety (H&S)		1
Penalties and fines (P&F)		1
Legal Factors *AHP Weight = 0.09742*	*AHP Score* (5th)	
Uncertainties about PIB (UPIB)		1
Legal actions (LA)		2
Regulatory procurement issues (RPI)		2
Regulatory limitations on emissions (RLE)		2

5.3 Qualitative Analysis (Multiple Case Study)

Following the results of the quantitative method, it was necessary to validate the findings through a qualitative method. As such, the qualitative analysis for this study relied on the analysis of the interviews as a means of validating the findings of the questionnaires.

5.3.1 Interviews

As stated in section 4.7.2, to validate the results of the questionnaire for research reliability, interviews were conducted to understand how the identified factors operationalise across the NNPC refineries. In addition, considering that environmental and legal factors ranked amongst the lowest of the PESTEL factors using AHP analysis, it was necessary to determine from the relevant authorities at the refineries if the sub-environmental and sub-legal factors had indeed no significance on the operations of the refineries.

Drawing from a pool of senior refinery staff across the three facilities, the key questionnaire findings were put to test via telephone interviews (see Section 4.7.2).
Fifteen interviews were conducted in total as an additional official was later identified in PHRC bringing the total participants of the interviewees at PHRC to 5; 4 officials were interviewed at Warri refinery, 3 for Kaduna refinery and another 3 NNPC officials from different NNPC subsidiaries (see Figure 7, Section 2.2.3) as a means of triangulation. Table 34 shows the demographics of these interview participants.

Table 34: Demographics of interview participants

Participants	Role	Departments	Years of Experience
PHC -1	Director	PHRC	25
PHC - 2	Plant Manager	PHRC	15
PHC - 3	Maintenance Engineer	PHRC	11
PHC - 4	Maintenance Supervisor	PHRC	12
PHC - 5	Administrator	PHRC	15
WRP – 1	Production Manager	WRPC	17
WRP – 2	Plant Manager	WRPC	15
WRP – 3	Materials Manager	WRPC	12
WRP - 4	Process Engineer	WRPC	11
KRP – 1	Plant Manager	KRPC	18
KRP - 2	Technical Supervisor	KRPC	11
KRP - 3	Maintenance Engineer	KRPC	15
SUB – 1	Director	Corporate Services	20
SUB – 2	Supervisor	Downstream	15
SUB – 3	Director	Downstream	21

Source: Author generated.

Various codes were used in Table 34 to classify the participants from the three refineries (given that PHRC I and II are treated as one unit – see Section 5.2) and those from the NNPC subsidiaries. In this sense, PHC stands for participants from both Port Harcourt refineries (treated as one unit), WRP for participants from Warri refinery, KRP for participants from Kaduna refinery and SUB describes participants from NNPC subsidiaries. It was considered necessary to triangulate the findings from the three refineries from other NNPC subsidiaries to eliminate any bias from the refineries' participants. This also helped to ensure both literal and theoretical replication in order to establish consistency and/or explore any contrasts across the refineries (Ridder, 2017 and Eisenhardt, 1991). The interviews were conducted using open-ended questions mapped onto the research aims and objectives (See Table 35, Section 5.3.1 and Appendix 7). This approach is consistent with the non-standard, semi-structured interview format adopted to allow the researcher the flexibility to ask further questions (See Section 4.7.2). In addition, a sequential order was followed starting with the participants from PHRC, and progressing to WRPC, KRPC and other NNPC subsidiaries. The choice of this order was purely based on convenience to allow the researcher to maintain some order to the data collection.

The focus of the interview for the refineries was to explore how the PESTEL factors generally operationalise across the refineries, their interrelationships as well as the significance (if any) of the least ranking factors from the AHP results. Whereas the interviews done for other subsidiaries were to confirm these findings from external sources. Unfortunately, the interviews conducted across the subsidiaries did not produce any new findings but further confirmed the initial findings from the respondents of the three refineries. As such, data collection was therefore discontinued as saturation point was reached by this number. According to Bowen (2008), a saturation point in a research study refers to a point during data collection where the addition of more research participants does not produce new insights but increases replication and redundancy. Hence, the data set is judged to be complete at this point.

NVivo 20 was used to carry out thematic analysis for the interview results to identify emergent themes from the participants' responses. According to Scharp and Sanders (2019), the six steps undertaken for conducting a thematic analysis include:
(1) gaining familiarity with the data, (2) creating coding categories or subcategories, (3) generating themes, (4) reviewing themes, (5) labelling themes, and (6) identifying exemplars.

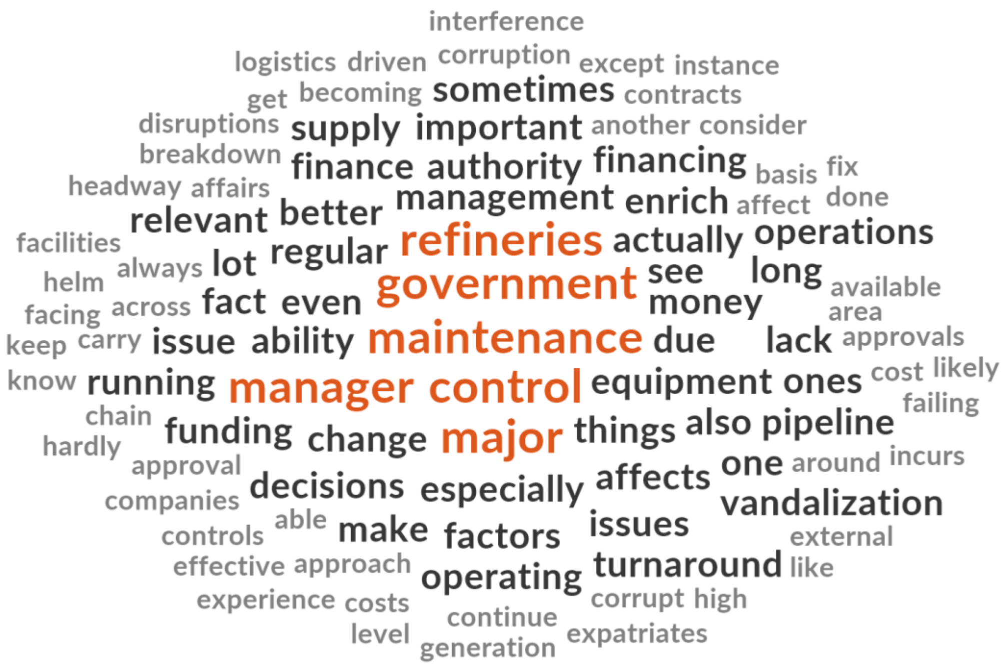
Thematic analysis was chosen over content analysis (adopted by Iheukwumere et al., 2021b) in this study as it offers a more flexible and beneficial method, which provides a multidimensional account of the research data (Vaismoradi et al., 2013). In addition, given that this study was designed to explore the nature of causal interrelationships between variables, a content analysis was deemed inappropriate as it overly relies on frequency and counting to develop its themes. Marks and Yardley (2004) note that this approach presents a danger of missing important themes due to mere quantification. Whereas a thematic analysis being theory driven, compensates for this by appropriately allowing the researcher's knowledge to guide the identification of themes.

To categorise the research findings into relevant themes, the study adopted a combination of pre-set and emergent themes. Taylor-Powell and Renner (2003) describes pre-set themes as those themes which are predetermined by the researcher from the literature, while emergent themes are those themes which emerge from the data. The combination of these themes was to eliminate any bias in the coding exercise and to allow the emergent themes to provide some triangulation for the pre-set themes (Kohlbacher, 2006). Patton (1999) describes triangulation as a means of using multiple methods in qualitative research to provide validity to a phenomenon through the convergence of information from different sources. Accordingly, the pre-set themes were chosen as the themes already established from the literature which formed the input for the questionnaires as shown in Table 10 (Chapter Two, Section 2.4). Whereas the emergent themes are the themes that emerged from the responses of the participants outside the pre-set themes.

Using NVivo 20 software, the relationships associated with sentences were coded into nodes, which enhanced the understanding of causality of the variables at play within the refineries. Although Rutledge (2008) and Engel and Schutt (2016) note that using NVivo to analyse qualitative data can present some challenges for a researcher due to the time it requires to learn the package and pre-process the data into the computer system. However, Sharp et al., (2019) acknowledge that NVivo can be effective and powerful for dealing with large data sets, as well as provide richer insights into qualitative data in a timely manner compared to humans. NVivo 20 was chosen for this analysis as the available qualitative data analysis software from the university, the use of which appropriate training was also provided for the researcher.

The NVivo analysis output using a word cloud for the most frequently used words across the interview transcripts is as shown in Figure 35. This is useful as an initial overview of the themes emerging from the research data.

Figure 35: NVivo 20 Word cloud image of the most frequently used interview words



A close observation of Figure 35 reveals several generated word themes bordering on maintenance, management and control, government involvements, financing, corruption, vandalization, supply and costs issues with the NNPC refineries.

A hierarchical chart produced from NVivo 20 (Figure 36) from the analysis of the interview data further provides evidence on the weight of these themes by references. As such, this can be regarded as a valid triangulation for the initial questionnaire findings.

Figure 36: A hierarchy chart of themes by references

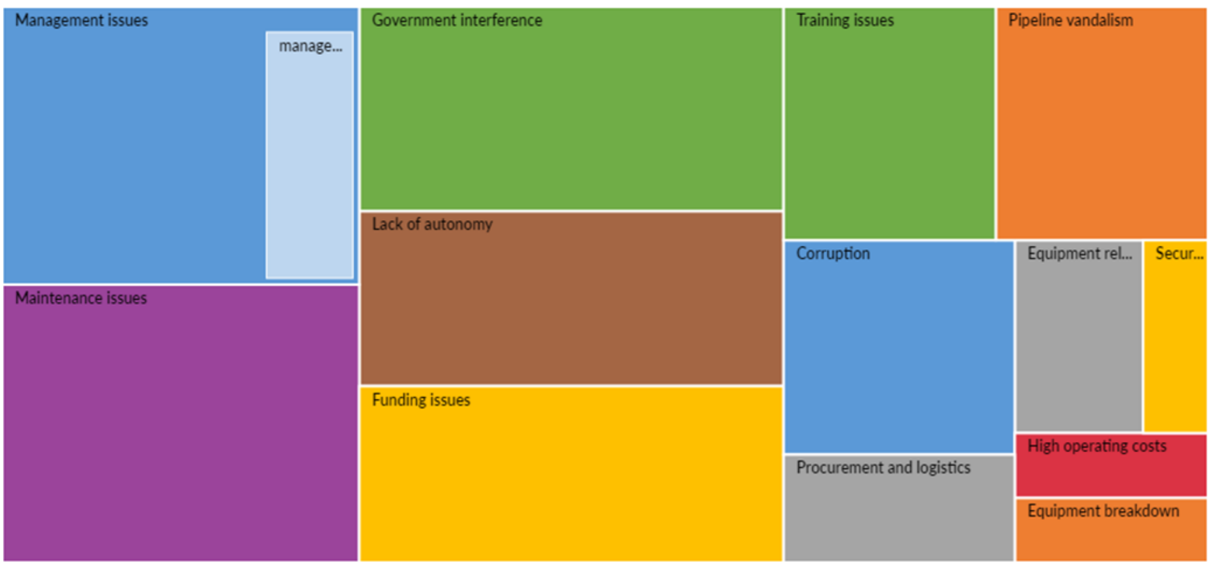


Figure 36 indicates that management issues and maintenance issues appear to be the most common themes identified by the interviewees. This is closely followed by government interference, lack of autonomy, funding issues, corruption, pipeline vandalism, procurement and logistics, equipment reliability, high operating cost, and equipment breakdown. These factors appear to be consistent with the findings of Ogbuigwe (2018), Akinola (2018), Wapner (2017) and Iwayemi (2008), which outlined the challenging factors limiting the performance of NNPC refineries.

Following the multiple case study protocol shown in Fig 27 (Section 4.5.7), some of the significant findings of the interviews conducted across the three refineries are as shown in Table 35. For example, when asked to describe how the various PESTEL factors influence the performance of the refineries, the following remarks ensued:

Table 35: Interview findings across the refineries

Refinery	Participant Code	Remarks	Emerging Theme(s)
PHRC	PHC-1	The factors which affect the refineries are multi-dimensional. Personally, I would say the main ones are politically driven. This is because as long as these refineries remain under government control, nothing major can change. We do not have any authority to make any major decisions here except by approval by the government. Typically, it would be hard to operate a refinery in this manner. You see, sometimes when there is a need to respond quickly to a situation in the plant here, before one can obtain all the necessary approvals to resolve that issue, a lot of things would have worsened. […] this truly affects our ability to keep the refineries running smoothly in terms of our ability to carry out regular maintenance. Again, I would say those social factors like pipeline vandalization are also important factors to consider but those are not entirely under our control. We our doing our bit to engage the communities through our CSR but I think government needs to do more on their own end to quell those agitations. Even though the incidence has reduced right now [March 2021] but we can't guarantee how long things would stay quiet in this regard.	Political interference Lack of autonomy Maintenance issues Pipeline vandalism

	PHC-2	Government should relinquish control of running the refineries and change our model of operation. If the management of the refineries have the authority to make their own decisions and control the money for maintaining their facilities, things would be better. The lack of control we experience affects our ability to do proper maintenance. Another thing is that operating cost is high as the PHRC incurs unnecessary operating costs. One major area this occurs is by outsourcing power generation contracts to external companies which the refineries continue to pay for even at zero operations. On the contrary, I think the refinery itself should be able to do this. This is tied to corruption with officials at the top trying to enrich themselves.	Government interference Lack of autonomy Operating cost Corruption
	PHC-3	For me, most of the factors all interrelate to affect our performance here. The most important ones would be political interference from the government in the sense that we are not allowed to make timely decisions regarding our plants. This is especially due to the fact that we don't have control of major financing. However, the environmental and legal factors are less impactful on our operations.	Political interference Funding issues
WRPC	WRP-1	For many years now, things have not been running as they should in this refinery. For instance, there has hardly been an effective turnaround maintenance done here since I started. It seems to me that people at the helm of affairs at government level are always more likely to enrich themselves than to actually get things working across the refineries...too many issues every now and then have slowed down the progress of the refineries. If not the issue of pipeline vandalization and supply disruptions, it will be that of equipment breakdown. Maybe the adoption of the NLNG operating model would make things better. As long as government remains in control of issues here, I don't see us making much headway. Even the management can also be selfish and corrupt [….] This reflects in lack of relevant training on a regular basis for the staff. In fact, some of the trainings undergone by some staff sometimes are not that relevant to what they actually do.	Maintenance issues Corruption Pipeline vandalism Training issues
	WRP-3	I think all the factors mentioned in the questionnaire come into play in one way or the other. For example, sometimes lapses in security may result in pipeline breakage. Our inability to freely access funding of course impacts our ability to keep our plants running as it should be. You know our plants have been down	Security issues Pipeline vandalization Maintenance issues

		for more than a year now [April 2021] and this is because there are plans by the government to carry out major maintenance. This turnaround maintenance has hardly been effectively carried out in this facility since I started working here.	
	WRP-4	Actually, most of the factors are interlinked in one way or the other. […] there is a lot of management issues to what the refineries are facing as well. For example, there is no structured approach to maintenance. The maintenance done usually depends on the level of funding available, the management philosophy at the time etc. If the equipment are really well maintained the way they should, there would be hardly any major breakdowns due to improved reliability.	Management issues, Maintenance issues, Funding issues Equipment reliability
KRPC	KRP-1	For me, the factors are all related in the way they affect our operations. You know that government controls the money for funding our maintenance. So, if this money is not released especially as at when due it usually affects the smooth operations of things around here. You see, most of the equipment we use are failing and are becoming obsolete. Timely turnaround or regular maintenance should have been able to fix or replace these equipment, but this is not being done as expected.	Lack of autonomy Government interference Funding issues Maintenance issues Equipment reliability
	KRP-2	A lot of relationships can of course be drawn around those factors […] Our problems usually tend to centre around logistics and supply of equipment parts, funding for general maintenance and corruption within the management. […] If I am asked where major changes should come from, I would say change the logistics and supply chain managers, the finance managers, and the maintenance managers with expatriates. These are where the main problems lie…there is a lot of corruption with the way our people manage things…	Management issues Corruption Procurement & logistics Maintenance issues Funding issues
	KRP-3	We truly experience most of the factors mentioned in that questionnaire […] overwhelming maintenance problems, government control, supply issues. The only thing is that we do not experience pipeline vandalism within the Kaduna environs. But we suffer supply disruptions when there is a breach as a result of attack on our line within the Niger Delta Area. So, we are definitely affected as we are all in the loop.	Maintenance issues Pipeline vandalism Crude oil supply issues
	SUB-1	The main problem with the refineries is the lack of control to determine their own affairs. NNPC used to set aside a budget for maintaining the refineries, but the government later took over	Lack of autonomy Training issues Funding issues

		the control of that and are now the ones who determine when money should be released to the refineries for maintenance […] Well, I'm aware that the refineries do not have any structured approach for training their staff. Some people have worked there for many years and haven't been sent for a single training, while some have attended a few. Training at the refineries usually depends on so many factors – the area you work, how your boss feels about it, and the funding available. The truth is that the original policy for maintaining the refineries designed by the equipment builders is not being implemented and this has really affected the operations at those plants […]	Management issues Policy issues
	SUN-3	The refineries are down because there is lack of political will to truly get things done. Can you imagine that the refineries built to supply Nigeria's refined products have hardly had any major maintenance for years now [….]. Most of the factors I saw in the questionnaire are relevant to the poor performance of the refineries. Primarily, government control of the refineries does not augur well with its performance. This is related to how government releases funds to carry out major works there. Again, there tend to be corruption here as some of the people in charge are sometimes inclined to looking for what they will gain from things like this […]	Political will Government interference Funding issues Corruption

Table 35 indicates that a thematic analysis of the interview transcripts with NVivo 20 produced themes which aligned with many of the pre-set themes established from the literature and explored by the questionnaire. These results further validate the AHP results and is a valid triangulation.

5.3.2 Interview Analysis

Respondents from PHRC, WRPC and KRPC all appeared to agree that government interference, maintenance issues, funding issues, pipeline vandalism, corruption, management issues, equipment reliability, and training issues were some of the main factors affecting the performance of the refineries. For example: PHC-1 stated: *"[...] Personally, I would say the main factors are politically driven. [...] As far as these refineries remain under the control of government, nothing major can change [...]"*. The statement affirms the respondent's opinion that political factors operationalise as government control (interference) and play a key role in limiting the performance of the refineries. This submission is consistent with the opinions of various scholars that government control over the refineries has created major setbacks regarding timely and effective decision making which affects the refineries (Iheukwumere et al., 2021b, Ogbuigwe, 2018; and Igboanugo et al., 2016).

On the effect of maintenance issues WRP-1 stated: *"For many years now things have not been working as it should [...] for instance, there has hardly been an effective turnaround maintenance since I started here [...]".* This assertion echoes the sentiments of other participants that none of the refineries has been serviced as recommended by the manufacturers. This observation contradicts the standard practice for refinery maintenance as reported by Duffuaa and Ben-Daya (2004) that turnaround maintenance of facilities like refineries ought to be carried out every 24-36 months of operation. In addition, further evidence suggests that continuous non-commitment of the government via the NNPC to fix the refineries is associated with poor funding occasioned by corruption from officials who seek personal gains at the expense of the common good. This notion is captured by the statements of KRP-2: "*If I am asked where major changes should come from, I would say change the logistics & supply chain manager, the finance manager, and the maintenance manager with expatriates. These are where the main problems lie…there is a lot of corruption [...]".*

Also, SUB-1 observes that "[…] *the main problem with the refineries is the lack of control to determine their own affairs. NNPC used to set aside a budget for maintaining the refineries, but the government later took over the control of that and are now the ones who determine when money should be released to the refineries for maintenance [...]".*

Clearly, the refineries have struggled under government control for many years. Ogbuigwe (2018) noted that since the early 1990s when the refineries fell under the control of politicians who have little political will to fix the facilities, it has been difficult to operate the assets in line with best practice.

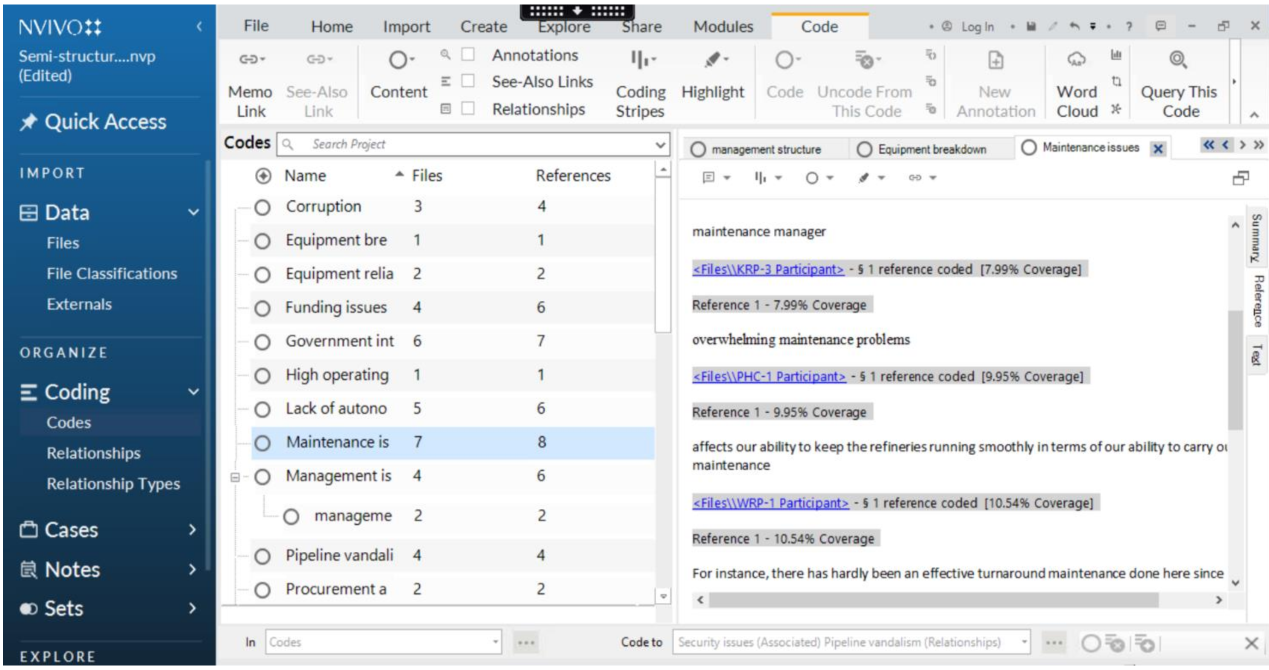
When asked how interference from the government is operationalised in the refineries, respondents across the three refineries shared similar views. For example, PHC-4 stated *"[...] when government fails to release needed funds in time, it delays the time the refineries will need to get the problems resolved*." This assertion implies that the untimely response from government when issues arise in the refineries prolongs intervention time and as a result compounds issues. This statement is corroborated by WRP-1 who reported that *"[...] since I started working here, I have never witnessed a time when an equipment would breakdown or was about to breakdown and an appeal is made for funds to quickly resolve the issue and get approved in time*". Clearly, this implies that such associated delays in the release of funds contributes to worsening equipment conditions. KRP-1 appears to convey the message clearer by stating that "[…] *if the boss of each refinery had the full authority to access adequate funds, they would be more likely to intervene and respond to issues in time.*"

Since intervention time is a recurring theme from these assertions, it was therefore included as one of the emergent themes (variables) for inclusion in the causal loop diagram.

In addition, when asked to explain how maintenance issues are operationalised across the refineries, the participants concurred there were no structured approaches towards maintenance across the refineries. Instead, there is rather a reactive approach (e.g., corrective and turnaround) towards maintenance across the plants rather than proactive. This condition clearly falls short of best practice across the industry, where such facilities are known to operate with regular maintenance schedule (Forsthoffer, 2011). WRP-2 noted that "[…] *although we have various maintenance schemes at the refineries such as preventive, corrective, and turnaround maintenance [...] these programs are not being implemented as they should [. . .] it is usually when things break down that we go and check what has happened* […]" This assertion not only confirms a reactive approach to maintenance but also implies that unattended maintenance issues at the refineries accumulate over time and result to equipment breakdown. It is, therefore, important to capture the link in the model by breaking maintenance issues into the relevant types (accumulated and reactive maintenance issues).

A screenshot of the NVivo 20 window showing some of these themes is as shown in Figure 37.

Figure 37: A screenshot of NVivo 20 coding window



It is important to note, however, that some new variables appeared as emergent themes from this qualitative analysis, and these include equipment reliability, procurement and logistics, and intervention time. The appearance of these variables was consistent across the three refineries, and they were therefore included in the overall variables.

Lastly, considering that most the themes arising from the interview seem to validate political, technical, social, and economic factors, it was necessary to investigate if any of the legal and environmental sub-factors had any significance to the operations of the refineries. To this end, WRP-2 stated *"[…] well I am not aware of how the listed legal and environmental factors do affect our operations. The only thing I can say is that we experience incidences of fire in the refineries, and this sometimes leads to shutdowns depending on the location and magnitude of the fire. In fact, sometimes we lose certain equipment due to damage from the fire. These incidents also put the lives of our staff at risk… […]"*

Another official from Port Harcourt refinery (PHC-1) also corroborated this by stating: "*Actually, in terms of environmental factors, I would say those factors like pollution, penalties & fines do not really affect us. This is because I don't recall any time, we have had to pay any penalties or fines due to pollution etc. Although one can acknowledge that our activities, of course, contribute to environmental pollution, but it does not affect the performance of the refineries rather I would say it affects the environment negatively. It is only the issue of health and safety that I would say we experience in terms of accidents or related incidences, especially fire incidents which may accidently occur around our jetties or pipeline areas. Sometimes these can cause us to shut down for a while in order to fix the affected equipment* […].

On the same issue of legal and environmental factors, an engineer from KRPC (KRP-3) alluded that:
"*I don't think that our performance here has been affected by legal issues per se. But the only factor I can see listed within the legal factors which is relatable is the procurement issue. The way we are affected by procurement is that there is a limitation to the type of items we can procure by ourselves. Again, this is related to funding availability and the issue of autonomy and control…. No refinery manager can purchase an item above his approved budget, and this is a real problem…. In terms of the environment, I would say that our activities rather impact on the environment and not the environment affecting us. For example, you know that when there is pipeline breakage, there would be serious pollution on the ground from the spillage and sometimes fire outbreak, especially if a refined product is involved. As for limitations on emissions, we do not have that issue here yet. However, the issue of the petroleum industry bill [*now Petroleum Industry Act*] is a known problem, but the government is at it now. I think it's an example of how delays in political decisions can impact on the industry as a whole. We can only hope that the efforts the government is making on that front will yield positive results with time […]*"

These statements provide evidence that most of the legal and environmental factors are not significant with regards to the performance of the NNPC refineries. The only exceptions in this category were the Petroleum Industry Bill [now Petroleum Industry Act], which relates to political indecision under political factors, procurement issues which was corroborated by previous statements regarding poor procurement and logistics practice across the refineries, and incidences of fire which relates to health and safety. Therefore, these factors were included in the variables as additional emergent themes considered as a valid triangulation.

5.3.3 Triangulation of research findings

Nightingale (2009) opines that triangulation is an analysis technique employed by multi-method research designs to complement the findings of one method with the other. The use of triangulation in management and social sciences is an acknowledgement that no one method of enquiry presents a perfect measure and as such, validates the importance of mixed methods (Johnson and Onwuegbuzie, 2004). As discussed in Section 5.3.1, interviews were used to provide triangulation for the quantitative method in this study.

Table 36 summarises the findings of both the quantitative and the qualitative methods in this study.

Table 36: Synthesized significant factors affecting NNPC refineries

<table>
<tr><th>Quantitative Factors</th><th></th><th>Synthesized Qualitative Factors</th></tr>
<tr><td>Political Factors</td><td></td><td rowspan="18"><u>Validated pre-set themes</u>
Political interference
Lack of autonomy
Maintenance issues
Pipeline vandalism
Operating cost
Corruption
Funding issues
Training issues
Management issues
Security issues
<u>Additional emergent themes</u>
Procurement and logistics
Equipment reliability
Intervention time
Safety issues

<u>Unvalidated themes</u>
Pollution</td></tr>
<tr><td>Govt interference</td><td>✓</td></tr>
<tr><td>Funding issues</td><td>✓</td></tr>
<tr><td>Political indecision</td><td>✓</td></tr>
<tr><td>Political will</td><td>✓</td></tr>
<tr><td>Managerial appointments</td><td>×</td></tr>
<tr><td>Economic Factors</td><td></td></tr>
<tr><td>Cost of spare parts</td><td>✓</td></tr>
<tr><td>Subsidy issues</td><td>×</td></tr>
<tr><td>Operating capital</td><td>✓</td></tr>
<tr><td>Exchange rates</td><td>✓</td></tr>
<tr><td>Profit margins</td><td>✓</td></tr>
<tr><td>Social Factors</td><td></td></tr>
<tr><td>Theft/attacks on pipelines</td><td>✓</td></tr>
<tr><td>Illegal refining</td><td>✓</td></tr>
<tr><td>Security issues</td><td>✓</td></tr>
<tr><td>Compensations</td><td>✓</td></tr>
<tr><td>Collusion and sabotage</td><td>✓</td></tr>
</table>

Grievances and community disputes	✓	Penalties and fines Legal actions Regulatory limitations on emissions.
Technical Factors		
Maintenance issues	✓	
Ageing facilities	✓	
Facility design	✓	
Limited plant capacity	×	
Crude oil/Feedstock supply	✓	
Staff training	✓	
Staff competence	✓	
Environmental Factors		
Pollution (air, land, and water)	×	
Health and safety issues	✓	
Penalties & Fines	×	
Legal Factors		
Petroleum Industry Bill issues	✓	
Legal actions	×	
Regulatory procurement issues	✓	
Regulatory limitations on emissions	×	

The highlighted variables in Table 36 are the factors that would be dropped due to their relative insignificance on the performance of the refineries. Following the multiple case study protocol design as shown in Figure 27 (Section 4.5.7), a summary case report can then be written based on these findings.

5.4 Summary Case Report

As indicated in Chapter 4 (Section 4.4), a mixed methods approach was adopted in this chapter to sample and analyse the results of the data collected through case studies of the three refineries. The quantitative analysis employed the Analytical Hierarchy Process (AHP) method to identify the more significant factors affecting the NNPC refineries, while the qualitative method employed thematic analysis to interpret the results of the interviews.

Both analyses indicate that all the refineries experience similar performance challenges considering their central management and control by the NNPC Group. The quantitative method clearly identified such factors as government interference, lack of autonomy, corruption, funding issues, cost of operations, spare parts costs, maintenance issues, training issues and pipeline vandalization as some of the significant factors that affect the performance of the refineries. The qualitative process validated these findings and clarified the insignificance of some of the themes from legal and environmental factors that could have been misconstrued. In addition, the qualitative method provided additional themes that were not originally captured through the quantitative method as developed from the literature. These factors include equipment reliability, procurement, and logistics issues, and intervention times, which can be considered a valid addition to the list.

From the analyses, the respondents from all the refineries agreed with the assertions of Ogbuigwe (2018), Akinola (2018) and Wapner (2017) that lack of autonomy, corruption and government interference are some of the crucial factors limiting the performance of the NNPC refineries. In addition, it can be seen that pipeline vandalization also disrupts product supply to and from the refineries. These phenomena are common across all the refineries. The only technical difference is the manner in which this is operationalised for Kaduna refinery (KRPC), which unlike its counterparts (PHRC and WRPC), does not experience pipeline attacks within its environs. KRPC, however, is only affected by such pipeline breaches in Southern Nigeria as such incidences usually constitute a disruption in the trunkline that supplies or conveys KRPC's products (i.e., a disruption to inward and backward flow to and from the refineries).

From the foregoing, it can be argued that the multiple factors which affect the refineries are interrelated as can be seen from the interview and AHP findings. As such, a model that will adequately capture and explain their interrelationships in more detail is required to answer research question 3 (RQ3) - "*How do the factors significantly interrelate and how can these be modelled?*" Hence, the need to develop a causal loop model as justified in Section 3.3.3.1 to help unravel these phenomena.

5.5 Chapter Conclusion

This chapter presented the details of the process of data collection and analysis for this study. It demonstrated the application of a mixed methods approach to enquiry, which is combined through a case study involving all the NNPC refineries (PHRC, WRPC and KRPC) to obtain reliable data.

The analysis of both methods of enquiry presented in the chapter produced a synthesised pool of validated variables considered significant to the performance of the refineries. As such, it was determined that the political, economic, social, and technical (PEST) factors and their sub-factors are more significant than the environmental and legal factors with respect to the performance of the refineries. The findings from these analyses are consistent with the results from other analytical techniques applied to evaluate these data as shown by Iheukwumere et al. (2021a/2021b).

Using these variables, a causal loop diagram will be developed in the subsequent chapter to represent their interrelationships in deriving sub-optimal performance across the refineries.

CHAPTER SIX: MODEL DEVELOPMENT AND VALIDATION

6.1 Introduction

In Chapter 5, the methods of data collection and analyses for this study were presented. That chapter utilised both the quantitative and qualitative methods to identify significant factors limiting the performance of NNPC refineries. This chapter (6) builds on the significance of these factors by producing realistic causal loop models to explain their interrelationships in the context of their influence on the poor performance of the refineries. The model will be validated by relevant experts within the industry and academia to reveal potential leverage points (PLP), where policy intervention can be applied to address the performance gaps and improve future practice within Nigeria's oil refining industry.

6.2 The Role of Models for Representing Relationships

Bernard and Ryan (2010) suggest that there is a consensus that models are developed to enhance the understanding of the complexities of the real world. The objective of a model is to provide an idealised representation of a real-life construct as a means of providing an improvement in a system. Mitchell (1993) suggests that models are used in management sciences to provide structure and clarification for devising solutions to problems. Essentially, modelling in management sciences deals with the application of scientific methods to complex organisational problems with the aim of aiding decision making. Some management areas which have benefited from such modelling processes include environmental health decision-making (Currie et al., 2018), stakeholder engagement (Inam et al., 2015), production and operations management, as well as inventory and scheduling management (Sterman, 2010).

While modelling, however, there are important guidelines that must be followed. Leonard and Beer (1994) recommend the selection of important features that can be replicated. This means the selection of features that can be evaluated through the mental models drawn from data collected via interviews and expert discussions. This approach reduces complications and ensures the development of concise models (Sherwood, 2011).

Ranganath (2008) and Sterman (2010) opine, however, that it is usually difficult to produce a perfect model, and as such, efforts must be made while modelling to replicate the real-life scenario as closely as possible. This implies that models should be open for validation through testing, evaluation, and refinement. According to Sterman (2010), this is usually done with the participation of professionals who daily experience the issues in question. In other words, modelling processes that combine a participatory approach through data-gathering techniques arising from a quantitative and/or a qualitative method of enquiry are capable of producing more reliable results.

Pidd (2009) and Leonard & Beer (1994) suggest that there are many approaches to systems-based modelling in management sciences. These include system dynamics, soft systems methodology, viable systems modelling, socio-technical systems and causal loop models. However, as established in Chapter 3 (Section 3.3.3.1), this study adopted the concept of causal loop diagrams to model the interrelationships of the factors affecting the NNPC refineries. For clarity, it should be noted that causal loop diagrams form the foundation to system dynamics modelling, which explores the dynamic interrelationships of the variables under study. While causal loop diagrams represent a model for causalities, they do not show dynamic changes amongst the variables in the system, which falls under the purview of system dynamics. As such, system dynamics modelling was not incorporated into this study. The reason for this is because system dynamics modelling would require real-time production data from the refineries to determine the impact of changes in systems variables on actual production (Sterman 2010). Unfortunately, given the time such exercises require for iterations, including the fact that the refineries had been on an extended lockdown due to an ongoing maintenance, this was not possible within the timeframe for this research. Hence, another approach was required.

6.3 Model development

In management sciences, models are typically used in combination with other analytical methods to solve complex problems (Mingers, 2004). Wilson (1990) opined that models are a means through which constructs requiring the understanding of the real world are developed.

In developing the model for this study, some guidelines outlined by Kim (1992) were followed. This is as shown in Table 37.

Table 37: Guidelines for causal loop diagrams

Guidelines	Remarks
Theme selection	The selection of appropriate theme that will help the researcher articulate and communicate deeper insights into the issue under investigation is crucial.
Time horizon	Although time itself should not be included as part of the causal variables, it is important to highlight the effect of the variables as a consequence of time.
Behaviour over time charts	The diagram should, where possible, incorporate structures that would produce projected behaviour.
Boundary issues	It is important to recognise the boundary of the issue or problems being resolved.
Level of aggregation	The use of appropriate patterns to keep variable interactions simpler to avoid unnecessary clutter in the diagram is essential
Signification delays	It is important to identify the links (if any) that have significant delays to other variables.

Source: Adapted from Kim (1992)

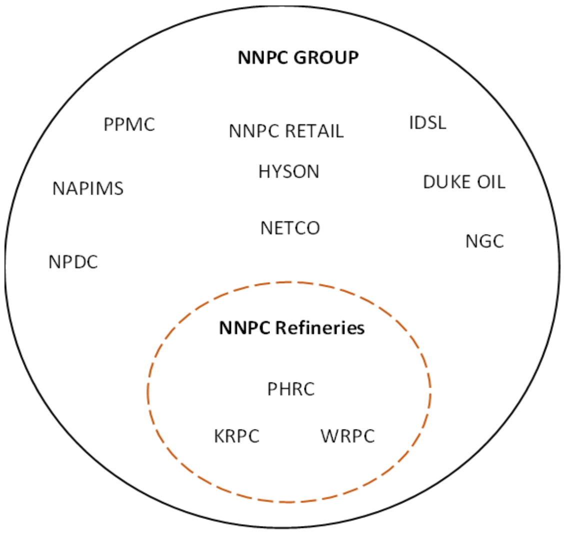
Table 37 indicates that theme selection, time horizon, behaviour over time, boundary issues and level of aggregation were some of the important guidelines to consider, while drawing causal loop diagrams.

The causal loop diagram representing the model for the refineries were developed using the synthesised causal factors from both the quantitative and qualitative methods of enquiry as shown in Table 36. The researcher facilitated the process with the initial construction based on the output of the research data and further obtained validation from selected senior experts from the refineries. This was done in an iterative manner via emails and chat forums going back and forth between the researcher and these experts to obtain inputs, suggestions, and final revisions to the model. This is because as noted earlier, most of the stakeholders worked from offsite locations as a result of the ongoing maintenance of the refineries. This approach has been judged equally effective as it ensures that the relevant inputs of key stakeholders with good understanding of the system behaviour have been captured in the model construction (Purwanto et al., 2019).

6.4 Boundary and Variable Types

As noted by Sherwood (2011) and Sterman (2010), it is important to describe the boundary of a system as well as the kinds of variables involved within the context of their operationalisation. Accordingly, the boundary of the system in focus regarding the causal loop diagram in this study is the NNPC refineries as contained within the larger NNPC Group. Figure 38 represents this structure.

Figure 38: NNPC Refinery Boundary with the NNPC Group



Source: Author generated

Figure 38 shows that the system in focus is the NNPC refineries. As such, the causal interdependencies of the variables driving the performance challenges in the refineries are treated in the context of their operationalisation within the refineries as a sub-system of the larger NNPC Group, which is, in turn, part of a larger system.

In addition, using the factors identified from the data analyses (Sections 5.2 and 5.3), two classifications are rendered for the types of variables acting within the refinery system - endogenous (internal) and exogenous (external) variables.

Endogenous variables are those variables (factors) that act within the NNPC refinery as a system with no significant external components, while exogenous variables are those factors that predominantly act on the refinery system externally. While endogenous variables may directly affect the performance of the refineries from within, exogenous variables operate as outside forces affecting the performance of the refinery system. Figure 39 shows the operationalisation of these factors.

Figure 39: Endogenous and Exogenous variables on NNPC refinery system

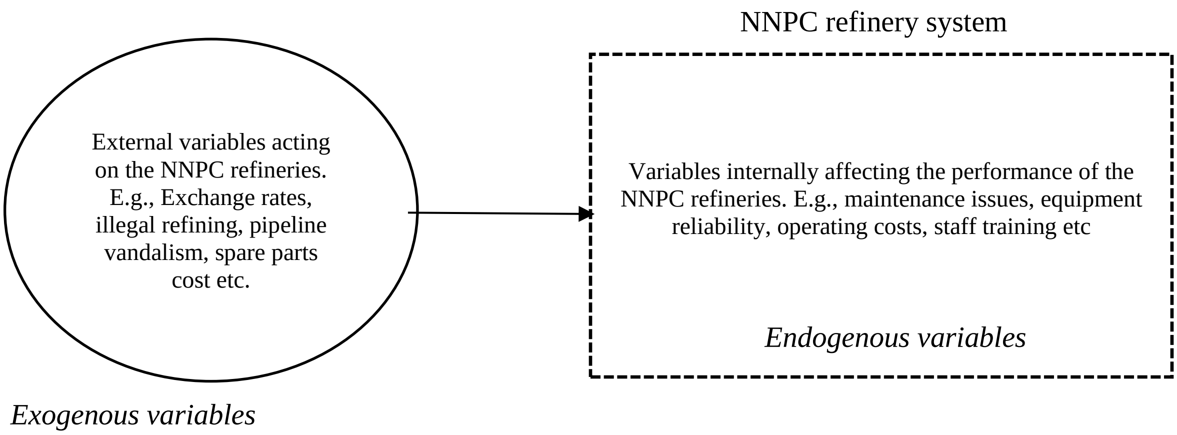


Table 38 provides the full detail of these variables according to their mode of operations.

Table 38: Overall endogenous and exogenous variables

Endogenous variables	**Characteristics**
Management issues Collusion and sabotage Operating capital Maintenance issues Ageing refineries Equipment reliability Funding issues Procurement and logistics Crude oil/Feedstock supply Staff training Staff competence Safety issues Intervention time	Factors which internally affect the operations of the refineries
Exogenous Variables	
Cost of spare parts Political indecision Government interference Political will Illegal refining Security issues Pipeline vandalization Exchange rates Stakeholder involvements	Factors which externally affect the operations of the refineries

Source: Author

Table 38 shows endogenous and exogenous variables for the model. It can be argued that the listed endogenous variables such as management issues, collusion and sabotage, operating capital, maintenance issues, ageing refineries, equipment reliability, funding issues, procurement and logistics, crude oil/feedstock supply, staff training, staff competence, safety issues, and intervention time all significantly fall under the control and internal affairs of the refineries. Whereas the listed exogenous variables such as cost of spare parts, political indecision, government interference, illegal refining, security issues, pipeline vandalism/attacks, exchange rates, and stakeholder involvements significantly operate externally with respect to the affairs of the refineries.

Using the Vensim software, these variables are used to develop the initial causal loop model (Figure 40), which attempts to correctly depict how the challenges within the refineries operate. Sherwood (2011) opined that the correct development of such models is the first step for seeing leverage points for intervention in a system. For this reason, the initial causal loop model was validated by the refinery experts and the correct model representing causal interrelationships of the challenging factors across the NNPC refineries was used to inform a proposed model where policy interventions can be applied to address the performance gaps of the refineries.

Figure 40: Initial causal loop model showing the challenges of the NNPC refineries

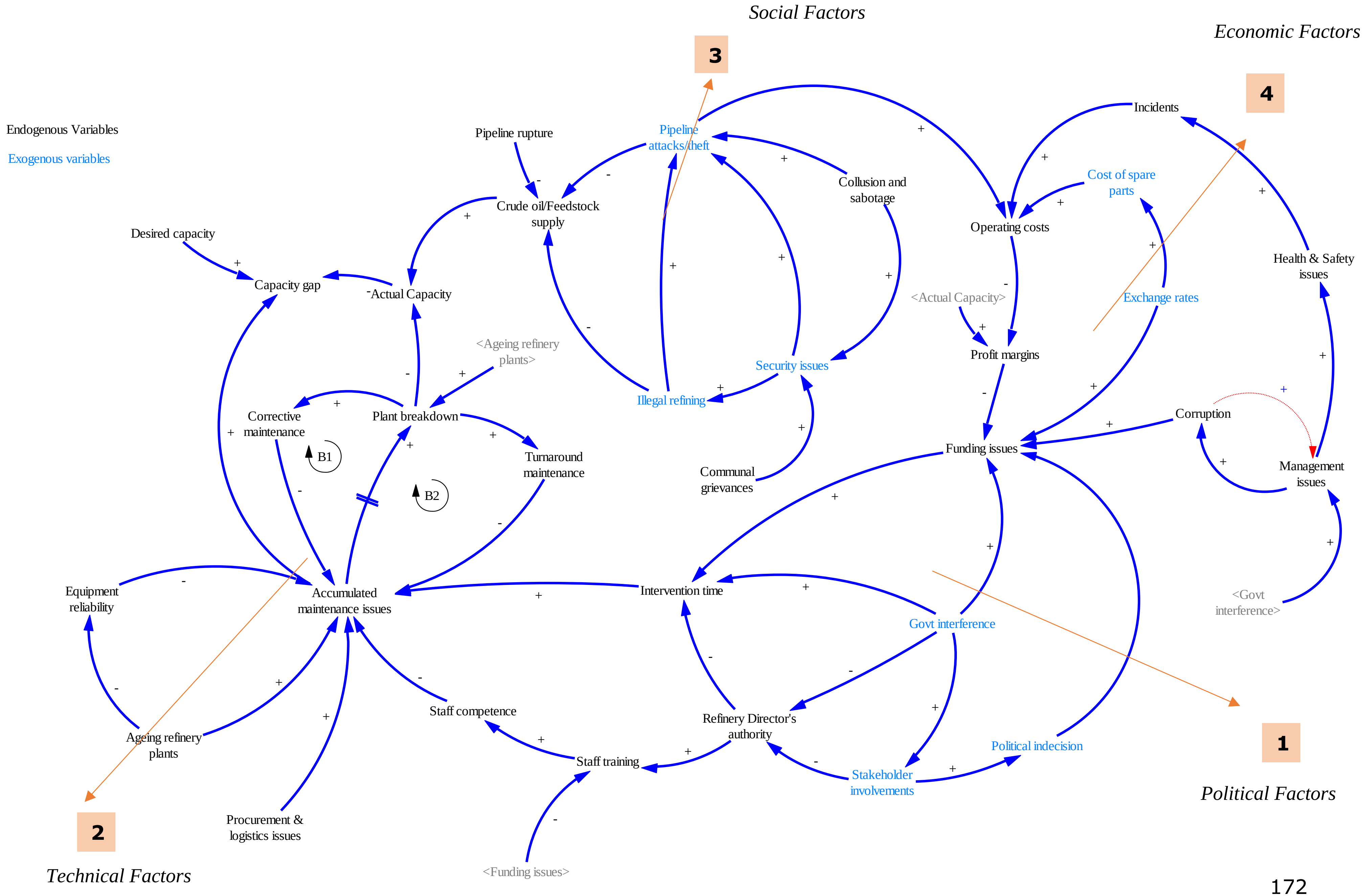


Figure 40 shows the initial model which reveals the interrelationships of the significant political, economic, social, and technical (PEST) factors in four cluster segments. This is because the last two PESTEL factors - environmental and legal factors did not yield any significant factors to form clusters of their own in the model. To understand the model, it is important to note that variables with *issues* appended to their names represent problem variables e.g., funding issues, security issues, management issues and accumulated maintenance issues can all be interpreted as funding problems, security problems etc.

Navigating through the four cluster segments of the model, it can be observed that in segment 1 representing political factors, government interference is positively linked to three variables (intervention time, funding issues, and stakeholder involvements) and negatively linked to refinery management authority. This implies that more government interference leads to increased intervention time, funding issues, stakeholder involvements and reduces refinery management authority. A full explanation of the causal links is provided for the validated model in Section 6.5 for the avoidance of repetition.

6.5 Model Validation

Jackson et al. (2000) opined that model validation strengthens the support for models based on expert reviews and factual checks. Anderson et al. (2015) supports this argument by acknowledging that model validation implies its correctness and reliability for making accurate forecasts. It was considered essential, therefore, to validate this model with the input of the experts who are knowledgeable on how the identified challenges operationalise across the NNPC refineries. As such, the model was sent to 9 experts across the refineries, with three experts polled from each of the refineries. This exercise was carried out to provide a conceptual validation of the model in order to determine whether the assumptions based on data analyses underlying the operationalisation of these factors were justifiable (Kerr and Goethel, 2014). The demography of the experts who validated this model is presented in Table 39.

Table 39: Demography of experts who validated the causal loop model.

Participant Code	Role	Station	Years of Experience
PHC-1	Director	PHRC	25
PHC-2	Plant Manager	PHRC	15
PHC-4	Maintenance Supervisor	PHRC	12
WRP-1	Production Manager	WRPC	17
WRP-2	Plant Manager	WRPC	15
WRP-3	Materials Manager	WRPC	12
KRP-1	Plant Manager	KRPC	18
KRP-2	Technical Supervisor	KRPC	11
KRP-3	Maintenance Engineer	KRPC	15

Table 39 indicates that 3 professionals from each refinery (PHRC, WRPC and KRPC) from mid to senior level management participated in the review and validation of the model. A summary of the suggestions and revisions to the initial model, as a result of this expert review, is presented in Table 40.

Table 40: Summary of expert model revisions

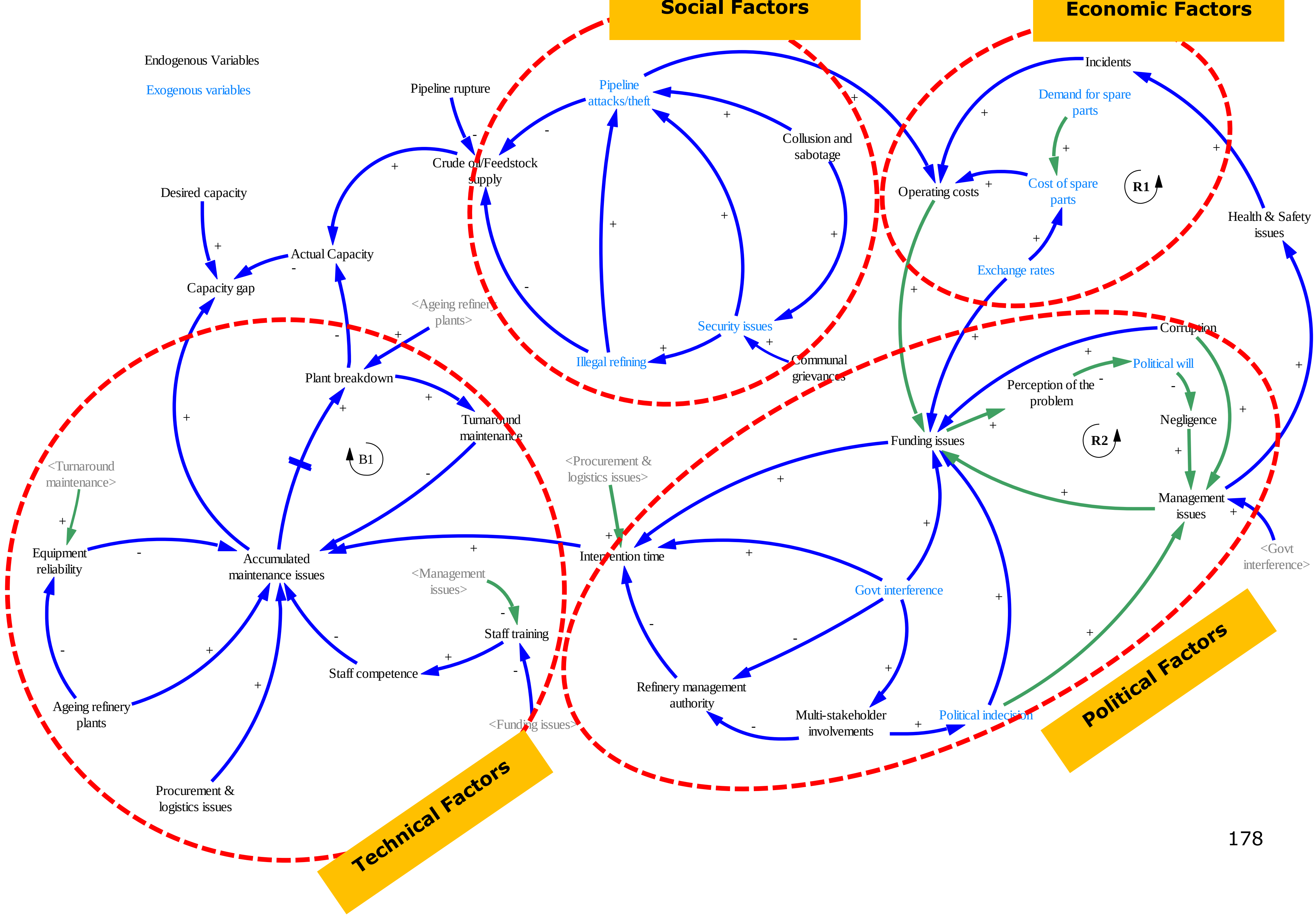
Participant Code	Relevant expert comments	Changes effected
PHC-1	While the other loops seem reasonable, the connection of profit margins in the model does not seem to reflect reality as the refineries do not independently control product sales but PPMC. Also, check for the connection of more factors around management issues. For example, *funding issues* usually raises the perception of the problem in government's view and thereby dampens the *political will*. This comes back to affect the refinery management.	Profit margins has been removed from the validated model. A proper connection has been made from *funding issues* through *problem perception* and to *political will* connecting to *management issues*. *Political indecision* has been properly linked to *management issues*.
PHC-2	I am impressed with the loops around the social issues, maintenance issues and so on. However, the model should be checked for more possible connections. I believe corruption contributes to more management issues as well as funding issues.	A proper link has been established between *corruption*, *management issues* and *funding issues*.
PHC-4	The maintenance loops seem rational regarding how the refineries eventually break down. I believe though that some form of maintenance could improve equipment reliability.	Duffuaa and Ben-Daya, (2004) supports the argument that turnaround maintenance improves equipment reliability. This connection has been correctly established in the model with a positive link.
WRP-1	The issue I have in the model is that I don't think that increasing refinery management authority will necessarily lead to increased staff training. An overhaul of the operating philosophy of the refinery would be needed to achieve	This section has been re-drawn to un-link *refinery management authority* from *staff training* and properly link *management issues* and *funding issues* to *staff training*. A change in

	this. I also believe that staff training issues may be influenced by funding issues as well as management issues.	operating philosophy will become a useful variable in the proposed model for policy intervention.
WRP-2	Typically, procurement and logistics issues as it relates to supply chain can also increase intervention time when poorly managed. Also, check the connections around Profit margins. This doesn't really sit well with our mode of operations.	Profit margins have been removed from the revised model. *Procurement and logistics* have been linked to positively influence *intervention time.*
WRP-3	Is exchange rate the only factor that may affect spare parts cost? The link between refinery management authority and staff training is not convincing. Check the model again for potential missing links.	This link has been re-drawn to un-link *refinery management authority* from *staff training*. Also, demand for spare parts cost is believed to also affect cost and has been connected.
KRP-1	I am happy with the maintenance loops. However, should the level of corruption not influence management issues and vice versa?	A loop has been appropriately linked between management issues and corruption.
KRP-2	I do not get the direct picture of how the refinery director's authority may increase training. I understand that this can give the management the freedom to manage trainings. However, the connection is not quite clear.	This link has been re-drawn to un-link refinery management authority from staff training as this is not an accurate reflection of reality.
KRP-3	I believe that funding issues can affect management issues as well. The other loops appear logically connected based on causalities. However, the issue of profit margin is not quite relevant there.	Profit margin has been removed from the model as it is not a major factor affecting performance. A proper link has been established between funding issues and management issues.

Table 40 shows the summary of relevant expert comments on the model which resulted in its revision. A revised and improved model is presented in Figure 42 with the revision links in green. For example, three of the experts (PHC-1, WRP-2, KRP-3) noted that, while high operating costs may somehow compound funding issues, its impact on profit margins is not a direct performance driver on the refineries. This is due to the fact that the refineries do not govern their inputs and outputs but are rather supplied crude oil by PPMC and also return their products to PPMC for sale. The refineries, however, receive money for their operations through yearly allocations from the parent NNPC Group. In addition, some experts (KRP-2, WRP-1, WRP-3) noted that increasing refinery management's authority will not necessarily increase staff training practices as a change in management philosophy would be required to achieve this. The professionals also pointed out that corruption contributes to management problems (issues) and as such, should have a link, which would produce another loop. Figure 42 depicts the validated model showing the challenges of the NNPC refineries.

It is important to note that this modelling exercise helped provide a clearer appreciation of how the significant factors interdependently drive poor performance within the refineries in terms of gaps in actual production capacity from the desired optimum capacity. As such, even some factors that were previously considered significant such as profit margins were later seen in a different context when the causal loop diagram was drawn.

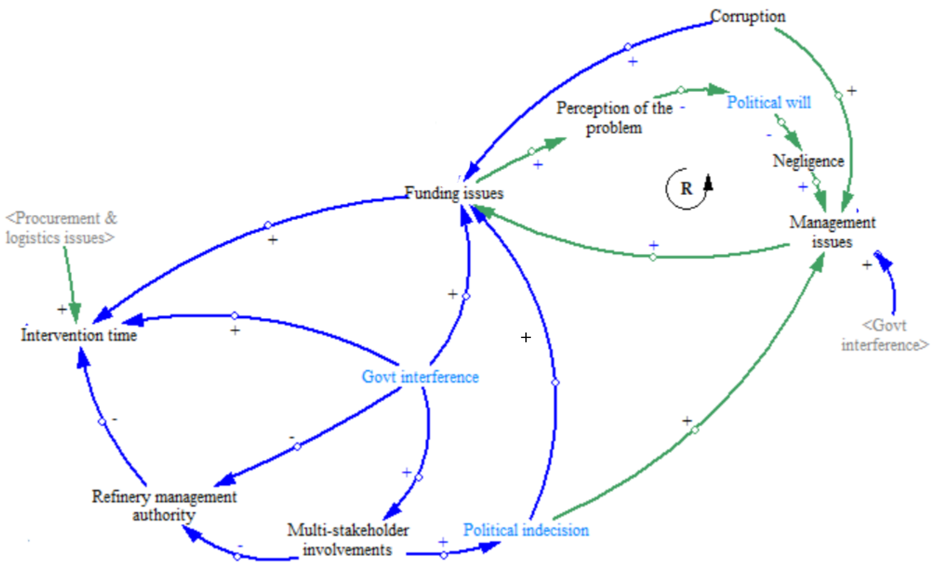
Figure 41: Validated causal loop model for NNPC Refinery Challenges



6.6 Analysis of the initial validated causal model on challenges of the refineries

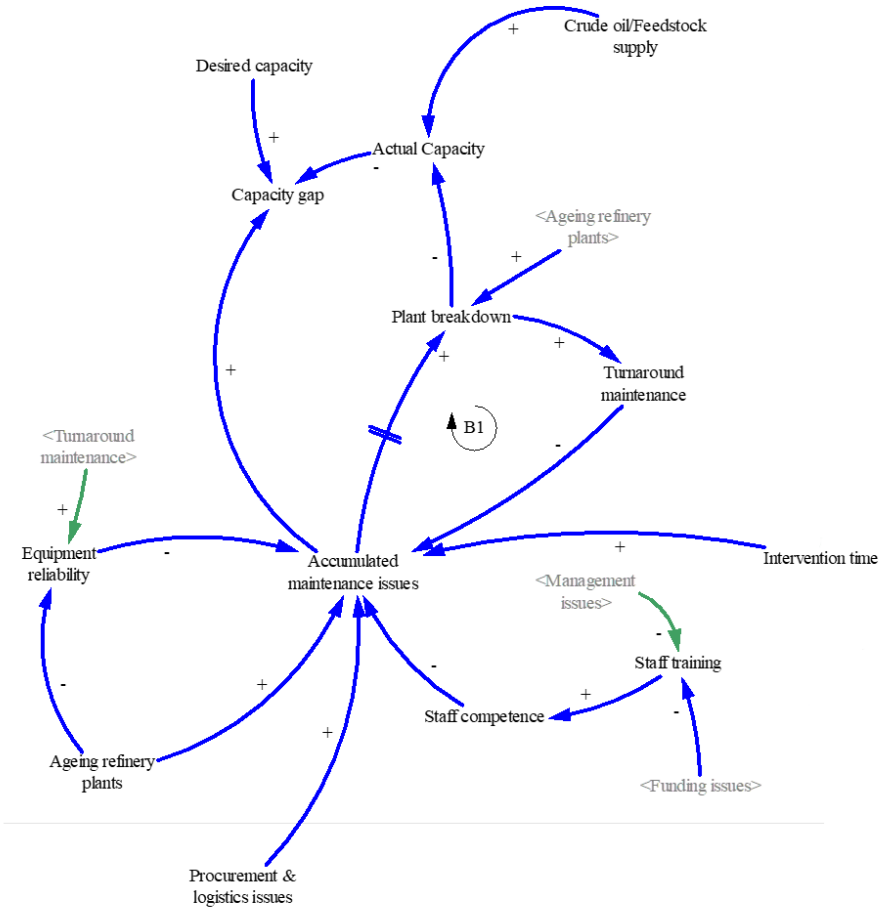
The model as shown in Figure 41 was developed based on the results of the quantitative and qualitative data analysis (Sections 5.1 – 5.3) as well as inputs through validation from key stakeholders as of October 2021. The interrelationships can be seen in the significant four cluster segments representing political, technical, social, and economic factors enclosed in red (dashed line) bubbles. The effected changes as a result of the validation are depicted by the green arrows. Figure 42 shows the political sector segment of the model.

Figure 42: Political Factor Segment



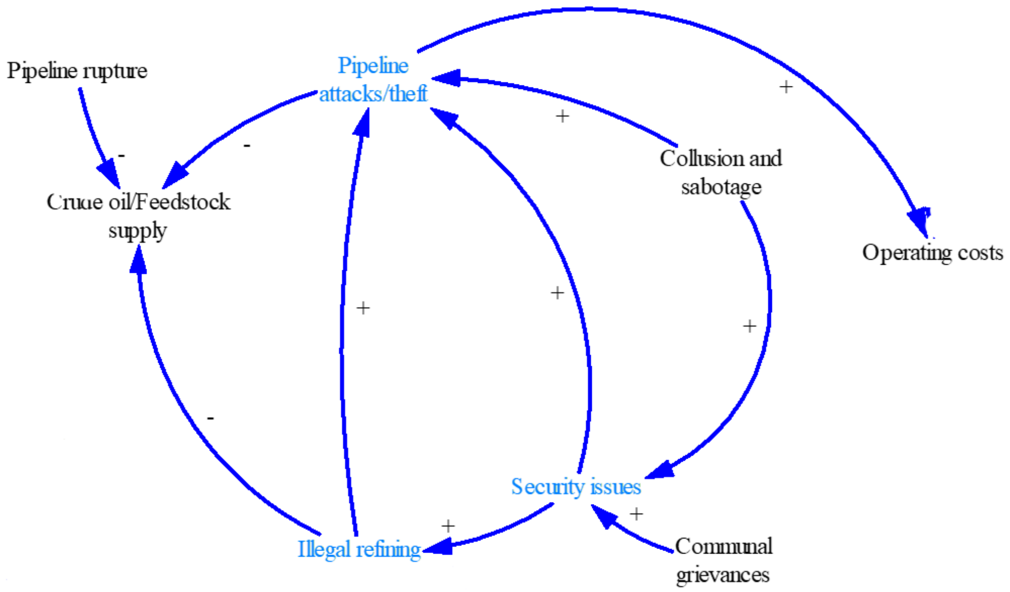
In segment -1 representing political factors (Figure 42), it can be observed that *government interference* is a major driver positively linking *intervention time*, *funding issues*, *multi-stakeholder involvements*, and negatively linking *refinery management authority*. This implies that more government interference leads to increased intervention time, funding issues and multi-stakeholder involvements, whilst diminishing the refinery management authority. In addition, part of the political segment shows that funding issues are connected in a reinforcing loop through problem perception (+), political will (-), negligence (-), and management issues (+). The sign notations on the links implies that the more funding problems experienced at the refineries, the higher the perception of the problem in government's view, therefore the less the political will to fix the problem and the more the negligence of the issues, which compounds the problems for the refinery management. *Corruption* also increases both the *funding issues* and *management issues* through a lack of accountability, transparency and public diversion of funds meant to fix the refineries by the government. This segment of the model is connected to the technical segment (Figure 43) through prolonged *intervention time*, which contributes towards *accumulated maintenance issues*.

Figure 43: Technical Factor Segment



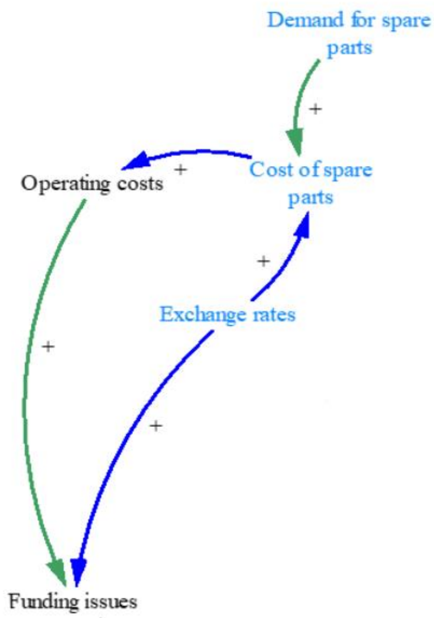
In segment-2 representing technical factors (Figure 43), it can be seen that *accumulated maintenance issues* (as a variable) is both a major receiver and driver of other variables in the segment. The notations of the variables in this segment indicates that less *equipment reliability* due to increasing *ageing of the refinery plants* will lead to *accumulated maintenance issues*, just as more *procurement issues*, *staff competence issues*, and prolonged *intervention time* will do. Over time, the *accumulated maintenance issues* lead to *plant breakdown*. This plant breakdown, in turn, forces a reactive *turnaround maintenance* directed to fix the refineries. This is a recurring balancing loop which never fixes the plants as the turnaround maintenance actions have hardly been done since early 2000s (Ogbuigwe, 2018). The overall effect of this loop is the resultant widening of *capacity gap* through reduced *actual capacity* of the refineries. This segment of the model also connects the social segment (Figure 44) through gaps in production capacity as a departure from the desired optimum (target) capacity.

Figure 44: Social Factor Segment



In segment 3 representing social factors (Figure 44), it can be observed that *pipeline attacks* (vandalization) is positively linked by *illegal refining*, *collusions & sabotage* as well as *communal grievances* through *security issues*. In addition, *pipeline attacks* and *pipeline ruptures* are negatively linked to *crude oil supply* to the refineries. This simply implies that more *illegal refining*, *security issues* and *collusion & sabotage* lead to more *pipeline attacks*, which reduces available *crude oil supply* to the refineries. *Pipeline attacks* interacts with the next segment (economic factors – Figure 45) through the increment of *operating costs* of the refineries in the model.

Figure 45: Economic Factors Segment



In segment 4 of the model representing economic factors (Figure 45), it can be seen that *operating costs* is positively linked to *funding issues* which is also positively inked by *exchange rates*. *Exchange rates,* in turn, is positively linked *to cost of spare parts* which is also positively linked by *demand for spare parts*. These notations and their connections imply that higher *operating costs* leads to more *funding issues* (problems) just as higher *exchange rates* do. High *exchange rates* also increase the *cost of spare parts* just as *demand for spare parts* do.

The interrelationships amongst these segments reveal crucial linkages which inform potential leverage points for policy interventions.

6.7 Finding leverage points for policy intervention

Senge (1990) defines leverage points in a system as places in the structure of the system where a solution can be applied as a shift or change in the structure to bring about enduring significant improvements in the behaviour of the system. As such, Meadows (1999) identified 12 places to intervene in a system as points of leverage to improve its performance. However, Roxas et al. (2019) carried out an extensive study on systems thinking literature employing causal loop diagrams as tools for policy intervention to synthesise Meadow's (1999) 12 points of intervention into three categories, namely: weakest leverage, medium leverage, and strongest leverage as shown in Table 41.

Table 41: Categorized Meadows' Twelve Points of Leverage.

Proposed potential leverage points (PLP) criteria	Leverage points (in increasing order of effectiveness)	Categories
Common cause to multiple effects that can accelerate or decelerate the operation of a system	12—constants, parameters, numbers 11—sizes of buffers and other stabilizing stocks, relative to their flows 10—structure of material stocks and flows 09—lengths of delays, relative to the rate of system change	**Weakest leverage** (Physical leverage points)
Can be influenced by an intervener	08—strength of negative feedback loops, relative to the impacts they are trying to correct against 07—gain around driving positive feedback loops 06—structure of information flows 05—rules of the system	**Medium leverage** (Information and controls as leverage)
Root cause characterized by being independent (i.e., cannot cite further causes)	04—power to add, change, evolve, or self-organize system structure 03—goals of the system 02—mindset or paradigm out of which the system—its goals, structure, rules, delays, parameters—arises 01—power to transcend paradigms	**Strongest leverage** (Ideas as lev erage)

Source: Roxas et al. (2019)

Accordingly, Roxas et al. (2019) used this framework to propose three set of characteristics that will aid the identification of potential leverage points (PLP) in a system that satisfies Meadow's 12 points of leverage. These characteristics include:

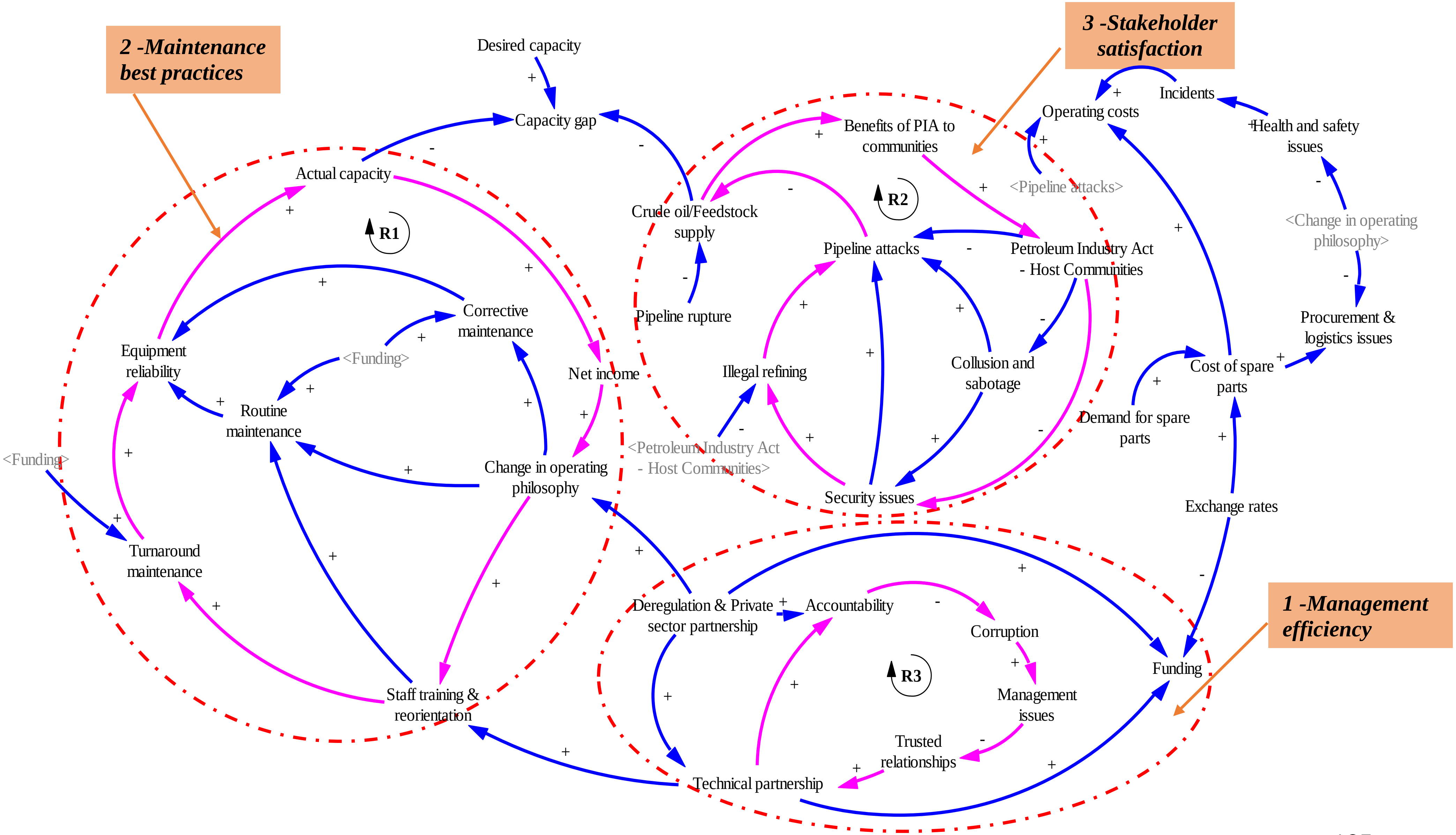
1. Common cause to multiple effects that can accelerate or decelerate the operation of a system: This is where a variable in a causal loop diagram (CLD) results in the greatest number of effects and thereby drives the CLD. This implies a point in the system where a small shift can result in big changes in the system.
2. Can be influenced by an intervener: This is a point in the system where an intervening variable can be allowed to make significant improvements in the system.
3. Root cause characterised by being independent i.e., cannot cite further causes. This is a point in the system where a variable generates significant and irreversible changes when thresholds have been reached.

Looking for these characteristics across the validated CLD (Figure 42) which shows the challenges of the refineries, policy intervention points can be observed across government interference (within political factors) as a major driver of several variables (first characteristic), accumulated maintenance issues as a major driver and receiver of influence from several variables (first and second characteristics), and pipeline attacks, collusion & sabotage, as well as security issues as the root causes driving shortage of crude oil to the refineries (third characteristic).

Making policy interventions across these linkages will significantly change the structure and behaviour of the system to obtain the desirable behaviour targeted at addressing the performance gaps of the refineries (Meadows, 1999 and Sterman, 2010).

Figure 46 shows the proposed CLD, which this research provides the basis for addressing the performance gaps of the refineries through the recommended policy interventions.

Figure 46: Validated Recommended Model for Improved Performance of NNPC Refineries



The proposed model as shown in Figure 46 was re-sent to the industry professionals for validation. The industry experts considered the revised model to be reasonably logical to help address the problems of the refineries, whilst noting that it is also possible the model could be drawn in other ways to produce similar results.

A detailed examination of Figure 46 reveals that the initial PESTEL model has been collapsed into three sub-divided segments (1-3) with dotted red lines. These segments represent the proposed policy interventions capable of addressing the systemic issues across the refineries. Specifically, these proposed policy interventions are named management efficiency, stakeholder satisfaction, and maintenance best practices to reflect the overarching goals of the emergent sub-systems.

In addition, the model shows several feedback loops acting within the system to drive incremental gains that contribute towards closing the performance gap of the system. Table 42 shows the various loops (from the Vensim software) acting within the segments to achieve this improvement.

Table 42: Identified feedback loops on the proposed model

Loops for Stakeholder Satisfaction	**Loops for Maintenance Best Practices.**
Loop Number 1 of length 3	*Loop Number 1 of length 4*
Petroleum Industry Act - Host Communities	Change in operating philosophy
	Routine maintenance
Pipeline attacks	Equipment reliability
Crude oil/Feedstock supply	Actual capacity
Benefits of PIA to communities	Net income
Loop Number 2 of length 4	*Loop Number 2 of length 4*
Petroleum Industry Act - Host Communities	Change in operating philosophy
	Corrective maintenance
Security issues	Equipment reliability
Pipeline attacks	Actual capacity
Crude oil/Feedstock supply	Net income
Benefits of PIA to communities	*Loop Number 3 of length 5*
Loop Number 3 of length 4	Change in operating philosophy
Petroleum Industry Act - Host Communities	Staff training & reorientation
	Turnaround maintenance
Illegal refining	Equipment reliability
Pipeline attacks	Actual capacity
Crude oil/Feedstock supply	Net income
Benefits of PIA to communities	*Loop Number 4 of length 5*
Loop Number 4 of length 4	Change in operating philosophy
Petroleum Industry Act - Host Communities	Staff training & reorientation
	Routine maintenance

Collusion and sabotage Pipeline attacks Crude oil/Feedstock supply Benefits of PIA to communities *Loop Number 5 of length 5* Petroleum Industry Act - Host Communities Security issues Illegal refining Pipeline attacks Crude oil/Feedstock supply Benefits of PIA to communities *Loop Number 6 of length 5* Petroleum Industry Act - Host Communities Collusion and sabotage Security issues Pipeline attacks Crude oil/Feedstock supply Benefits of PIA to communities *Loop Number 7 of length 6* Petroleum Industry Act - Host Communities Collusion and sabotage Security issues Illegal refining Pipeline attacks Crude oil/Feedstock supply Benefits of PIA to communities	Equipment reliability Actual capacity Net income **Loops for Management Efficiency** *Loop Number 1 of length 4* Management issues Trusted relationships Technical partnership Accountability Corruption

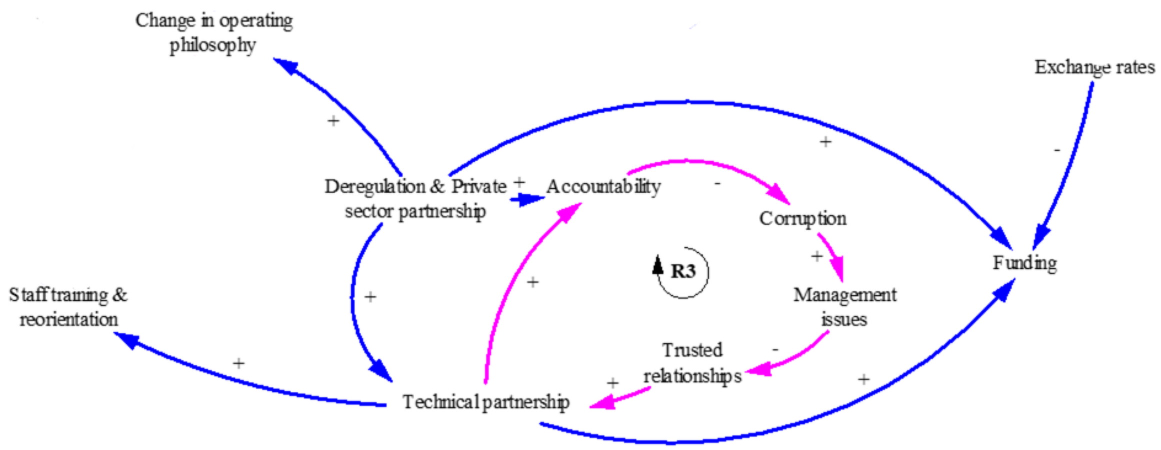
Source: Output form Vensim Model

Table 42 indicates that 7 reinforcing loops can be found within the stakeholder satisfaction cluster, 4 reinforcing loops within the cluster of maintenance best practices and 1 reinforcing loop within the cluster of management efficiency.

6.8 Segment analysis and policy framework

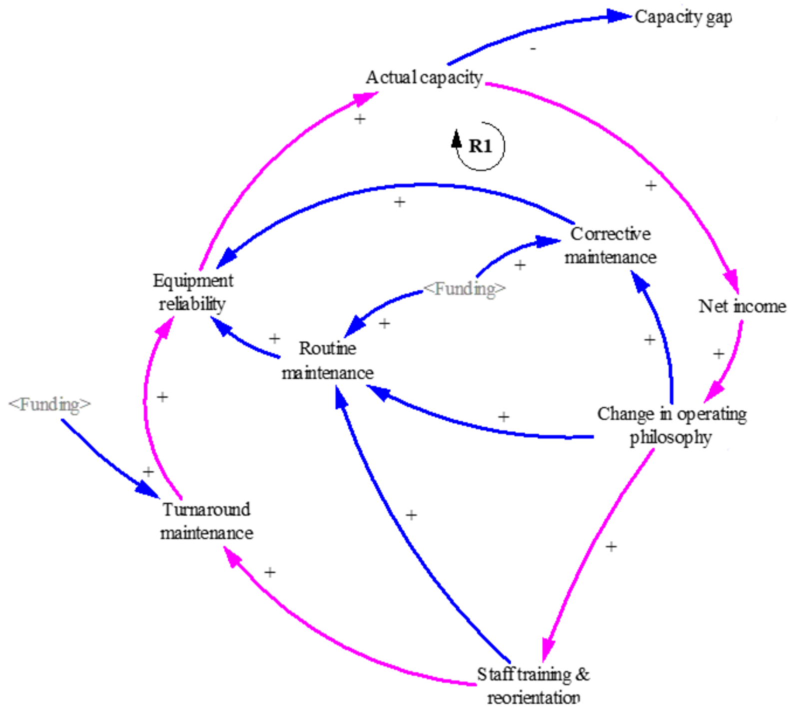
To provide a more detailed analysis of the clusters, it is important to break the segments once again into separate clusters.

Figure 47: Model Segment for Management Efficiency



Across segment -1 representing management efficiency, it can be seen that this theme is proposed to be pursued through full deregulation and private sector partnership to overcome the influence of government control and over-regulation in the system (Graham, 2020). This variable is positively linked to *accountability* as the more the involvement of private sector participation in the operations of the refineries, the more the demand for accountability, hence the less corruption experienced in the organisation. Less corruption also leads to less management issues. This, in turn, would lead to more trusted relationships across the organisation (+). It is important to note that this is a reinforcing loop (R3) which further strengthens the technical partnership with the private sector (+). This segment interlinks with the second segment (maintenance best practices) through staff training & re-orientation and change in operating philosophy informed by technical partnership with the private sector.

Figure 48: Model Segment for Maintenance best practices



In Segment 2, which deals with maintenance best practices, it can be observed that the main reinforcing loop represented by the pink lines (R1) is driven by change in operating philosophy across the refineries. This change positively drives *staff training and re-reorientation* in the sector. Such new orientation and training will encourage the implementation of the necessary maintenance culture through the adoption of routine preventative and scheduled turnaround maintenance. These practices will, in turn, improve equipment reliability and eliminate accumulated maintenance issues which causes regular plant breakdowns (in previous model). Systemically, this strategy will potentially drive the increment of the actual production of the refineries, which will increase the organisational income and thereby re-enforce the operating philosophy through continuous improvements. Altogether, these interdependencies will contribute towards closing the gap between actual capacity and desired optimum capacity.

Figure 49: Model segment for Stakeholder Satisfaction

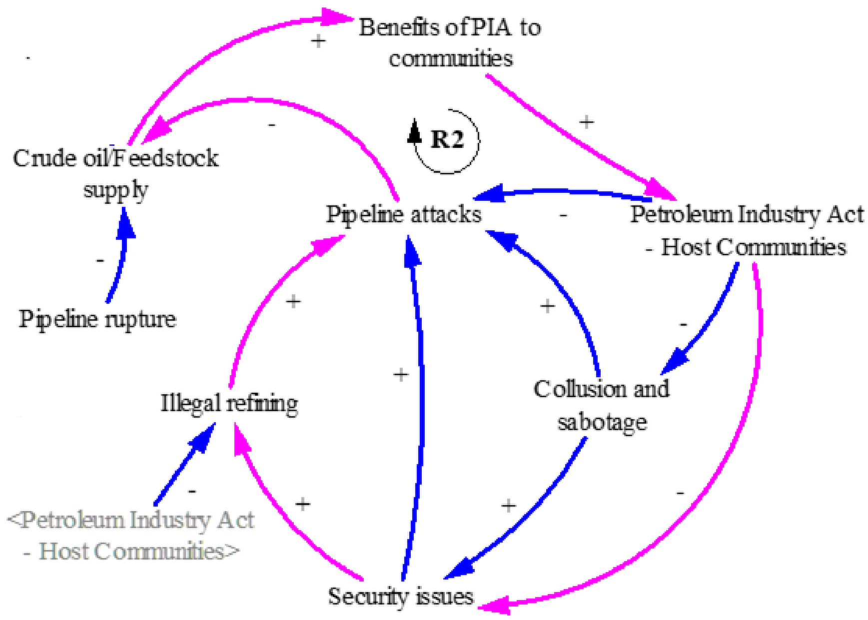
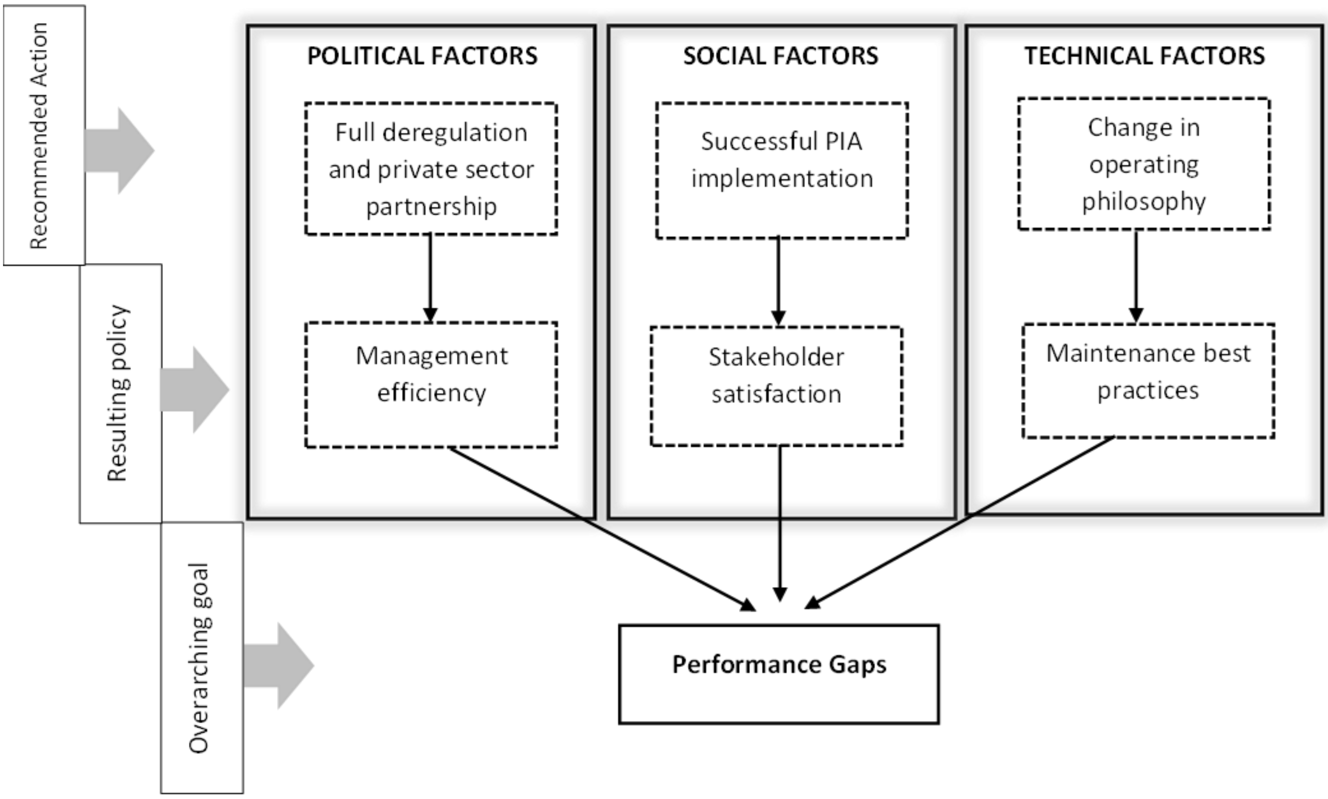


Figure 49 shows the segment representing stakeholder satisfaction. For this cluster, the introduction of the new Petroleum Industry Act (PIA) signed in August 2021, is believed to be capable of acting as a major policy shift to address the social issues. The detailed implications of this policy shift are presented in Chapter 7 (Discussions). The links in this cluster, however, show that the PIA will reduce security issues, pipeline attacks, as well as collusion and sabotage within the communities. This section of the model has 7 reinforcing loops (presented in Table 42) within the longest loop (R2, Figure 49), all acting towards closing the supply gap of crude oil to the refineries.

As such, it implies that, out of the four significant PESTEL factors affecting the refineries (PEST), the leverage for addressing the performance gaps lies within the political, social, and technical factors. Economic factors present little leverage as such factors as exchange rates and cost of spare parts lie outside the control of the refineries. However, operating cost can be reduced through policies applied at the social, political, and technical (SPT) segments (Figure 46 and 50). Figure 50 shows the proposed policy intervention framework for addressing these performance gaps.

Figure 50: Proposed Policy Intervention Framework for addressing the NNPC refinery challenges



Source: Author generated

Figure 50 shows that there are three segments comprising political, social, and technical (PST) factors at which policy interventions can be applied to potentially close the performance gaps of the NNPC refineries. These policy interventions are grouped into three levels, namely:

- recommended actions which comprise full deregulation and partnership with the private sector at the political segment
- successful PIA implementation at the social segment and
- change in operating philosophy at the technical segment.

This level give rise to the resulting policies (2nd level) within each PST segment, which altogether contributes towards an overarching goal (3rd level) of closing the performance gaps of the refineries. As such, management efficiency can be pursued through full deregulation and private sector partnership as a political approach to fix the governance issues of the refineries. Stakeholder satisfaction can be achieved through the successful implementation of the PIA as a social approach to resolve the social issues within and around the operating environment of the refineries. While maintenance best practices can be pursued through a change in operating philosophy as a technical approach to fix the maintenance culture of the refineries.

It is important to note that this framework emphasises intervention measures and as such, is not typical of standard policy frameworks, which incorporates standard definitions, development/deployment guide, and review processes (Damianou, 2002). Accordingly, each of these approaches, if carefully implemented would systemically close the performance gaps of the refineries over time through marginal incremental gains i.e., small increments across all segments which aggregates over time to larger gains.

It addition, it can be noted that the three underpinning philosophies for the proposed policy intervention are more aligned with soft systems methodology than hard systems (see Section 3.4). This is because a soft systems methodology acknowledges that systemic problems are diffuse and less clearly defined with approximate solutions capable of dealing with its challenges, while a hard systems approach assumes that the problems are well defined and have a single scientific, optimum solution (Checkland, 1981 and Hasan, 2011). This implies that changing the operating philosophy of the refineries, rolling back regulations in the downstream sector to allow private sector participation in the refinery management, and implementing a meaningful engagement of all relevant stakeholders represent new ways of approaching the problems of the refineries with a view of making incremental gains over time towards their optimum performance.

6.9 Chapter Conclusion

This chapter presented the three stages of model development for this study. It described the steps for the development of the initial model (Figure 40), which was validated to produce a more accurate model representing the problems of the refineries (Figure 41). The validated model was then used to inform a policy intervention model (Figure 46) proposed to address the performance gaps across the refineries. Hence, the proposed policy intervention model provided the basis for developing the policy framework to address the issues.

The policy framework showed that the leverage points for addressing the refinery issues laid mainly within the political, social, and technical issues affecting their performance.

Consequently, it proposed three main approaches to address the issues through management efficiency, maintenance best practices, and stakeholder satisfaction. It argued that a coherent implement of these approaches would close the performance gaps of the refineries.

The next chapter (Chapter 7) will provide more details on how these interventions can potentially lift the performance of the refineries.

CHAPTER SEVEN: DISCUSSIONS

7.1 Introduction

The aim of this study was to explore the challenges of the Nigerian crude oil refining industry with a view of understanding the causal interrelationships of the factors that affect their performance. In addition, the research aims to develop a causal loop model that will provide the basis for a policy intervention framework for the Nigerian government for addressing the challenges of the refineries. As the preceding chapter has demonstrated how the causal loop model (developed through quantitative and qualitative data collection and analytical techniques) informed the development of the policy intervention framework, this chapter presents a detailed discussion of the framework including the policies that underpin its purpose.

7.2 Policy Analysis

Haynes et al. (2020) observed that policymakers can derive substantial applied value from systems thinking which can help them re-conceptualise the problem and its contexts. Cairney (2021) suggests that systems thinking diagrams such as Causal Loop Diagrams (CLDs) can provide a platform to identify points in a system where interventions can be made to rethink its cause and effect. Geyer (2012), however, notes that while making policies based on systems thinking, it is important to avoid single-shot policies that tend to adopt a one-size-fits-all approach to solving complex problems. The causal loop model developed in Chapter 6 of this study shows the various interdependencies of the factors that drive sub-optimal performance across the NNPC refineries. In the proposed model that addresses the issues with the refineries, three identified leverage points were used to inform a policy framework to close the performance gaps of the refineries.

The underpinning philosophy behind this policy framework is discussed in the following sections.

7.2.1 Segment 1 - Management efficiency

In segment -1 of the model, management efficiency is pursued through full deregulation and private sector partnership with the refineries. It can be seen that government interference in the initially validated model (Figure 41) has been replaced with full deregulation and private sector partnership with the refineries. Full deregulation was considered a necessary condition to achieve any form of partnership with the private sector as the Nigerian government currently operates a partially deregulated petroleum policy, which regulates the pump price of petrol and kerosene, excluding that of diesel (Olujobi, 2021). Nkogbu and Okorodudu (2015) argued that full deregulation would provide the necessary incentive for private sector participation in Nigeria's downstream petroleum sector by allowing market forces to determine commodity prices. Unfortunately, private sector participation in Nigeria's downstream sector has remained unimpressively low due to high regulation by the government (Section 2.4). According to Olujobi (2020/2021), the main barriers for full deregulation of the Nigerian downstream sector include corruption, bad governance, and inefficient government regulators to enforce the legal framework.

Technically, deregulation implies the removal of government control on petroleum firms through the de-monopolisation of oil trade within the industry to encourage effective competition and profitable development of the sector (Olujobi, 2021; and Nkogbu and Okorodudu, 2015). Baghebo et al. (2015) also notes that deregulation provides a pathway for private sector investment in a sector by freeing government involvements through easing the numerous rules regulating the free market, which will allow prices to be determined by market forces. Although it has been argued that deregulation might lead to less government oversight with associated fraudulent activities resulting to poor service delivery (Goetz and Vowles, 2009). However, Olawore (2012) opines that full deregulation of the downstream petroleum sector in Nigeria will allow private investor participation to transform the sector by promoting transparency through fuel availability, employment opportunities, and better economic growth resulting to increased revenue for the government. These studies provide some evidence for proposing full deregulation as a pre-condition for private sector partnership.

The importance of private sector partnership for the refineries is related to the significance of government interference gleaned from the research findings as a major barrier to efficiency through independent control and timely decision making across the refineries (Sections 5.2 and 5.3). This policy change is supported by literature findings suggesting that private sector partnership with state-owned firms improves efficiency and performance, raises quality of management, and lessens public sector influence across organisations (Graham, 2011/2020 and Potter, 2015).

It should be noted that private sector partnership represents a level of privatisation. The Organisation for Economic Cooperation and Development (OECD) (2018) notes that privatisation involves the full or partial divestment of government incorporated assets. This implies that privatisation of state-owned enterprises (SOEs) can be full or partial. In their assessment of privatisation for state infrastructure, Deloitte (2018) reported that there appears to be a continuous spectrum of models of privatisation with state ownership at one end, privately owned at the other end, and with private sector participation in the middle. As such, Graham (2020) identifies three popular types of privatisations along this spectrum – Initial public offerings (IPOs), Public-Private Partnerships (PPPs) and Freehold sale to a single or consortium of investors. While the initial public offering and the PPP models embrace elements of shared ownership between the state and the private sector, the freehold sale depicts a full transfer of ownership to the private sector.

Le Grand and Robinson (2018) opined that privatisation essentially involves the reduction of state involvements in three areas: provision, subsidy, and regulation. The current structure of the NNPC refineries uses subsidy and regulation to provide cheaper petroleum products for the Nigerian population. Unfortunately, this practice has been fraught with corruption and has become unsustainable over the years (Section 2.4.2 and 2.5.4) (Akinola, 2018). According to Le Grand and Robinson (2018), the most popular form of privatisation is the replacement of the state by the market, where the service will be undertaken by profit-maximizing businesses operating in a competitive unregulated environment.

However, there has been legitimate concerns that privatising state-owned entities may lead to organisations prioritizing profits over crucial social services and as such may not be suitable for certain public sectors such as healthcare and water distribution (Lethbridge, 2016). On the contrary, privatisation has been shown to work effectively for the oil and gas sector across Europe, North America, and Asia (Kaznacheev, 2016). Even across Africa, especially in Nigeria, the most successful organisations particularly in the oil and energy sector are run by the privately incorporated International Oil companies (IOCs), usually in partnership with the national government (Abdul-

Rahamoh et al., 2013). In addition, most of the best global performing refineries according to Solomon Associates, an industry assessor, are run by the private sector (Solomon Associates, 2020). Even some refineries, such as Sinopec, where state-ownership comprise a significant portion of its shareholding are usually operated in partnership with private organisations (Palmer, 2019).

The benefits of introducing privatisation into state-owned enterprises have been severally highlighted. According to a study carried out by the OECD (2018) across 25 European countries from 2008 to 2017 over the impact of privatisation of state-owned enterprises on performance, the result showed that privatisation is increasingly becoming popular amongst the EU countries and has resulted to a growth in revenue from $110bn in 2008 to $266bn in 2016. In addition, Potter (2015) noted that the incentive for profits encourages private-run organisations to introduce new technologies that increase productivity. NNPC refineries would benefit from such technological innovation as most equipment in the facilities have become outdated and require urgent upgrade to meet current industry standards (Eti et al., 2006; and Ogbuigwe, 2018).

The decision to privatise state-owned assets such as refineries must, however, be governed by justifiable rationales to be successful. The OECD (2018) suggests that in emerging economies where the rationales for state ownership of enterprises are more broadly defined, especially for the provision of public services, the failure of such enterprises to comply with such objectives would ideally make them eligible candidates for privatisation. The NNPC refineries clearly fall into this category of state-owned assets with a history of repeated failure to supply much needed public products (Sections 2.1 to 2.3), thereby necessitating their privatisation.

Chaouk et al. (2019), OECD (2018) and Potter (2015) all acknowledge that the choice of a privatisation model for state-owned assets must, however, be tailored to the socio-political needs of the nation. While the Nigerian petroleum sector generally operates with forms of Joint Venture partnerships between the government and the International Oil Companies at the upstream sector (see Section 2.1), the downstream sector has little to no record of partnerships with the private sector as the facilities in this sector such as the refineries and their product pipelines are owned by the NNPC. Given the poor performance of the downstream sector compared to the upstream sector, it can be argued that the downstream sector will benefit from the expertise of the private organisations that run similar services elsewhere. This is an approach that could potentially improve the chances of better service delivery from the sector to satisfy the general Nigerian public.

According to Le Grand and Robinson (2018), a simple recommendation of privatisation, whereby the state is replaced by the private sector is hardly sufficient, as it is necessary to specify the kind of state involvement to be replaced alongside the kind of private sector participation to be involved. The popular model of privatisation for the NNPC refineries suggested by the NNPC GMD in 2021 was referred to as the NLNG model. In this model, the federal government co-owns the Nigerian Liquefied Natural Gas (NLNG) company with a minority stake alongside a consortium of other IOCs with the expertise to run and manage the company (George, 2021). The fact that this model has effectively worked for the NLNG for more than three decades in Nigeria appears to provide some evidence that it can equally be suitable for the refineries. This model, which represents a partnership with an experienced private sector is the recommended model from this study as supported by the model in Figure 46 (Section 6.7). The implementation of this model will provide an opportunity for the government to not only be partly involved in the refining business but also ensure that abuses from the private sector are checkmated for the interest of the public.

7.2.2 Segment 2 - Maintenance Best practices

In segment 2, maintenance best practices is proposed to drive operational efficiency across the refineries through the implementation of processes that prioritize routine preventative maintenance alongside scheduled turnaround maintenance programs over a reactive maintenance culture. As evidenced by the results of this study, this approach can be driven by a change in the operating philosophy across the refineries brought about by a change in management strategy led by a profit-oriented private sector (see Section 6.7).

To sustain this practice, it would be essential for the NNPC refineries to incorporate international benchmarking standards to measure and monitor their performance against peer group refineries. A good example of such standard is the Solomons Associates, which provide regular performance assessments of oil refineries across a wide range of criteria such as reliability, margin generation, safety, operating expense control, and utilisation maximisation (Solomon Associates, 2020). These assessments are provided through a data-driven process that recommends improvement strategies based on their outcomes.

One of the key drivers of success in this segment would be a change in the operating philosophy for the refineries as revealed by the research findings (Section 6.5). Ideally, setting a business philosophy requires senior management commitment to identify and set important goals of the business. A business philosophy refers to an organisation's goals and purposes, including its moral obligations (Drucker, 2012). This implies how an organisation operates with respect to its values, belief systems and how they organise to achieve their goals. As such, it is the guiding statement and watchword of the organisation that determines the direction and behaviour of its employees. An organisational philosophy that values hitch-free operations with uninterrupted equipment breakdowns would also prioritise the effective training and development of competent manpower to support those vital operations.

It should be noted that the implementation of the optimum maintenance culture across the NNPC refineries will systemically reduce or eliminate disruptive breakdowns and lower the operating losses incurred through extended downtimes (Abbasinejad et al., 2021). This will contribute towards closing the performance gaps as production capacity rises to meet desired targets as demonstrated in the model of this study (Figure 46). To achieve this, it would be necessary for the planned turnaround maintenance (which as of October 2021 is still underway) to be completed. It is important to note that this exercise provides a timely opportunity for NNPC to revitalise the refineries using current technologies that will reduce operational and product emissions, hence lowering the environmental footprint of the refineries. This will provide greater advantage for the refineries in finding responsible international operators with experience for partnership with a new management strategy.

7.2.3 Segment 3 - Stakeholder satisfaction

In segment -3 of the model (Figure 46), involving stakeholder satisfaction, it can be observed that the introduction of a major policy shift that incorporates community engagement and stakeholder buy-in will reduce tensions and agitations leading to sabotage that ultimately result in damages of oil installations. The Host Communities

Section of the Petroleum Industry Act (PIA HC) signed by the Nigerian president in August 2021 is expected to help address this issue.

The aim of the Host Communities section of the PIA (PIA HC) is to foster sustainable prosperity, peace and good relations between oil licensees and lessees (settlor) and the communities. To achieve this, the PIA is to establish the Host Communities Development Trust aimed at benefitting the host communities of oil operations. The trust is to be funded by the settlor with 3% of their actual annual operating expenditure in the preceding year. The Act stipulates that where hostilities occur within any of the communities in any year resulting to damages to oil facilities such as pipelines, the host community shall forfeit its entitlement for that year to the tune amounting to the cost of repair of such damages to the oil facility. This provision, by implication, places a huge responsibility on the host communities to be more accountable in policing and protecting oil facilities resident in their communities. This development appears to be well thought-out and is expected to reduce the incentive for the local beneficiaries of the trust from damaging the infrastructure that guarantees the continuity of these benefits. Osobajo and Moore (2017) showed that activity links, resources ties, mutual benefits, communication, and mutual goals are some of the conditions that enhance relationship quality between businesses and their host communities. As such, the successful implementation of the PIA HC can be argued to possess the capacity to offer significant opportunities for community engagement and empowerment to ensure stakeholder satisfaction. This will help fix the incidences of pipeline attacks, and communal grievances within the host communities.

Essentially, the significant factors driving the performance challenges of the NNPC refineries identified by this study were used to develop a causal loop model which showed their interrelationships. As can be seen from the model (Figure 41, Section 6.5), most of the challenging factors stem from the Political, Economic, Social and Technical issues. While most of the identified Environmental and Legal factors did not influence the performance of the refineries as much. The leverage, however, rests much within the political, social, and technical factors as the economic factor did not present sufficient opportunities for leverage regarding policy intervention.

The recently passed Petroleum Industry Act (PIA), on one hand, possesses a significant policy impact through stakeholder satisfaction to address most of the social issues relating to communal tensions and infrastructure vandalization. On the other hand, the failure of the PIA to incorporate strategies for the involvement of the private sector in the management of the refineries may be counterproductive towards their management efficiency. This is because the signed PIA still confers total ownership of the refineries on the federal government by only creating a new authority (Nigerian Midstream and Downstream Petroleum Regulatory Authority – NMDPRA) to replace the existing DPR for regulating the midstream and downstream sector (Ernst & Young, 2021). However, it is too early to speculate the outcome which this regulatory authority would have on the management of the refineries. The lack of a clear strategy in the PIA for private sector involvement for the management of the refineries presents a missed opportunity for technological innovation and management expertise required to drive an efficient management system in the industry. It would, therefore, be essential for the Nigerian government to rethink a management strategy for the refineries that is open to private sector participation.

7.3 Chapter Conclusion

This chapter details the three approaches based on the findings of this research study to address the NNPC refinery problems. It builds an argument through literature to support its findings that for the refineries to achieve efficiency in management, a private sector led partnership with experienced and competent partners will be essential for the refineries. It also recommends that the complete deregulation of the downstream petroleum sector in Nigeria will be crucial to allow such partnership to thrive as the need to compete in a free-market environment will be a necessity for the survival of the organisation.

In addition, it developed the point to support the finding that a coherent and successful implementation of the recently passed Petroleum Industry Act (PIA) will address the social issues resulting to recurring attacks on oil facilities in the Niger Delta. This proposition is based on the argument that the implementation of the provisions of this Act will satisfy the community stakeholders and quell agitations that lead to vandalization of oil facilities.

Lastly, it found that to achieve maintenance best practices, a change in operating philosophy of the refineries will be needed to address the poor maintenance culture inherent in the organisation. This change in operating philosophy can be driven by the experienced private sector the organisation chooses to partner with.

The next chapter concludes the entire research, providing its contribution to knowledge as well as a personal reflection on this research journey.

CHAPTER EIGHT: CONCLUSIONS AND RECOMMENDATIONS

8.1 Introduction

This research has presented an appraisal of the performance challenges facing the NNPC refineries under six identified categories covering political, economic, social, technical, environmental, and legal (PESTEL) factors. It assessed the previous efforts made by the Nigerian government to address these issues and identified gaps in previous research in this area. It used a systems thinking framework to show causal interrelationships amongst the identified factors. As a result, it identified leverage points in the model for policy intervention to close the performance gaps in the refineries.

This chapter focuses on the conclusions, and recommendations of this study as well as future research potentials arising from the implications of the study. To achieve these, the chapter will recapitulate the research aims and objectives of the study and itemize how these have been met. The contributions of this research to knowledge, including its limitations shall also be reiterated.

8.2 Recapitulation of research aims and objectives

This research was inspired by the researcher's quest to understand why the performance of Nigerian refineries has remained unimpressively low for years despite the market opportunities that exist to provide incentive to address the issues. The study discovered that while there were studies that have identified several challenges militating against the performance of the refineries, there was none offering a systemic view of the issues. As such, it adopted a systems thinking approach to understudy the interrelationships amongst the significant factors driving the performance of the refineries. This was done with a view of identifying potential policy intervention measures to address the issues. Hence, it is expected that the outcome of this research will satisfy the aims and objectives it was set out to achieve.

Accordingly, the research aims of this study were to:

1. To explore the challenges of the Nigerian refining industry with a view of understanding the causal interrelationships of the factors that affect its performance.
2. To develop a model that will provide the basis for a policy intervention framework to guide Nigerian policymakers for addressing the challenges of the refineries.

In the course of this research project, these aims were pursued through the following objectives (see Section 1.3):

1. The first objective was to critically review and evaluate the measures undertaken by the Nigerian government in addressing the problems of the refining sector.
2. The second objective was to establish and evaluate the significant factors across the political, economic, social, technical, environmental, and legal (PESTEL) issues that contribute to inefficiency in the refining sector.
3. The third objective of the study was to develop and validate a model to enhance the understanding of systemic interrelationships of the significant factors affecting the refineries' performance.
4. While the fourth objective was to use this model to inform a policy intervention framework for addressing the refinery challenges.

8.2.1 Research Objective One

The efforts of the Nigerian government to remedy the productivity problems of the refineries were assessed by this study (Section 2.5). Based on the findings from the literature, source documents and government papers five initiatives have been undertaken by the government at different times from 2002 to 2017 to address the productivity issues of the refineries. These include:

1. The commencement of issuance of licenses in 2002 to private organisations to construct refineries in Nigeria.
2. Awards of contracts for the refurbishment of existing refineries in Nigeria in 2003.
3. Attempted sale or divestment of the NNPC refineries to private organisations in 2007.
4. The attempted removal of petroleum subsidy in Nigeria in 2011.
5. The introduction of the 7 big wins by the Federal Government in 2015 as well as the enactment of the National Petroleum Policy (NPP) in 2017.

Unfortunately, none of these initiatives have yielded any reliable results as the low productivity issues experienced across the refineries have persisted. A review of literature on the failure of these initiatives suggested a number of reasons for their ineffectiveness. These include unstructured refinery licensing scheme, poor or non-existent vetting systems for refinery licensees, corruption-ridden contract awards that were either shabbily carried out or were not performed, lack of trust from the public sector over the sale of the refineries, public aversion over petroleum subsidy removal, and long delays in the passage of the Petroleum Industry Act (Nkaginieme, 2005; DPR, 2017; PWC, 2017; Akinola, 2018; and Iheukwumere et al., 2020).

Research objective one was useful for understanding the previous government efforts and their barriers for achieving reliable solutions for the problems of the refineries.

8.2.2 Research Objective Two

The second research objective was explored through literature search to understand the various factors that drive sub-optimal performance across the refineries (Section 2.4). Using a framework of political, economic, social, technical, environmental, and legal (PESTEL) issues to categorise the factors, a list of 29 factors influencing the low productivity of the refineries were summarised in Table 10 (Section 2.4). These factors were used to produce the survey questionnaire for quantitative data collection from the refinery workers. This was carried out to test the significance and validity of the factors which were gleaned from multiple literature sources. A quantitative analysis using the AHP was adopted to rank these factors according to their significance in driving the performance challenges on the refineries (Section 5.2).

Research objective two showed that the significant factors that drive the performance of the refineries ultimately rest within the political, economic, social, and technical (PEST) issues as the environmental and legal factors did not produce much significance regarding the performance of the refineries. This objective was relevant for identifying the main factors that would be useful for modelling the behaviour of the refinery system.

8.2.3 Research Objective Three

Research objective three was focused on developing a validated model based on causal loop diagrams to enhance the understanding of systemic interrelationships of the issues that drive poor performance across the refineries. The analytical hierarchy process (AHP) method was used as a framework to derive a prioritised set of factors that were validated though a qualitative method to create the causal loop model based on a systems thinking approach (Sections 4.7.1 to 4.8 and Sections 6.2 to 6.7).

The validation of the causal loop model was done by 9 experts comprising 3 mid-level to senior officials from each of the refineries (PHRC, WRPC, and KRPC). The validated model (Figure 41, Section 6.5) provided a platform for seeing the whole complexities of the interrelationships amongst the causal factors and was useful for revealing potential leverage points for policy intervention. Following this, a proposed model containing applied interventions observed across the political, social, and technical (PST) segments of the model to reverse the declining performance of the refineries was developed and validated (Figure 46, Section 6.7).

8.2.4 Research objective Four

The proposed causal loop model containing the intervention policies underpinned the development of a policy intervention framework for closing the performance gaps of the refineries. The framework showed that there are three levels of policy interventions, which cut across the PST segment of the model.

At the first level, the framework contains three recommended actions which cut across the PST segments (Figure 50, Section 6.8). As such, it proposed the adoption of full deregulation and private sector partnership for the refineries as a political approach to achieve management efficiency across the refineries. It also proposed the successful implementation of the Petroleum Industry Act (PIA) as a social approach to achieve stakeholder satisfaction with the social actors that present hostile threats to oil infrastructure. Lastly, the framework proposed a change in operating philosophy to achieve maintenance best practices as a technical approach for fixing the poor maintenance culture in the organisation. The details of these discussions are presented in Chapter Seven (Sections 7.2.1 to 7.2.3).

8.3 Review of Research Questions

It is important to note that in addressing the above research objectives, the research questions posed in Section 1.2 of this study were equally answered by this study. The four main research questions posed by this study were:

1. What are the specific factors that drive the low productivity of the NNPC refineries?
2. How can these factors be prioritised such that effective decision making can be inferred?
3. How do the factors significantly interrelate and how can these be modelled?
4. How can these analyses produce outcomes that will guide policymakers to inform solutions that will improve future practice in Nigeria's refining industry?

Table 43 provides a summary of the findings of this study in answering the research questions, including their validity and reliability.

Table 43: Research findings to research questions

Research Questions	Findings/Answers	Reliability and Validity
What are the specific factors that drive the low productivity of the NNPC refineries?	The specific factors affecting the refineries rest within the political, economic, social, and technical (PEST) factors. This can be seen from the analyses of the study findings presented in Table 31 (Chapter 5).	Cross-checking multiple sources of evidence through triangulation of the quantitative method with the qualitative method.
How can these factors be prioritised such that effective decision making can be inferred?	The analytical hierarchy process (AHP) which has been proven to be an effective and established technique useful for ranking and prioritization was applied to obtain a prioritised set of factors driving the performance of the refineries. These factors were used for developing the causal loop models as can be seen in Chapters 5 and 6 of this study.	The use of established and proven mathematical technique based on the AHP and validation of the data output through interviews.
How do the factors significantly interrelate and how can these be modelled?	The use of a systems thinking approach in this study effectively demonstrated the interrelationships of the multiple factors in driving the causal underperformance of the refineries. The details of this methodology and how they were applied are presented in Chapter 3.	The factors used for modelling the causal loop diagrams were obtained through a mixed methods approach in which one method of enquiry validated the other. In addition, the developed model was sent for validation and

		received expert revisions from the professionals who experience the issues under investigation.
How can these analyses produce outcomes that will guide policymakers to inform solutions that will improve future practice in Nigeria's refining industry?	Systems thinking methodology, which is useful for revealing leverage points in a system was applied to show points of leverage in the refinery system, where policy changes were applied to inform an intervention framework from this study.	The policy intervention framework produced by this study was validated by the experts as capable of producing desired outcomes over time to address the performance gaps across the refineries.

Table 43 indicates that in addition to achieving the research objectives, the research questions of this study were also effectively answered.

8.4 Contribution to knowledge

The concept of originality is of paramount importance in any academic research. Walker (1997) identified various ways through which originality in research could be demonstrated such as new application of existing theory to new areas; a blend of new ideas; new methodologies, tools & techniques; new areas of research, as well as new interpretation of existing material.

In terms of methodology, this study fills a gap in literature as a contribution to knowledge across four key areas:

- The study exhaustively categorised all the factors affecting the performance of the NNPC refineries using the PESTEL framework. This was a step further from previous literature that have only identified aspects of the challenges without due categorisation (Igboanugo et al., 2016, Wapner, 2017, Ogbuigwe, 2018 and Badmus et al., 2013). The benefit of placing the identified factors under their categories is to help policymakers focus issues within identifiable domains while seeking to address the challenges of the refineries.
- In addition, the study applied a proven structured mathematical technique using the Analytical Hierarchy Process (AHP) to prioritise the identified factors in terms of their significance for deriving inefficiency. As such, it determined that the more significant factors in this regard are the political, economic, social, and technical (PEST) factors, which are similar across the refineries (Sections 5.2 and 5.3).
- Furthermore, the study used the concept of causal loop model to demonstrate the interdependencies of the significant challenging factors as per how they derive sub-optimal performance across the refineries. This was useful for identifying the potential leverage points for policy interventions to address the performance gaps in the refineries.
- Lastly, the study adopted meadows guidelines for 12 points of leverage to identify policy intervention points in the system to address their performance gaps. This provided the basis for the resulting policy intervention framework as a major outcome of this study.

As such, this methodology laid the foundation for the development of three approaches for closing the performance gaps of the refineries:

- Political – proposed adoption of full deregulation and private sector participation in the management of the refineries to improve their management efficiency.
- Technical – proposed adoption of maintenance best practices through a change in operating philosophy to improve the maintenance culture within the organisation.
- Social – coherent implementation of the PIA to address social issues through stakeholder satisfaction to quell oil infrastructure vandalization in the Niger Delta region.

This study argues that a systemic and coherent adoption and implementation of these measures will potentially lead to marginal incremental gains over time to address the problems of the NNPC refineries.

8.5 Contribution to practice

The policy intervention framework developed from this study will be useful to inform future practice across Nigerian refining sector. This is because the three recommended actions arising from the framework developed by this study as policy suggestions provide a reliable guide for managing the Nigerian refinery sector. Accordingly, the adoption of a change in operating philosophy to improve maintenance best practices, the successful implementation of the PIA to achieve stakeholder satisfaction, and the full deregulation of the downstream sector for private sector participation will all effectively contribute towards a solution through political, social, and technical approaches to the problem (See Section 6.8 and Figures 46 - 50). It is also important to note that as the refineries are currently undergoing a turnaround maintenance, there is an opportunity to upgrade the facilities with new technologies that will help reduce operational and product emissions to lower their environmental impact.

Secondly, Nigerian policymakers and researchers can build on the causal interdependencies from the CLD model established by this study to simulate dynamic changes in actual production of the refineries based on various policy adjustments in the system.

Lastly, the systemic viewpoint espoused by this study through the identified PESTEL factors, can help the management of NNPC refineries to adopt new ways of looking at complex issues within the organisation. This approach will likely increase the quality of decision-making processes across the organisation based on inputs from multiple perspectives.

8.6 Research limitations and future research potentials

While this study achieved its aims and objectives, some limitations were, however, encountered in the course of this study. The discussion of these limitations is presented in line with suggestions for future research.

Data collection for this study was primarily focused on the NNPC organisation and did not extend to the federal government officials. This was in line with the boundary established by this study as it focused primarily on NNPC refineries as a subsystem within the larger NNPC group (See Section 6.4). As such, government officials being directly inactive within this subsystem makes it less important to be involved.

Secondly, the construction of causal loop models as done in this study involves a subjective process requiring the interpretation of the researcher and the participants' mental models of how things work. As such, it may be difficult to replicate the relationship nature between agencies established in one context of the study in another context (Sterman, 2010). Also, this study adopted the concept of systems thinking to develop the causal loop models. Bridgeland and Zahavi (2008) notes that while causal loop diagrams can be simulated to resolve issues on how the dynamics of a system can play out, they are rarely simulated directly as they do not possess all the information required to build dynamic models. Hence, the causal loop models presented here can be used as an intermediate step in building a larger system dynamic model.

As noted in Section 6.8, the framework developed from this study suggests that the leverage points for addressing the refinery issues rests more within the soft systems methodology as opposed to hard systems approach. This is because the political, social, and technical approaches proposed as solutions to the refinery problems are rather diffuse and subtle requiring accommodations of different worldviews between the stakeholders who are active within the system. This is consistent with the principle of CATWOE (Customers, Actors, Transformation, Worldview, Owner and Environment) espoused by Checkland (1990) which argues that changes can be effected in organisations through the identification of the necessary transformation processes shared by the worldviews of the various stakeholders (owners, customers, and actors) of the business within their operating environment. As such, a future study can explore this dimension to uncover additional pathways through which a soft systems model could provide a richer context to the solutions of the NNPC refineries.

With respect to the current issues of climate change, this work contributes to an aspect of decarbonisation by an oil refinery through efficiency improvements. Some government led studies report that oil refineries have significant roles to play regarding reduction of greenhouse gases. For example, a United Kingdom Petroleum Industries Association (UKPIA) report (2020) identified some areas with potentials in this regard to include hydrogen conversion technologies, low carbon liquid fuels (LCLFs) production, and optimisation of refinery processes for efficiency improvements. The body posits that these areas hold important promise to the global economy not only for the numerous jobs it supports but for the fact that refined petroleum products (RPPs) would still be required to power heavy duty equipment such as industrial plants, and machinery, marine vessels, high duty generators, and aviation engines for the foreseeable future.

8.7 Recommendations

This section presents the conclusions of this research with its recommendations.

This study demonstrates the usefulness of systems thinking for solving complex organisational problems. Reviewing the performance challenges of Nigerian refineries across the PESTEL factors, this study identified that the significant performance challenges rests mostly within the PEST factors as the environmental and legal factors had less significant effect on the refineries’ performance. However, the study observed that while the identified environmental factors do not necessarily affect the performance of the refineries, the operations of the refineries do impact negatively on the environment through environmental degradation associated with pipeline vandalization and illegal refining activities, and unmonitored emissions from refinery operations.

Therefore, adopting the policy intervention framework developed in this study to address these social issues through the implementation of the PIA, will potentially help fix the negative environmental impacts from the refineries.

In addition, the management and control of the refineries will benefit from structural overhaul that reduces government control through private sector partnership. In this arrangement, government would need to reduce its ownership stake in the refineries by allowing a competent private sector operator to run the refineries and make equitable returns. This approach will lead to management efficiency by infusing the necessary managerial and technical competence required to drive optimum performance across the refineries, as well as engender a change in operating philosophy required to address the poor maintenance culture observed across the industry.

Lastly, the complete removal of regulations that fix pump prices of refined petroleum products would be essential to encourage private sector partnership as the need for profit-making would become a necessary incentive. However, as government remains a partner in the business, it would be easier for abuses from excessive profiteering to be checkmated in the interest of the public.

8.8 Personal reflections

Reflecting on this study, the researcher views big organisational problems as complex and require a holistic approach to develop effective solutions. The factors that determine the performance of big organisations like the NNPC refineries are often multifaceted and usually have both internal and external dimensions. Hence, the accurate diagnosis of such organisational problems lies beyond the comprehension of a single individual as the synthesis of multiple mental models from key stakeholders offers the best approach. As such, policy formulations to address any identified performance gaps must also be approved and validated by such stakeholders to be effective.

Secondly, a research journey such as a PhD study is an evolutionary process that requires an open mindset from a researcher to be effective. This is because research studies can produce outcomes that totally counter the researcher’s initial beliefs about the issue under investigation and a researcher must be willing to accept these findings regardless of their initial presumptions.

Lastly, this researcher personally views the process of pursuing a PhD programme to be totally self-transformative. This is due to the fact that the process is full of personal challenges requiring courage, commitment, intellect, perseverance, hard work, and strong will to accomplish. To go through these challenges and succeed, one must be eternally grateful and humbled.

REFERENCES

ABBASINEJAD, R., HOURFAR, F. and ELKAMEL, A., 2021. Optimum Maintenance Interval Determination for Field Instrument Devices in Oil and Gas Industries Based on Expected Utility Theory. Computers & Chemical Engineering, p.107362.

ABDUL-RAHAMOH, O.A., TAIWO, F.H. and ADEJARE, A.T., 2013. The analysis of the effect of petroleum profit tax on Nigerian economy. Asian Journal of Humanities and Social Sciences (AJHSS), 1(1), pp.25-36.

ABDULRAHMAN, M.D.A., SUBRAMANIAN, N., LIU, C. and SHU, C., 2015. Viability of remanufacturing practice: a strategic decision-making framework for Chinese auto-parts companies. Journal of Cleaner Production, 105, pp.311-323.

ACKOFF, R. 1994. Systems thinking and thinking systems. System dynamics review vol. 10. Nos 2-3; 175 -188. John Wiley and Sons Ltd.

ACKOFF, R. 2003. The four types of systems. [Online]. Available from: http://acasa.upenn.edu/4sys.htm [Accessed August 2018].

ACKOFF, R., 2008. Systems thinking for curious managers. Triarchy Press.

ACKOFF, R.L., 1962. Scientific method: Optimizing applied research decisions. New York: Wiley.

ADEWUMI, A., KAGAMBA, J. and ALOCHUKWU, A., 2016. Application of chaos theory in the prediction of motorised traffic flows on urban networks. Mathematical Problems in Engineering, 2016.

AGUNOBI, K.N., OBIENUSI, E.A. and ONUOHA, D.C., 2014. An investigation of the pattern and Environmental impact of oil spillage in Etche Local Government Area of Rivers State, Nigeria. Journal of Natural Sciences Research, 14(16), pp.124-137.

AKANLE, O., ADEBAYO, K. and ADETAYO, O., 2014. Fuel subsidy in Nigeria: contexts of governance and social protest. International Journal of Sociology and Social Policy, 34(1/2), pp.88-106.

AL-HANAWI, M.K., ALSHARQI, O., ALMAZROU, S. AND VAIDYA, K., 2018. Healthcare finance in the Kingdom of Saudi Arabia: a qualitative study of householders' attitudes. Applied health economics and health policy, 16(1), pp.55-64.

ALSHISHTAWY, M.M., 2010. Four decades of progress: Evolution of the health system in Oman. Sultan Qaboos University Medical Journal, 10(1), p.12.

AMAGOH, F., 2008. Perspectives on organizational change: systems and complexity theories. The Innovation Journal: The public sector innovation journal, 13(3), pp.1-14.

AMBITUUNI, A., HOPKINS, P., AMEZAGA, J.M., WERNER, D. and WOOD, J.M., 2015. Risk assessment of a petroleum product pipeline in Nigeria: the realities of managing problems of theft/sabotage. Safety and Security Engineering V, pp.49-60.

AMBITUUNI, A., AMEZAGA, J. and EMESEH, E., 2014. Analysis of safety and environmental regulations for downstream petroleum industry operations in Nigeria: Problems and prospects. Environmental Development, 9, pp.43-60.

ANDERSON, M.P., WOESSNER, W.W. AND HUNT, R.J., 2015. Applied groundwater modeling: simulation of flow and advective transport. Academic press.

ANDERSON, P., 1999. Perspective: Complexity theory and organization science. Organization science, 10(3), pp.216-232.

ANDREWS, T.M., DELTON, A.W. AND KLINE, R., 2018. High-risk high-reward investments to mitigate climate change. Nature Climate Change, 8(10), pp.890-894.

ANGELA, M; EMEKA, O., KEVIN, I., OLUWASANMI, O., FRANCIS, E. and OLAYEMI, O., 2019. Challenges and prospects of converting Nigeria illegal refineries to modular refineries. The Open Chemical Engineering Journal, 13(1).

ANTILL, N. and ARNOTT, R., 2000. Valuing oil and gas companies: A guide to the assessment and evaluation of assets, performance and prospects. Elsevier.

ARISTOTLE, A. 1933. Metaphysics (Vol. 1, p. 9). Cambridge, MA: Harvard University Press.

ARIWERIOKUMA, S. 2009. The Political Economy of Oil and Gas in Africa. London: Routledge.

ARNOLD, R.D. and WADE, J.P., 2015. A definition of systems thinking: A systems approach. Procedia computer science, 44, pp.669-678.

AROWOSEGBE, J.O., 2009. Violence and national development in Nigeria: The political economy of youth restiveness in the Niger Delta. Review of African Political Economy, 36(122), pp.575-594.

ASHBY W.R. 1961. An Introduction to Cybernetics. London: Chapman & Hall Ltd.

ASIMIEA, A. and OMOKHUA, G. 2013. Environmental impact of illegal refineries on the vegetation of the Niger Delta, Nigeria. Journal of Agriculture and Social Research, Vol. 13, No.2, 2013.

ATRIS, A.M., 2020. Assessment of oil refinery performance: Application of data envelopment analysis-discriminant analysis. Resources Policy, 65, p.101543.

ATSEGBUA, L., 1993. Acquisition of oil rights under contractual joint ventures in Nigeria. Journal of African law, 37(1), pp.10-29.

ATUMAH, S. 2016. Nigeria's Oil Refineries in Oblivion. The Vanguard Newspapers [Accessed July 2018].

AWUZIE, B.O. and MCDERMOTT, P., 2019. Infrastructure delivery systems: governance and implementation issues. Springer.

AZADEH, A.; ROOHANI, A.; and HAGHIGHI, S. M. 2015. Performance optimization of gas refineries by ANN and DEA based on financial and operational factors. World. J. Eng., 12 (2) (2015), pp. 109-134

BADMUS, I., FAGBENLE, R. O., & OYEWOLA, M. O. 2013, "Fuel-mix and energy utilization analysis of Kaduna Refining and Petrochemical Company Nigeria", International Journal of Energy Engineering, Vol. 3 No. 3, pp. 190-199.

BADMUS, I., OYEWOLA, M.O. and FAGBENLE, R.O., 2012. A review of performance appraisals of Nigerian Federal Government-Owned Refineries. Energy and Power Engineering, 4(01), p.47.

BADRI, M.A., 1999. Combining the analytic hierarchy process and goal programming for global facility location-allocation problem. International journal of production economics, 62(3), pp.237-248.

BADRI, M.A., 2001. A combined AHP–GP model for quality control systems. International Journal of Production Economics, 72(1), pp.27-40.

BAGHEBO, M. and NIYEKPEMI, O. B. 2015. Dynamics of the Downstream Petroleum Sector and Economic Growth in Nigeria. Int'l J. Soc. Sci. Stud., 3, p.134.

BAHARI, S.F., 2010. Qualitative versus quantitative research strategies: contrasting epistemological and ontological assumptions. Sains Humanika, 52(1).

BALA-GBOGBO, E. 2020. Nigeria Starts Era of Micro Refineries with Tiny New Plant. Bloomberg Business. November 24.

BALDONI, J. (2008, June 16). Management Misdiagnosis. Harvard Business Review. Retrieved March 22, 2022, from https://hbr.org/2008/06/management-misdiagnosis

BALLEW, M.T., GOLDBERG, M.H., ROSENTHAL, S.A., GUSTAFSON, A. and LEISEROWITZ, A., 2019. Systems thinking as a pathway to global warming beliefs and attitudes through an ecological worldview. Proceedings of the National Academy of Sciences, 116(17), pp.8214-8219.

BALOUGA, J., 2012. Nigerian local content: challenges and prospects. International Association for Energy Economics, 4, pp.23-26.

BAMISAYE, O. A. and OBIYAN, A. S. 2006. "Policy Analysis of Oil Sector in Nigeria," European Journal of Social Sciences, Vol. 3, No. 1, 2006, pp. 37-48.

BARTLETT, J.E.; KOTRLIK, J.W.; and HIGGINS, C.C. 2001. Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research. Information technology, learning, and performance journal, 19(1), p.43.

BATESON, G., 1972. The logical categories of learning and communication. Steps to an Ecology of Mind, pp.279-308.

BAZILIAN, M., & ONYEJI, I. 2012. Fossil fuel subsidy removal and inadequate public power supply: Implications for businesses. Energy Policy, 45, 1-5.

BBC. 2012. Nigerian fuel subsidy: Strike suspended. [Online]. Available from: https://www.bbc.co.uk/news/world-africa-16579001 (Accessed January 2021).

BEER, S. 1985. Diagnosing the system for organisation. Wiley, Chichester.

BEHFAR, K. and OKHUYSEN, G.A., 2018. Perspective—Discovery within validation logic: Deliberately surfacing, complementing, and substituting abductive reasoning in hypothetico-deductive inquiry. Organization Science, 29(2), pp.323-340.

BERNARD, H. R. & RYAN, G. W. 2010. Analyzing qualitative data: Systematic approaches, California, SAGE Publications, Incorporated.

BEVILACQUA, M. and BRAGLIA, M., 2002. Environmental efficiency analysis for ENI oil refineries. Journal of cleaner production, 10(1), pp.85-92.
BEYAZAY-ODEMIS, B., 2015. The nature of the firm in the oil industry: International oil companies in Global Business. Routledge.

BHUSHAN, N. and RAI, K., 2007. Strategic decision-making: applying the analytic hierarchy process. Springer Science & Business Media.

BIESTA, G., 2010. Pragmatism and the philosophical foundations of mixed methods research. Sage handbook of mixed methods in social and behavioral research, 2, pp.95-118.

BISHOP, R. 2017. "Chaos", The Stanford Encyclopedia of Philosophy, Edward N. Zalta (ed.), [Online]. Available from: <https://plato.stanford.edu/archives/spr2017/entries/chaos/> (Accessed April 2021)

BISHOP P. A., and HERRON R. L. 2015. Use and misuse of the Likert item responses and other ordinal measures. International journal of exercise science. 8(3):297.

BOARDMAN, J. and SAUSER, B., 2008. Systems thinking: Coping with 21st century problems. CRC Press.

BOATENG, P., CHEN, Z. and OGUNLANA, S.O., 2015. An Analytical Network Process model for risks prioritisation in megaprojects. International Journal of Project Management, 33(8), pp.1795-1811.

BORIS, O.H., 2015. The Upsurge of Oil Theft and Illegal Bunkering in the Niger Delta Region of Nigeria: Is There a Way Out?. Mediterranean Journal of Social Sciences, 6(3 S2), p.563.

BOWEN, G.A., 2008. Naturalistic inquiry and the saturation concept: a research note. Qualitative research, 8(1), pp. 137-152

BRACE, I., 2018. Questionnaire design: How to plan, structure and write survey material for effective market research. Kogan Page Publishers.

BRIDGELAND, D.M. and ZAHAVI, R., 2008. Business modeling: a practical guide to realizing business value. Morgan Kaufmann.

BROWN, A.L., 1992. Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. The journal of the learning sciences, 2(2), pp.141-178.

BRYMAN, A., 2011. Research methods in the study of leadership. The SAGE handbook of leadership, pp.15-28.

BRYMAN, A. 2012. Social research methods. 4th Edition. Oxford University Press

BUCHANAN, D. and BRYMAN, A. 2012. (EDS), Handbook of Organizational Research Methods. London: Sage.

BUCKINGHAM, A. and SAUNDERS, P., 2004. The survey methods workbook: From design to analysis. Polity Press.

BURRELL, G. and MORGAN, G. 1979. Sociological paradigms and organisational analysis. London: Heinemann.

BUSCH, G. 2008. How Emeka Offor ruined the National Refineries. An interview with Sahara reporters. Retrieved from http://saharareporters.com/2007/06/20/how-emeka-offor-ruined-national-refineries-dr-gary-k-busch (Accessed January 2019).

CABRERA, D. 2006. Systems thinking (Doctoral dissertation). Ithaca, NY: Cornell University.

CAIRNEY, P., 2021. Policy Analysis as Systems Thinking. In The Politics of Policy Analysis (pp. 129-137). Palgrave Macmillan, Cham.

CAIRNS, D. Undated. Hard versus Soft Sytems Methodology. A lecture. Available from: http://www.cs.stir.ac.uk/~dec/teaching/CSC9T4/lectures/HardSys.pdf (Accessed Novemeber, 2021).

CAMPBELL, C.J., 2013. Nigeria. In Campbell's Atlas of Oil and Gas Depletion (pp. 51-53). Springer, New York, NY.

CAMPBELL, J. and PAGE, M.T., 2018. Nigeria: what everyone needs to know®. Oxford University Press.

CBN, 2020. CBN Exchange Rates. [Online]. Available from: https://www.cbn.gov.ng/rates/ExchRateByCurrency.asp (Accessed December 2020).

CHAN, W.T., 2015. The role of systems thinking in systems engineering, design and management. Civil Engineering Dimension, 17(3), pp.126-132.

CHAOUK, M., PAGLIARI, R. and MIYOSHI, C., 2019. A critical review of airport privatisation in the Kingdom of Saudi Arabia: case study of Medina Airport. Case Studies on Transport Policy, 7(2), pp.433-442.

CHARNES, A., COOPER, W. W., & RHODES, E. 1978, "Measuring the efficiency of decision-making units", European journal of operational research, Vol. 2 No. 6, pp. 429-444.

CHECKLAND, P. 1978. "The Origins and Nature of 'Hard' Systems Thinking." Journal of Applied Systems Analysis 5: 99–110.

CHECKLAND, P. 1981. Systems Thinking Systems Practice. Chichester: John Wiley.

CHECKLAND, P. and J. SCHOLES 1990. Soft Systems Methodology in Action. Chichester: John Wiley.

CHECKLAND, P. B. 1972. Towards a systems-based methodology for real world problem solving, Journal of Systems Engineering, 3(2), 87–116.

CHEN, Z., LI, H., REN, H., XU, Q. and HONG, J., 2011. A total environmental risk assessment model for international hub airports. International Journal of project management, 29(7), pp.856-866.

CHENG, V., RHODES, J. and LOK, P., 2010. A framework for strategic decision making and performance among Chinese managers. The International Journal of Human Resource Management, 21(9), pp.1373-1395.

CHIKWEM, F.C. 2016. The Political Economy of Fuel Importation Probes and Development of Refineries in Nigeria. Insight on Africa, 8(1), pp.18-39.

CHIMA, R.I., OWIODUOKIT, E.A. and OGOH, R., 2002. Technology transfer and acquisition in the oil sector and government policy in Nigeria.

CHURCHMAN, C. W. 1968. The Systems Approach. New York. Dell
CLARK, J.S., PORATH, S., THIELE, J. and JOBE, M., 2020. Action research. New Prairie Press.

CNN. 2010. Death and oil in Niger Delta's illegal refineries. [Online]. Available from: http://edition.cnn.com/2010/WORLD/africa/08/03/nigeria.oil.niger.delta/index.html [Accessed June, 2018].

COHEN, L., MANION, L., & MORRISON, K. 2000. Research methods in education (5th ed.). London: Routledge Falmer.

COLE, D. 2019. Applying systems thinking to project management: summary and last thoughts. APM.

CONCAWE, 2004. Trends in oil discharged with aqueous effluents from oil refineries in Europe: 2000 survey. Concawe (address as above) Report no. 4/04, 9 pp. (available at www.concawe.org).

CONNELLY, L.M., 2014. Ethical considerations in research studies. Medsurg Nursing, 23(1), pp.54-56.

CONWAY, J.M. and LANCE, C.E., 2010. What reviewers should expect from authors regarding common method bias in organizational research. Journal of Business and Psychology, 25(3), pp.325-334. https://doi.org/10.1007/s10869-010-9181-6

CRESWELL, J.W., 2003. A framework for design. Research design: Qualitative, quantitative, and mixed methods approaches, pp.9-11.

CRESWELL, J.W. and POTH, C.N., 2018. Qualitative inquiry and research design: Choosing among five approaches. Sage publications.

CRESWELL, JOHN W., and J. DAVID CRESWELL. 2017. Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

CROSS, P., DESROCHERS, P., SHIMIZU, H., 2013. The Economics of Petroleum Refining: Understanding the business of processing crude oil into fuels and other value-added products

CROTTY, M. 1998. Foundations of social research. London: Sage

CRUZ, A.M. and KRAUSMANN, E., 2013. Vulnerability of the oil and gas sector to climate change and extreme weather events. Climatic change, 121(1), pp.41-53.

CURRIE, D.J., SMITH, C. and JAGALS, P., 2018. The application of system dynamics modelling to environmental health decision-making and policy-a scoping review. BMC public health, 18(1), pp.1-11.

DAMIANOU, N.C., 2002. A policy framework for management of distributed systems (Doctoral dissertation, University of London).

DAWSON, S., MANDERSON, L. and TALLO, V.L., 1993. A manual for the use of focus groups. Boston: international Nutrition foundation for developing countries.
DENZIN, N. 2010. Moments, mixed methods, and paradigm dialogs. Qualitative Inquiry 16: 419–427.

DESCOMBE, M., 2003. The good research guide. For Small-scale Research Projects.

DEVOLD, H., 2013. Oil and gas production handbook: an introduction to oil and gas production. Lulu. com.

DEYOUNG, C.G. and KRUEGER, R.F., 2018. A cybernetic theory of psychopathology. Psychological Inquiry, 29(3), pp.117-138.

DIMIC, S.; PAMUCAR, D.; LJUBOJEVIC, S.; ĐOROVIC, B. 2016. Strategic Transport Management Models—The Case Studyof an Oil Industry.Sustainability.,8, 954

DOUVEN, I. 2021, May 18. Abduction (Stanford Encyclopedia of Philosophy). Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/abduction/

DPR. 2017. General requirements and guidance information for the establishment of modular refineries in Nigeria. Federal Ministry pf Petroleum Resources. [Online]. Available from: https://www.dpr.gov.ng/wp-content/uploads/2018/03/general-requirements-and-guidance-information-for-the-establishment-of-modular-refineries-in-nigeria.pdf [Accessed March 2018].

DRUCKER, P., 2012. The practice of management. Routledge.

DUBOIS, A. and GADDE, L.E., 2002. Systematic combining: an abductive approach to case research. Journal of business research, 55(7), pp.553-560.

DUFFUAA, S. & BEN-DAYA, M. 2004. Turnaround maintenance in petrochemical industry: Practices and suggested improvements. Journal of Quality in Maintenance Engineering. 10. 184-190.

DUGGAN, J. 2016. System Dynamics Modeling with R. Springer International Publishing AG.

EBOH, C. 2010, December 22. UPDATE 1-Nigeria shuts refineries after pipeline attacks. U.S. Retrieved April 10, 2020, from https://www.reuters.com/article/nigeria-oil-idUSLDE6BL18720101222

ECOWAS, 2007. Atlas on regional integration. [Online]. Available from: https://www.oecd.org/swac/publications/38798400.pdf (Accessed February 2021)

EGBERONGBE, F.O., NWILO, P.C. and BADEJO, O.T., 2006. Oil Spill Disaster Monitoring along Nigerian Coastline". Paper presented at. In 5th FIG Regional Conference: Promoting Land Administration and Good Governance.

EHINOMEN, C. and ADELEKE, A., 2012. An assessment of the distribution of petroleum products in Nigeria. Journal of Business Management and Economics, 3(6), pp.232-241.

EIA, 2011. U.S. Energy Information Administration. Nigeria, the largest crude oil producer in Africa, is a major source of U.S. imports. [Online]. Available from: https://www.eia.gov/todayinenergy/detail.php?id=3050 [Accessed February 2018].

EIA, 2017. US Energy information administration. When was the last refinery built in the US. [Online]. Available at: https://www.eia.gov/tools/faqs/faq.php?id=29&t=6 [Accessed February 2017].

EILAM, B., and REISFELD, D. 2017. A curriculum unit for promoting complex system thinking: the case of combined system dynamics and agent-based models for population growth. J. Adv. Educ. Res. 2, 39–60. doi: 10.22606/jaer.2017.22001

EISENHARDT, K.M. 1991. Better stories and better constructs: The case for rigor and comparative logic. Academy of Management Review, 16(3): 620–627.
EKWE-EKWE, H., 1985. The Nigerian Plight: Shagari to Buhari. Third World Quarterly, 7(3), pp.610-625.

EL-KATIRI, L., FATTOUH, B. AND SEGAL, P., 2013. Anatomy of an oil-based welfare state: rent distribution in Kuwait (pp. 183-205). Routledge.

EMOVON, I. and OGHENENYEROVWHO, O.S., 2020. Application of MCDM method in material selection for optimal design: A review. Results in Materials, 7, p.100115.

ENERGY INTELLIGENCE - OIL DAILY. 2004. Valero Preys on Weakness of Distressed Sellers. Vol 54, No. 23.

ENGEL, R.J. and SCHUTT, R.K., 2016. The practice of research in social work. Sage Publications.

ERNST & YOUNG. 2021, September. Nigerian government signs Petroleum Industry Bill 2020 into Law. Ernst & Young Nigeria. https://www.ey.com/en_gl/tax-alerts/nigerian-government-signs-petroleum-industry-bill-2020-into-law

ERNST and YOUNG. 2021. Nigeria's Government considers Petroleum Industry Bill 2020, a new framework for the oil and gas sector. [Online]. Available from: https://www.ey.com/en_gl/tax-alerts/nigeria-s-government-considers-petroleum-industry-bill-2020-a-new-framework-for-the-oil-and-gas-sector (Accessed January 2021)

ESCOBAR, M.T., AGUARÓN, J. and MORENO-JIMÉNEZ, J.M., 2004. A note on AHP group consistency for the row geometric mean priorization procedure. European Journal of Operational Research, 153(2), pp.318-322.

ESTACHE, A., IANCHOVICHINA, E., BACON, R. and SALAMON, I., 2013. Infrastructure and employment creation in the Middle East and North Africa. World Bank Publications.

ETI, M. C., OGAJI, S. O. T., & PROBERT, S. D. 2004. Implementing total productive maintenance in Nigerian manufacturing industries. Applied energy, 79(4), 385-401.

ETI, M.C., OGAJI, S.O.T. and PROBERT, S.D., 2006. Development and implementation of preventive-maintenance practices in Nigerian industries. Applied Energy, 83(10), pp.1163-1179.

FABOYEDE, O. S. 2010. Forensic Accounting as Panacea to the Management Dilemma of Oil Refineries in Nigeria. Journal of Management Research, 2 (2). pp. 145-152. ISSN 0976-4739

FAHEY, L. and NARAYANAN, V.K., 1986. Macro environmental analysis for strategic management (The west series in strategic management) West Publishing Company, St. Paul, MN

FANCHI, J. R. and CHRISTIANSEN, R. L. 2017. Introduction to petroleum engineering. John Wiley & Sons.

FEILZER, Y.M., 2010. Doing Mixed Methods Research Pragmatically: Implications for the Rediscovery of Pragmatism as a Research Paradigm. J Mix Meth Res 2008; 4 (1): 6-16.

FINANCIAL TIMES. 2018. Nigeria's fuel subsidies bill set to soar on rising oil price. [Online]. Available from: https://www.ft.com/content/8094bfd4-ca29-11e8-9fe5-24ad351828ab (Accessed December 2020)
FINCHAM, J.E., 2008. Response rates and responsiveness for surveys, standards, and the Journal. American journal of pharmaceutical education, 72(2).

FLEISHER, C.S. and BENSOUSSAN, B.E. 2003. "Chapter 17: Macroenvironmental (STEEP) Analysis" Strategic and Competitive Analysis: Methods and Techniques for Analyzing Business Competition. Prentice Hall. Upper Saddle River, New Jersey 07458: 269-283.

FORRESTER J.W. 1968. Principles of Systems. 2nd edition. Portland, Oregon: Productivity Press.

FORRESTER, J. W. 1997. Industrial dynamics. Journal of the Operational Research Society, 48(10), 1037-1041.

FORRESTER, J.W. 1961. Industrial Dynamics, MIT Press: Cambridge, MA.

FORRESTER, J.W., 1994. System dynamics, systems thinking, and soft OR. System dynamics review, 10(2-3), pp.245-256.

FORSTHOFFER, W.E., 2011. Forsthoffer's best practice handbook for rotating machinery. Elsevier.

FOSTER-FISHMAN, P.G., NOWELL, B. and YANG, H., 2007. Putting the system back into systems change: A framework for understanding and changing organizational and community systems. American journal of community psychology, 39(3-4), pp.197-215.

FOWLER JR, F.J., 2013. Survey research methods. Sage publications.

FOWLER, F. J. 2002. Survey research methods (3rd Ed.). Thousand Oaks, CA: Sage Publications.

FRANCISCO, C.; ALMEIDA, M.; and SILVA, D. 2012. Efficiency in Brazilian refineries under different DEA technologies regular paper. Int. J. Eng. Bus. Manag., 4 (35) (2012), pp. 1-11

GABLE, G.G., 1994. Integrating case study and survey research methods: an example in information systems. European journal of information systems, 3(2), pp.112-126.

GAJPAL, P.P., GANESH, L.S., RAJENDRAN, C., 1994. Criticality analysis of spare parts using the analytic hierarchy process. International Journal of Production Economics 35, 293–297.

GARY, J.H., HANDWERK, G.E. and KAISER, M.J., 2007. Petroleum refining: technology and economics. CRC press.

GENOVA, A. 2010. Nigeria's Nationalization of British Petroleum. The International Journal of African Historical Studies, 43(1), 115-136. Retrieved from http://www.jstor.org/stable/25741399

GEORGE, L. 2021, March. Nigerian govt mulls state oil firm's plan to privatize refineries - NNPC chief. Thomson Reuters. https://mobile.reuters.com/article/amp/idUSKBN2BF1IR

GEYER, R. 2012. Can Complexity Move UK Policy Beyond "Evidence-Based Policy Making" and the "Audit Culture"? Political Studies, 60(1), 20–43.

GHARAJEDAGHI, J. 2011. Systems Thinking: Managing Chaos and Complexity: A Platform for Designing Business Architecture, Elsevier, Amsterdam

GILL, J. and JOHNSON, P. 2010. Research methods for managers. 4th Ed. London: Sage.

GODDARD, W. and MELVILLE, S., 2004. Research methodology: An introduction. Juta and Company Ltd.

GOETZ, A.R. and VOWLES, T.M., 2009. The good, the bad, and the ugly: 30 years of US airline deregulation. Journal of Transport Geography, 17(4), pp.251-263.

GONZALEZ, F. and PRADENAS, L., 2019. Multi-criteria analysis to improve the service in gas stations. International Journal of the Analytic Hierarchy Process, 11(1), pp.67-90.

GOODMAN, M. 1991. Systems thinking as a language. Pegasus Classics. Vol. 2 No.3

GOODMAN, M. 1997. Systems thinking: What, why, when, where, and how? Systems thinker. Pegasus Communications. Vol. 8, No. 2.

GOODMAN, M., 2002. The Iceberg Model, Innovation Associates Organizational Learning, Hopkinton.

GRAHAM, A., 2011. The objectives and outcomes of airport privatisation. Research in Transportation Business & Management, 1(1), pp.3-14.

GRAHAM, A., 2020. Airport privatisation: A successful journey? Journal of air transport management, 89, p.101930.

GREENWOOD, D.J. and LEVIN, M., 2007. An epistemological foundation for action research. Introduction to action research, pp.55-76.

GROBMAN, G. M. 2005. "Complexity Theory: a new way to look at organizational change" (PDF). Public Administration Quarterly. 29 (3). Archived from the original (PDF) on 2016-08-07. Retrieved 2016-07-10.

GROVES, R. M. 2006. Nonresponse rates and nonresponse bias in household surveys. Public Opinion Quarterly, 70(5), 646-675.

GUBA, E.G. and LINCOLN, Y.S., 1994. Competing paradigms in qualitative research. Handbook of qualitative research, 2(163-194), p.105.

HAMMOND, D. 2005. Philosophical and ethical foundations of systems thinking. TripleC 3(2): 20-27, 2005.

HARALDSSON, H.V. 2004. “Introduction to system thinking and causal loop diagrams”, Department of Chemical Engineering, Lund University, pp. 3-4.

HARTLEY, P. and MEDLOCK III, K.B., 2008. A model of the operation and development of a national oil company. Energy Economics, 30(5), pp.2459-2485.

HASAN, R. 2011. Hard and Soft systems thinking. Munich, GRIN Verlag, https://www.grin.com/document/208273
HAYNES, A., GARVEY, K., DAVIDSON, S. and MILAT, A., 2020. What can policymakers get out of systems thinking? Policy partners’ experiences of a systems-focused research collaboration in preventive health. International journal of health policy and management, 9(2), p.65.

HEBRON, J. 1996. Co-operative inquiry:Research into the human condition. London: Sage

HELMS, M.M. and NIXON, J., 2010. Exploring SWOT analysis–where are we now? A review of academic research from the last decade. Journal of strategy and management.

HESSE-BIBER, S. 2015. Mixed methods research: The ‘thing-ness’ problem. Qualitative Health Research 25: 775–788.

HEUM, P., QUALE, C., KARLSEN, J.E., KRAGHA, M. and OSAHON, G., 2003. Enhancement of local content in the upstream oil and gas industry in Nigeria: A comprehensive and viable policy approach. SNF.

HODGE, G.A. and GREVE, C. 2016. On Public-Private Partnership Performance: A Contemporary Review, Public Works Management & Policy, pp. 1–24

HOUCHIN, K. and MACLEAN, D., 2005. Complexity theory and strategic change: an empirically informed critique. British Journal of Management, 16(2), pp.149-166.

HUGHES, P. and WHITE, E., 2010. The Space Shuttle Challenger disaster: A classic example of Groupthink. Ethics & Critical Thinking Journal, 2010(3).

IEA, 2020. Share of oil reserves, oil production and oil upstream investment by company type, 2018. [Online]. Available from: https://www.iea.org/data-and-statistics/charts/share-of-oil-reserves-oil-production-and-oil-upstream-investment-by-company-type-2018 (Accessed January 2020)

IEA ETSAP. 2014. Oil Refineries - Technology Brief P04 – April 2014 - www.etsap.org. [Online]. Available from: https://iea-etsap.org/E-TechDS/PDF/P04_Oil%20Ref_KV_Apr2014_GSOK.pdf

IGBOANUGO, A.C., GARBA, O.M. and OKAFOR, T.I., 2016. A Factorial Study of Corporate Performance of Nigerian Refineries. Nigerian Journal of Technology, 35(1), pp.71-79.

IHEUKWUMERE, O. E., MOORE, D., & OMOTAYO, T. 2020. Investigating the challenges of refinery construction in Nigeria: A snapshot across two-timeframes over the past 55 years. International journal of construction supply chain management, 10(1), 46-72.

IHEUKWUMERE, O., MOORE, D. & OMOTAYO, T. 2021a. A meta-analysis of multi-factors leading to performance challenges across Nigeria’s state-owned refineries. Applied Petrochemical Research 11, 183–197 https://doi.org/10.1007/s13203-021-00272-0

IHEUKWUMERE, O., MOORE, D. and OMOTAYO, T. 2021b, "Analysis of multi-factors affecting the performance of Nigeria's refineries: a systems thinking approach", International Journal of Productivity and Performance Management, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJPPM-11-2020-0585

IKELEGBE, A., 2005. The economy of conflict in the oil rich Niger Delta region of Nigeria. Nordic Journal of African Studies, 14(2), pp.208-234.

IKELEGBE, A., 2006. Beyond the threshold of civil struggle: youth militancy and the militia-ization of the resource conflicts in the Niger Delta region of Nigeria. African Study Monographs, 27(3), pp.87-122.

INAM, A., ADAMOWSKI, J., HALBE, J. and PRASHER, S., 2015. Using causal loop diagrams for the initialization of stakeholder engagement in soil salinity management in agricultural watersheds in developing countries: A case study in the Rechna Doab watershed, Pakistan. Journal of environmental management, 152, pp.251-267.

INGERSOLL, R.M., 2002. The teacher shortage: A case of wrong diagnosis and wrong prescription. NASSP bulletin, 86(631), pp.16-31.

ITO, A.S., YLIPÄÄ, T., GULLANDER, P., BOKRANTZ, J. AND SKOOGH, A., 2021. Prioritisation of root cause analysis in production disturbance management. International Journal of Quality & Reliability Management.

IWAYEMI, A. 2008. Nigeria’s dual energy problems: policy issues and challenges. Pp. 17–21 in Proc. 31st International Conference of the International Association for Energy Economics. Istanbul, Turkey. 18–20 June 2008.

JAAFARI, A., 2003. Project management in the age of complexity and change. Project management journal, 34(4), pp.47-57

JACKSON, L.J., TREBITZ, A.S. and COTTINGHAM, K.L., 2000. An introduction to the practice of ecological modeling. BioScience, 50(8), pp.694-706.

JAIN, A., 2015. SWOT Analysis in Thirukkural: Comparative Analysis with Humphrey SWOT Matrix. IQSR Journal of Business and Management (IQSRJBM), 7(1), pp.31-34.

JAMIESON, S. 2004. Likert scales: how to (ab) use them. Med Educ. 38(12):1217–1218

JESULEYE, O.A., SIYANBOLA, W.O., SANNI, S.A. and ILORI, M.O. 2007. Energy demand analysis of Port-Harcourt refinery, Nigeria and its policy implications. Energy policy, 35(2), pp.1338-1345.

JOHNSON, J. W., & LEBRETON, J. M. 2004. “History and use of relative importance indices in organizational research”, Organizational research methods, Vol. 7 No. 3, pp. 238-257.

JOHNSON, P. and CLARK, M. EDS., 2006. Business and management research methodologies. Sage.

JOHNSON, R. B. & ONWUEGBUZIE A. J. 2004. Mixed Methods Research: A Research Paradigm Whose Time Has Come. Educational Researcher. 33(7):14-26. doi:10.3102/0013189X033007014

JOHNSTON, D. 1994. International petroleum fiscal systems and production sharing contracts. PennWell Corporation. Tulsa, Oklahoma.

JOHNSTON, D.C. and JOHNSTON, D., 2006. Introduction to oil company financial analysis. PennWell Books.

KAHN, S. 1994. Nigeria, the Political Economy of Oil. Oxford Press. London. P.138-140

KALLESTRUP, K.B., LYNGE, L.H., AKKERMAN, R. and ODDSDOTTIR, T.A., 2014. Decision support in hierarchical planning systems: The case of procurement planning in oil refining industries. Decision Support Systems, 68, pp.49-63.

KATKO, T. S. 2006. Road Safety Fatalities, Management, and Policy in Finland, 1970-2003. Public Work Management & Policy, 11(2), 126-138. http://dx.doi.org/10.1177/1087724X06294066

KAZNACHEEV, P. and BAZALEVA, R., 2016. A comparison of the roles of privately and state-owned oil companies in developing the Arctic shelf. Energy Exploration & Exploitation, 34(1), pp.99-112.

KELLY, L.M. and CORDEIRO, M., 2020. Three principles of pragmatism for research on organizational processes. Methodological Innovations, 13(2), p.2059799120937242.

KENNEDY-DARLING, J., HOYT, N., MURAO, K. and ROSS, A. 2008. The energy crisis of Nigeria: an overview and implications for the future. The University of Chicago, Chicago, pp.775-784.

KERR, L.A. and GOETHEL, D.R., 2014. Simulation modeling as a tool for synthesis of stock identification information. In Stock Identification Methods (pp. 501-533). Academic Press.

KHAN, S.A., 1994. Nigeria: The political economy of oil (p. 10). Oxford: Oxford University Press.

KIM, D. H. 1990. “Reinforcing and balancing loops: Building blocks of dynamic systems”, The Systems Thinker, Vol. 1 No. 1, pp. 3.

KIM, D. H. 1992. Guidelines for Drawing Causal Loop Diagrams. The Systems Thinker, Vol 3, No 1, pp5-6

KLEIN, S.J.W.; WHALLEY, S. 2015. Comparing the sustainability of US electricity options through multi-criteria decision analysis. Energy Policy,79, 127–149

KOHLBACHER, F. 2006. The use of qualitative content analysis in case study research. Forum: Qualitative Social Research (Sozialforschung), 7.

KPMG. 2017. The National Petroleum Policy (NPP). Newsletter. {Online]. Available from: https://assets.kpmg/content/dam/kpmg/ng/pdf/tax/ng-the-national-petroleum-policy.pdf (Accessed January 2021)

KROSNICK, J.A., 2017. Questionnaire design. In The Palgrave handbook of survey research (pp. 439-455). Palgrave Macmillan, Cham.

KROSNICK, J.A., 2018. Questionnaire design. In The Palgrave handbook of survey research (pp. 439-455). Palgrave Macmillan, Cham.

KWAK, N.K. and LEE, C., 1998. A multicriteria decision-making approach to university resource allocations and information infrastructure planning. European Journal of Operational Research, 110(2), pp.234-242.

LEAVY, P., 2017. Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches.
LEE, B., 2012. Using documents in organizational research. Qualitative organizational research: Core methods and current challenges, pp.389-407.

LEISCHOW, S.J., BEST, A., TROCHIM, W.M., CLARK, P.I., GALLAGHER, R.S., MARCUS, S.E. and MATTHEWS, E., 2008. Systems thinking to improve the public's health. American journal of preventive medicine, 35(2), pp.S196-S203.

LEONARD, A. & BEER, S. 1994. The systems perspective: Methods and models for the future. AC/UNU Project.

LETHBRIDGE, J., 2016. Unhealthy Development: the UK Department for International Development and the promotion of health care privatisation.

LEWIN, A.Y., 1999. Application of complexity theory to organization science. Organization Science, 10(3), pp.215-217.

LEWIS, P., 1996. From prebendalism to predation: the political economy of decline in Nigeria. The Journal of Modern African Studies, 34(1), pp.79-103.

LI, V.; DONG, K.; SUN, R.; YU, J.; and XU, J. 2017. Sustainability assessment of refining enterprises using a DEA-based model. Sustainability, 9 (620) (2017), pp. 1-15

LINCOLN, Y.S., LYNHAM, S.A. and GUBA, E.G., 2011. Paradigmatic controversies, contradictions, and emerging confluences, revisited. The Sage handbook of qualitative research, 4, pp.97-128.crotty

LIPSEY, M.W., 1990. Design sensitivity: Statistical power for experimental research (Vol. 19). sage.

LOR, P. 2011. ‘Preparing for research: meta-theoretical considerations [online], available: http://pjlor.files.wordpress.com/2010/06/chapter-4-draft-2011-04-152.pdf. [Accessed November 2013]

LYNCH, M.J., STRETESKY, P.B. and BURNS, R.G., 2004. Determinants of environmental law violation fines against petroleum refineries: Race, ethnicity, income, and aggregation effects. Society and Natural Resources, 17(4), pp.333-347.

MAKINDE, T., 2005. Problems of policy implementation in developing nations: The Nigerian experience. Journal of Social sciences, 11(1), pp.63-69.

MAPLES, R.E., 2000. Petroleum refinery process economics. Pennwell books.

MARASOVIĆ, B. and BABIĆ, Z., 2011. Two-step multi-criteria model for selecting optimal portfolio. International Journal of Production Economics, 134(1), pp.58-66.

MARDANI, A., JUSOH, A., NOR, K., KHALIFAH, Z., ZAKWAN, N. and VALIPOUR, A., 2015. Multiple criteria decision-making techniques and their applications–a review of the literature from 2000 to 2014. Economic research-Ekonomska istraživanja, 28(1), pp.516-571.

MARK, M. 2012. Nigeria fuel subsidy scheme hit by corruption. The Guardian. [Online]. Available from: https://www.theguardian.com/world/2012/apr/19/nigeria-fuel-subsidy-scheme-corruption (Accessed April 2021)

MARKS, D.F. and YARDLEY, L., 2004. Research methods for clinical and health psychology. Sage.
MARMOT M.G., and WILKINSON R.D., 2006. Social Determinants of Health. Editors. Oxford, England: Oxford University Press.

MARTYNOVA, E., WEST, S.G. and LIU, Y., 2018. Review of principles and practice of structural equation modelling. Structural Equation Modelling: A Multidisciplinary Journal, 25(2),

MATELL, M. S., & JACOBY, J. 1971. Is there an optimal number of alternatives for Likert scale items? Study I: Reliability and validity. Educational and Psychological Measurement, 31(3), 657-674.

MAXWELL, J. C. [1876] 1992. Matter and Motion, New York: Dover.

MCCANN, P. and SHEPPARD, S., 2003. The rise, fall and rise again of industrial location theory. Regional studies, 37(6-7), pp.649-663.

MCGOWAN, J., 1991. Postmodernism and its Critics. Cornell University Press.

MEADOWS, D. 1999. Leverage points; places to intervene in a system. Harland, VT: The Sustainability Institute. Retrieved from http://www.sustainabilityinstitute.org/pubs/Leverage_Points.pdf [Google Scholar]

MEADOWS, D.H., 2008. Thinking in systems: A primer. Chelsea green publishing.

MEADOWS, D.H., MEADOWS, D.L., RANDERS, J. and BEHRENS, W.W., 1972. The limits to growth. New York, 102(1972), p.27.

MELLAHI, K., DEMIRBAG, M. and RIDDLE, L., 2011. Multinationals in the Middle East: Challenges and opportunities. Journal of World Business, 46(4), pp.406-410.

MINGERS, J. 2004. Future directions in management science modeling. Critical Realist Applications in Organisation and Management Studies, edited by: Fleetwood, S. and Ackroyd, S, 164-193.

MINGERS, J. and LEROY, W. 2010. A review of the recent contribution of systems thinking to operational research and management science. European journal of operational research. Vol 207. Issue 3 pg. 1147 - 1161

MIRKOUEI, A., MIRZAIE, P., HAAPALA, K.R., SESSIONS, J. and MURTHY, G.S., 2016. Reducing the cost and environmental impact of integrated fixed and mobile bio-oil refinery supply chains. Journal of cleaner production, 113, pp.495-507.

MITCHELL G. 1993.. The Practice of Operations Research. Chichester: Wiley.

MOHAJAN, H.K., 2017. Two criteria for good measurements in research: Validity and reliability. Annals of Spiru Haret University. Economic Series, 17(4), pp.59-82.

MONAT, J.P., and GANNON, T.F., 2015. Using system thinking to analyze ISIS. American Journal of Systems Science, 4(2), pp.36-49.

MONAT, J.P., and GANNON, T.F., 2018. Applying systems thinking to engineering and design. Systems, 6(3), p.34.

MONTUORI, A., 2011. Systems Approach. In: M.A. RUNCO and S.R. PRITZKER, eds, Encyclopaedia of Creativity (Second Edition). San Diego: Academic Press, pp. 414-421.

MUHRER, J.C., 2021. Risk of misdiagnosis and delayed diagnosis with COVID-19: A Syndemic Approach. The Nurse Practitioner, 46(2), p.44.

MYERS, M.D. 2008. "Qualitative Research in Business & Management" SAGE Publications

NAESS, P., 2018. Validating explanatory qualitative research: Enhancing the interpretation of interviews in urban planning and transportation research. Applied Mobilities.

NBS, 2020. Nigerian Gross Domestic Product Report (Q4 & Full Year 2020). [Online]. Available from: https://nigerianstat.gov.ng/elibrary (Accessed April 2021).

NELSON, W. L. 1976. "The concept of refinery complexity". Oil & Gas Journal, Sept.

NEPAL, B., YADAV, O.P. and MURAT, A., 2010. A fuzzy-AHP approach to prioritization of CS attributes in target planning for automotive product development. Expert Systems with Applications, 37(10), pp.6775-6786.

NGWU, E. C. 2014. Political Economy of Crude Oil Production and Nigeria's Downstream Sector. University of Nigeria, Nsukka.

NIGHTINGALE, A. 2009. Triangulation: International Encyclopedia of Human Geography.

NKAGINIEME, U., 2005. The Challenges of Building A New Refinery In Nigeria With Limited Energy Infrastructure & Regulated Petroleum Products Market. In 18th World Petroleum Congress. World Petroleum Congress.

NKOGBU, O. G. and OKORODUDU, O., 2015. Deregulation of the downstream sector of the Nigerian petroleum industry: the role of leadership. European Journal of Business and Management, 7(8), pp.2222-2839.

NNODIM, O. 2020. PPPRA clears marketers to import petrol. Punch. [Online]. Available from: https://punchng.com/pppra-clears-marketers-to-import-petrol/ (Accessed December, 2020)

NNPC ACT, 2004. Nigerian National Petroleum Corporation Act. [Online]. Available from: https://www.lawyard.ng/wp-content/uploads/2015/11/NIGERIAN-NATIONAL-PETROLEUM-CORPORATION-ACT-2004.pdf (Accessed January 2019)

NNPC ASB. 2016. NNPC Annual Statistical Bulletin. [Online]. Available from: http://www.nnpcgroup.com/Portals/0/Monthly%20Performance/2016%20ASB%201st%20edition.pdf [Accessed August 2018].

NNPC, 2018b. Warri refining and petrochemical company, limited. A subsidiary of Nigerian National Petroleum Corporation. [Online]. Avaliable from: http://wrpcnnpcng.com/about2.htm [Accessed July, 2018].

NNPC, 2019. Kaduna Refining and Petrochemical Company (KRPC). [Online]. Available from: https://nnpcgroup.com/Refining/Pages/KRPC.aspx (Accesses December, 2019)

NNPC. 2016. Nigerian Crude Oil Production Hits 2.7 Million Barrels... As NNPC, Benue Pledge to Resuscitate Makurdi Depot. [Online]. Available from: http://www.nnpcgroup.com/PublicRelations/NNPCinthenews/tabid/92/articleType/ArticleView/articleId/380/Nigerian-Crude-Oil-Production-Hits-27-Million-Barrels-As-NNPC-Benue-Pledge-to-Resuscitate-Makurdi-Depot.aspx [Accessed March 30, 2017].

NNPC. 2018. History of the Nigerian Petroleum Industry. [Online]. Available from: http://www.nnpcgroup.com/NNPCBusiness/Businessinformation/OilGasinNigeria/IndustryHistory.aspx [Accessed July, 2018].

NNPC. 2018c. Green Field Refinery Initiative. [Online]. Available from: http://nnpcgroup.com/NNPCBusiness/MidstreamVentures/GreenfieldRefineryInitiative.aspx [Accessed September, 2018].

NORDHAUS, W.D., 2009, June. The economics of an integrated world oil market. In International Energy Workshop (pp. 17-19).

NWILO, P.C. and BADEJO, O.T., 2006. Impacts and management of oil spill pollution along the Nigerian coastal areas. Administering Marine Spaces: International Issues, 119, pp.1-15.

OBI, C.I. 2010. Oil extraction, dispossession, resistance, and conflict in Nigeria's oil-rich Niger Delta. Canadian Journal of Development Studies/Revue canadienne d'études du development, 30(1-2), pp.219-236.

OBIAJUNWA, C.C., 2013. Skills for the management of turnaround maintenance projects. Journal of Quality in Maintenance Engineering, 19(1), pp.61-73.

O'CONNOR, M.A., 2002. The Enron board: The perils of groupthink. U. Cin. L. Rev., 71, p.1233.

ODULARU, G.O., 2008. Crude oil and the Nigerian economic performance. Oil and Gas business, pp.1-29.

ODUTOLA, A. 2021, December 9. Nigeria spends N2.52 trillion on petrol imports in the first 9 months of 2021. Nairametrics. Retrieved December 13, 2021, from https://nairametrics.com/2021/12/09/nigeria-spends-n2-52-trillion-on-petrol-imports-in-the-first-9-months-of-2021/

OGBUAGU, C. S. A. 1985. The politics of industrial location in Nigeria. Africa Development. Vol. 10, No. 4 pp. 97-122.

OGBUAGU, U., Ubi, P. and Effiom, L., 2014. Corruption and infrastructural decay: perceptible evidence from Nigeria. Journal of Economics and Sustainable Development, 5(10), pp.20-27.

OIL and GAS JOURNAL. 2001. Pipeline sabotage closes Nigerian refinery, another to follow. [Online]. Available from: https://www.ogj.com/refining-rocessing/article/17262604/pipeline-sabotage-closes-nigerian-refinery-another-to (Accessed January 2021).

OKOLO, P. & ETEKPE, A. 2010. Oil Pipeline Vandalization and the Socio-Economic Effects in Nigeria’s Niger Delta Region. SSRN Electronic Journal. 10.2139/ssrn.1723169.

OKON-EKONG, N. and JAMES, S. 2018. PIGB: Understanding the Politics Behind Buhari's Refusal. [Online]. Available from: https://www.thisdaylive.com/index.php/2018/09/03/pigb-understanding-the-politics-behind-buharis-refusal/ (Accessed February 2019)

OKOROMA, N.S., 2006. Educational Policies and Problems of Implementation in Nigeria. Australian Journal of Adult Learning, 46(2), pp.243-263.

OKOYE, A. 2012, "Novel linkages for development: corporate social responsibility, law and governance: exploring the Nigerian Petroleum Industry Bill", Corporate Governance, Vol. 12 No. 4, pp. 460-471.

OLAWORE, B., 2012. Only full deregulation of downstream sector will end fuel scarcity. Nigeria Il and as Downstream Sector Refining and Marketing Report, 2.

OLUJOBI, O.J., 2021. Deregulation of the downstream petroleum industry: An overview of the legal quandaries and proposal for improvement in Nigeria. Heliyon, 7(4), p.e06848.

OLUWAGBEMI, M. 2016. The ultimate presidential scam in Nigeria called refinery TAM. [Online]. Available from: [https://medium.com/@busanga/the-ultimate-presidential-scam-in-nigeria-called-refinery-tam-90ca9536db58 (Accessed January 2021).

OMOREGIE, U. 2019, "Nigeria's petroleum sector and GDP: The missing oil refining link", Journal of Advances in Economics and Finance, Vol. 4 No. 4, pp. 1 – 8.

OMOTAYO, T., AWUZIE, B., EGBELAKIN, T., OBI, L. and OGUNNUSI, M., 2020. AHP-Systems Thinking Analyses for Kaizen Costing Implementation in the Construction Industry. Buildings, 10(12), p.230.

ONDREY, G., 2009. World's largest refinery starts up a novel sulfur-removal system. Chemical Engineering, 116(10), pp.11-12.

ONUAH, F. 2021, March 18. Nigeria approves $1.5 billion Port Harcourt refinery upgrade. U.S. https://www.reuters.com/article/uk-nigeria-refinery-idUSKBN2BA10A (Accessed April 2021).

ONUOHA, F.C., 2008. Oil pipeline sabotage in Nigeria: Dimensions, actors and implications for national security. African Security Studies, 17(3), pp.99-115

OPEC. 2019. Annual statistical bulletin. [Online]. Available from: file:///H:/PhD%20Materials/STATISTICS/OPEC%20Annual%20Statistical%20Bulletin%202017.pdf [Accessed June, 2018].

ORMSTON, R., SPENCER, L., BARNARD, M. and SNAPE, D., 2014. The foundations of qualitative research. Qualitative research practice: A guide for social science students and researchers, 2, pp.52-55.

OSAE-BROWN, A. and CLOWES, W. 2021. Nigeria's Costly Fuel Subsidies Back After Crude Price Spike. [Online]. Available from: https://www.bloomberg.com/news/articles/2021-03-01/nigeria-s-nnpc-won-t-increase-fuel-prices-in march#:~:text=Nigerian%20spent%2010.7%20trillion%20naira,supporters%20of%20deregulation%20have%20argued. (Accessed April 2021)

OSOBAJO, O.A. and MOORE, D. 2017. The B2Com relationship: an empirical study of the measure of relationship quality in a business-to-community relationship. International business research [online], 10(7), pages 118-147. Available from: https://doi.org/10.5539/ibr.v10n7p118

OTOKUNEFOR, T.V. and OBIUKWU, C., 2005. Impact of refinery effluent on the physicochemical properties of a water body in the Niger Delta. Applied ecology and environmental research, 3(1), pp.61-72.

OWEH, I. 2018, March 15. Modular Refineries Overrated, Not Solution To Fuel Scarcity — Kachikwu. Independent Newspaper Nigeria. Retrieved June 15, 2019, from https://independent.ng/modular-refineries-overrated-not-solution-to-fuel-scarcity-kachikwu/

OWOJORI, A.A., 2011. The effect of the emerging economic policies in investment in Nigeria. Journal of Emerging Trends in Economics and Management Sciences, 2(3), pp.206-214.

OZCAN-DENIZ, G.; ZHU, Y.M. 2015. A multi-objective decision-support model for selecting environmentally conscious highway construction methods. Civ. Eng. Manag.,21, 733–747

PALMER, B. (2019, September 17). The Biggest Private Oil Companies in the World. Investopedia. Retrieved October 26, 2021, from: https://www.investopedia.com/articles/investing/013016/biggest-private-oil-companies-world.asp

PAN, W., CHEN, L. AND ZHAN, W., 2019. PESTEL analysis of construction productivity enhancement strategies: A case study of three economies. Journal of Management in Engineering, 35(1), p.05018013.

PASSOS, C., CRUZES, D.S., DYBÅ, T. and MENDONÇA, M., 2012, September. Challenges of applying ethnography to study software practices. In Proceedings of the 2012 ACM-IEEE International Symposium on Empirical Software Engineering and Measurement (pp. 9-18). IEEE.

PATTON, M. (2005) Qualitative Research & Evaluation Methods (4th ed.). Los Angeles, CA: SAGE.

PATTON, M.Q., 1999. Enhancing the quality and credibility of qualitative analysis. Health services research, 34(5 Pt 2), p.1189.

PAUL, M. and STROH, P. 1999. The learning family: Bringing the five disciplines home. Pegasus communications. Systems thinker. Vol 10, No. 6.

PEHRSON, S., STAMBULOVA, N.B. and OLSSON, K., 2017. Revisiting the empirical model ‘Phases in the junior-to-senior transition of Swedish ice hockey players’: External validation through focus groups and interviews. International Journal of Sports Science & Coaching, 12(6), pp.747-761.

PETERS, D.H., 2014. The application of systems thinking in health: why use systems thinking? Health research policy and systems, 12(1), pp.1-6.

PIDD, M. 2009. Tools for Thinking: Modelling in Management Science, 3rd Edition. Chichester: John Wiley and Sons.

PINTO, B., 1987. Nigeria during and after the oil boom: a policy comparison with Indonesia. The World Bank Economic Review, 1(3), pp.419-445.

POINCARÉ, H. 1913. The Foundations of Science: Science and Method, Lancaster: The Science Press.

POTTER, A., 2015. Balancing Opposition and Economic Benefits in Privatisation Policy. CUTS International. pp.325-329.

PROCTOR, R.W. and CAPALDI, E.J., 2006. Why science matters. Understanding the Methods of Psychological Research. Maldin, MA: Blackwell Publishing.

PURWANTO, A., SUŠNIK, J., SURYADI, F.X. and DE FRAITURE, C., 2019. Using group model building to develop a causal loop mapping of the water-energy-food security nexus in Karawang Regency, Indonesia. Journal of Cleaner Production, 240, p.118170.

PWC 2013. Economic Impacts of the Oil and Natural Gas Industry on the US Economy in 2011. American Petroleum Institute. [Online]. Available from: https://www.api.org/~/media/Files/Policy/Jobs/Economic_Impacts_ONG_2011.pdf

PWC. 2017. Nigeria's refining revolution. PWC Nigeria. Insights and Publications. [Online]. Available from: https://www.pwc.com/ng/en/publications/nigerias-refining-revolution.html [Accessed February, 2018].

QUICENO, G.; ÁLVAREZ, C.; ÁVILA, R.; FERNÁNDEZ, Ó.; FRANCO, C.J.; KUNC, M.; DYNER, I. 2019. Scenario analysis for strategy design: A case study of the Colombian electricity industry. Energy Strateg. Rev. 2019, 23, 57–68.

RAGOTHAMAN, A. and ANDERSON, W.A., 2017. Air quality impacts of petroleum refining and petrochemical industries. Environments, 4(3), p.66.

RAMANATHAN, R. and GANESH, L.S., 1995. Using AHP for resource allocation problems. European Journal of Operational Research, 80(2), pp.410-417.

RAMOS, G. and HYNES, W. 2019. Systemic thinking for policy making – the potential of systems analysis for addressing global policy challenges in the 21st century. [Online]. Available from: https://www.oecd.org/naec/averting-systemic-collapse/SG-NAEC(2019)4_IIASA-OECD_Systems_Thinking_Report.pdf (Accessed January 2021)

RANGANATH, B. J. 2008. System Dynamics: Theory and Case Studies. New Delhi:

RASHID, K.; RAZZAQ, A.; AHMAD, M.; RASHID, T.; TARIQ, S. 2017. Experimental and analytical selection of sustainable recycled concrete with ceramic waste aggregate. Constr. Build. Mater.2017,154, 829–840.

RASHID, Y., RASHID, A., WARRAICH, M.A., SABIR, S.S. and WASEEM, A., 2019. Case study method: A step-by-step guide for business researchers. International Journal of Qualitative Methods, 18, p.1609406919862424.

RAY, J. 1980. How many answer categories should attitude and personality scales use? South African Journal of Psychology, 10, 53–4.

REICHERTZ, J., 2004. 4.3 Abduction, deduction, and induction in qualitative research. A Companion to, p.159.

REUTERS, 2018a. Nigeria passes major oil reform bill after 17-year struggle. [Online]. Available from: https://www.reuters.com/article/us-nigeria-oil-law/nigeria-passes-major-oil-reform-bill-after-17-year-struggle-idUSKBN1F72I2 [Accessed August, 2018].

REUTERS, 2018B. UPDATE 1-Nigeria's presidency rebuffs landmark oil reform bill in current form. [Online]. Available from: https://www.reuters.com/article/nigeria-oil/update-1-nigerias-presidency-rebuffs-landmark-oil-reform-bill-in-current-form-idUSL3N1VJ55M [Accessed September 2018].

REUTERS. 2018C. Billionaire's huge Nigerian oil refinery likely delayed until 2022: sources. [Online]. Available from: https://www.reuters.com/article/us-nigeria-dangote-refinery/billionaires-huge-nigerian-oil-refinery-likely-delayed-until-2022-sources-idUSKBN1KV0WA [Accessed October 2018].

RIDDER, H.G., 2017. The theory contribution of case study research designs. Business Research, 10(2), pp.281-305.

ROGGIO, A.M., 2019. A systems thinking approach to the integration of food insecurity policy. Journal of Public Affairs, 19(3), p.e1862.

ROXAS, F.M.Y., RIVERA, J.P.R. and GUTIERREZ, E.L.M., 2019. Locating potential leverage points in a systems thinking causal loop diagram toward policy intervention. World Futures, 75(8), pp.609-631.

RUTLEDGE, L.S., 2008. Motivation and the professional African American woman. AuthorHouse.

SAATY, T. L. 1987. The analytic hierarchy process—what it is and how it is used. Mathematical modelling, 9(3-5), pp.161-176.

SAATY, T.L., 1977. A scaling method for priorities in hierarchical structures. Journal of mathematical psychology, 15(3), pp.234-281.

SAATY, T.L., 1980. The Analytical Hierarchy Process. McGrawHill, New York, NY.

SAATY, T.L., 2004. Decision making—the analytic hierarchy and network processes (AHP/ANP). Journal of systems science and systems engineering, 13(1), pp.1-35.

SAUNDERS, M., LEWIS, P. and THORNHILL, A. 2016. Research methods for business students. 7th ed. Pearson

SAUNDERS, M., LEWIS, P. and THORNHILL, A. 2019. Research methods. Business Students 4th edition Pearson Education Limited, England.

SAYER, A., 2004. Why critical realism. Critical realist applications in organisation and management studies, 11(6).

SAYNE, A., GILLIES, A., and KATSOURIS, C. 2015. Inside NNPC Oil Sales: A case for reform in Nigeria. Natural Resource Governance Institute.

SCHARP, K.M. and SANDERS, M.L., 2019. What is a theme? Teaching thematic analysis in qualitative communication research methods. Communication Teacher, 33(2), pp.117-121.

SCHOONENBOOM, J. and JOHNSON, R.B., 2017. How to construct a mixed methods research design. KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie, 69(2), pp.107-131.

SCHATZ, E., 2012. Rationale and procedures for nesting semi-structured interviews in surveys or censuses. Population studies, 66(2), pp.183-195.

SCHMIDT, F. and HUNTER, J. 2015, Methods of Meta-Analysis: Correcting Error and Bias in Research Findings, Sage Publications, London.

SCHMIDT, L. 2010. Using Archives: A Guide to Effective Research. Using Archives: A Guide to Effective Research. https://www2.archivists.org/book/export/html/14460

SCHMITZ, A. 2012. Mastering Public Relations. Saylor Academy

SCHOLTE, T. 2020. "A proposal for the role of the arts in a new phase of second-order cybernetics", Kybernetes, Vol. 49 No. 8, pp. 2153-2170. https://doi.org/10.1108/K-03-2019-0172

STOJČIĆ, M., ZAVADSKAS, E.K., PAMUČAR, D., STEVIĆ, Ž. and MARDANI, A., 2019. Application of MCDM methods in sustainability engineering: A literature review 2008–2018. Symmetry, 11(3), p.350.

STREINER, D. L. 2006. Building a Better Model: An Introduction to Structural Equation Modelling. The Canadian Journal of Psychiatry, 51(5), 317–324. https://doi.org/10.1177/070674370605100507

SCHULTZE, G. and MILLER, C., 2004. The search for meaning and career development. Career Development International.

SEBA, E. 2020. Shell weighs sale of Convent, Louisiana refinery. [Online]. Available from: https://www.reuters.com/article/us-refinery-sale-shell-convent-idUSKBN2482KM (Accessed April 2021).

SENGE, P. 1990. The fifth discipline – The art and practice of the learning organization. New York, NY: Doubleday. [Google Scholar]

SHARP, D.J., 1991. Uncovering the hidden value in high-risk investments. MIT Sloan Management Review, 32(4), p.69.

SHARP, H.; PREECE, J.; and ROGERS, Y. 2019. Interaction Design: Beyond Human-Computer Interaction (5th Ed). Wiley.

SHENTON, A. K. 2004. Strategies for ensuring trustworthiness in qualitative research projects. Education for information, 22, 63-76

SHERWOOD, D. 2011. Seeing the forest for the trees: a manager's guide to applying systems thinking. Nicholas Brealey Publishing.

SHILEI, L., & YONG, W. (2009). Target-oriented obstacle analysis by PESTEL modelling of energy efficiency retrofit for existing residential buildings in China’s northern heating region. Energy Policy, 37, 2098-2101. http://dx.doi.org/10.1016/j.enpol.2008.11.039

SIDDIG, K., AGUIAR, A., GRETHE, H., MINOR, P. and WALMSLEY, T., 2014. Impacts of removing fuel import subsidies in Nigeria on poverty. Energy Policy, 69, pp.165-178.

SINGH, H., 2021. Modular-mini refineries: Business opportunities in developing economies. African Journal of Science, Technology, Innovation and Development, pp.1-9.

SOLOMON ASSOCIATES. 2020, June 3. World's Best Refineries–What Sets Them Apart? [Video]. YouTube. https://www.solomoninsight.com/resources/webinar-worlds-best-refineries-what-sets-them-apart

SONG, J., SUN, Y. and JIN, L., 2017. PESTEL analysis of the development of the waste-to-energy incineration industry in China. Renewable and Sustainable Energy Reviews, 80, pp.276-289.

SPRADLIN, D. (2012, September). Decision making and problem solving: Are you solving the right problem? Harvard Business Review. Retrieved March 19, 2022, from https://hbr.org/2012/09/are-you-solving-the-right-problem

SQUALLI, J., 2007. Electricity consumption and economic growth: Bounds and causality analyses of OPEC members. Energy Economics, 29(6), pp.1192-1205.

SRDJEVIC, Z., BAJCETIC, R. & SRDJEVIC, B., 2012. Identifying the Criteria Set for Multicriteria Decision Making Based on SWOT/PESTLE Analysis: A Case Study of Reconstructing A Water Intake Structure. Water Resour Manage 26, 3379–3393. https://doi.org/10.1007/s11269-012-0077-2

STACEY, K. and CROOKS, E. 2016. Oil majors find virtue in integration. Financial Times.

STAKE, R.E., 1995. The art of case study research. Sage.

STERMAN, J.D., 2010. Does formal system dynamics training improve people's understanding of accumulation? System Dynamics Review, 26(4), pp.316-334.

STOBER, E. O. 2016. Nigeria's Petroleum Subsidy: In Whose Interest is it? Academic Journal of Economic Studies Vol. 2, No.1, March 2016, pp. 58-70

STOJČIĆ, M., ZAVADSKAS, E.K., PAMUČAR, D., STEVIĆ, Ž. and MARDANI, A., 2019. Application of MCDM methods in sustainability engineering: A literature review 2008–2018. Symmetry, 11(3), p.350.

TAHERDOOST, H., 2017. Decision making using the analytic hierarchy process (AHP); A step by step approach. International Journal of Economics and Management Systems, 2.

TAYLOR-POWELL, E. & RENNER, M. 2003. Analyzing qualitative data, University of Wisconsin -Extension, Cooperative Extension.

TEDDLIE, C., and TASHAKKORI, A. 2003. Major issues and controversies in the use of mixed methods in the social and behavioural sciences. In: Tashakkori, A, Teddlie, C (eds) Handbook of Mixed Methods in Social and Behavioural Research. Thousand Oaks, CA: SAGE, pp. 3–49.

TEOLI, D., SANVICTORES, T., and AN, J., 2019. SWOT analysis. [Online]. Available from: https://www.statpearls.com/articlelibrary/viewarticle/29790/ (Accessed April, 2021)

THE WORLD BANK. 2020. Population, total - Nigeria. [Online]. Available from: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=NG (Accessed January 2020)

THIETART, R.A. and FORGUES, B., 1995. Chaos theory and organization. Organization science, 6(1), pp.19-31.

THOMPSON, A. K. 2017, February 16. Social Surveys – Advantages and Disadvantages. ReviseSociology. Retrieved February 3, 2019, from https://revisesociology.com/2016/01/11/social-surveys-advantages-and-disadvantages/

TSANGAS, M., JEGUIRIM, M., LIMOUSY, L. and ZORPAS, A., 2019. The application of analytical hierarchy process in combination with PESTEL-SWOT analysis to assess the hydrocarbons sector in Cyprus. Energies, 12(5), p.791.

TURNER, T. 1977. Two Refineries: A Comparative Study of Technology Transfer to the Nigerian Refining Industry. World Development, Vol. 5, No. 3, pp. 235-256. Pergamon Press. Great Britain.

UDO, B. 2002C. Fuel subsidy gone forever in Nigeria – NNPC GMD. [Online]. Available from: https://www.premiumtimesng.com/news/headlines/386370-fuel-subsidy-gone-forever-in-nigeria-nnpc-gmd.html (Accessed January 2021).

UDO, B. 2018. Why Buhari withheld assent to PIGB – Presidential aide. Premium Times. [Online]. Available from: https://www.premiumtimesng.com/news/top-news/281790-why-buhari-withheld-assent-to-pigb-presidential-aide.html (Accessed January 2021)

UDO, B. 2020B. Three refineries lost N1.6trillion in 5 years, says NNPC audit report [Online]. Available from: https://www.premiumtimesng.com/business/business-news/398151-three-refineries-lost-n1-6trillion-in-5-years-says-nnpc-audit-report.html (Accessed December 2020)

UKPIA. (2020). A Transition, Transformation, and Innovation towards Net-Zero in UK downstream United Kingdom Petroleum Industries Association. Retrieved December 1, 2021, from https://www.ukpia.com/media-centre/news/2020/a-transition-transformation-and-innovation-towards-net-zero-in-uk-downstream/

UKPIA. 2018, June. United Kingdom Petroleum Industries Association statistiscal review. https://www.ukpia.com/media/1008/ukpia-statistical-review-2018.pdf

ÜLGEN, H. and MIRZE, S.K., 2007. İşletmelerde Stratejik Yönetim (4. Baskı). İstanbul: Arıkan Yayınları.

ULRICH, W. 1988. Systems thinking, systems practice, and practical philosophy: a program of research. Systems Practice. Pg. 137 – 163

UMAR, H.M. and UMAR, M.S. 2013. An Assessment of the Direct Welfare Impact of Fuel Subsidy Reform in Nigeria. Am. J. Econ., 3 (1) (2013), pp. 23-26

UMAR, M.B., 2005. Legal Issues in the Management of Nigeria's Production Sharing Contracts from a Study of the Nigerian National Petroleum Corporation's (National Petroleum Management Services') Perspective. Oil, Gas & Energy Law Journal (OGEL), 3(1).

UMUKORO, N., 2018. Homegrown Solution to African Problem: Harnessing Innovation for Petroleum Refining in Nigeria. Strategic Planning for Energy and the Environment, 37(4), pp.58-73.

UN Reports, 2021. Ending poverty. [Online]. Available from: https://www.un.org/en/global-issues/ending-poverty (Accessed April 2021).

VAISMORADI, M., TURUNEN, H. and BONDAS, T., 2013. Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. Nursing & health sciences, 15(3), pp. 398-405.

VAN, T.C., RAMIREZ, J., RAINEY, T., RISTOVSKI, Z. and BROWN, R.J., 2019. Global impacts of recent IMO regulations on marine fuel oil refining processes and ship emissions. Transportation Research Part D: Transport and Environment, 70, pp.123-134.

VANGUARD, 2015. How Yar'Adua was pressurised to revert refineries sold to Dangote-Obasanjo. [Online]. Available from: https://www.vanguardngr.com/2015/07/how-yaradua-was-pressurised-to-revert-refineries-sold-to-dangote-obasanjo/ (Accessed September 2019)

VERHOEFF, R.P., KNIPPELS, M.C.P., GILISSEN, M.G. and BOERSMA, K.T., 2018, June. The theoretical nature of systems thinking. Perspectives on systems thinking in biology education. In Frontiers in Education (Vol. 3, p. 40). Frontiers.

VIDEIRA, N., SCHNEIDER, F., SEKULOVA, F. and KALLIS, G. 2014. "Improving understanding on degrowth pathways: an exploratory study using collaborative causal models", Futures, Vol. 55, pp. 58-77.

VON BERTALANFFY, L. 1968. General System Theory: Foundations, Developments, Applications. New York: Braziller.

WAKE, H., 2005. Oil refineries: a review of their ecological impacts on the aquatic environment. Estuarine, Coastal and Shelf Science, 62(1-2), pp.131-140.

WALKER, D. H. T. 1997. Choosing an appropriate research methodology. Construction Management and Economics, 15(2), 149-159.
WALLIMAN, N., 2015. Social research methods: The essentials. Sage.

WANG, J.J., JING, Y.Y., ZHANG, C.F. and ZHAO, J.H., 2009. Review on multi-criteria decision analysis aid in sustainable energy decision-making. Renewable and sustainable energy reviews, 13(9), pp.2263-2278.

WANG, Y., WANG, Y., WU, X. and LI, J., 2020. Exploring the risk factors of infrastructure PPP projects for sustainable delivery: a social network perspective. Sustainability, 12(10), p.4152.

WAPNER, A. 2017. Downstream beneficiation case study: Nigeria. Columbia Centre on Sustainable Investment. [Online]. Available from: http://ccsi.columbia.edu/files/2013/10/Nigeria-Case-Study-May-2017_CCSI-Final.pdf [Accessed October 2018].

WATTS, M., 2004. Resource curse? Governmentality, oil and power in the Niger Delta, Nigeria. Geopolitics, 9(1), pp.50-80.

WATTS, M., 2006. The sinister political life of community: Economies of violence and governable spaces in the Niger Delta, Nigeria. The seductions of community: Emancipations, oppressions, quandaries, pp.101-142.

WEAVER, W., 1991. Science and complexity. In Facets of systems science (pp. 449-456). Springer, Boston, MA.

WEBER, A., 1982. On the location of industries. Progress in Geography, 6(1), pp.120-128.

WILKINSON, D. and BIRMINGHAM, P., 2003. Using research instruments: A guide for researchers. Psychology Press.

WILLIAMS, G., 1997. Chaos theory tamed. CRC Press.

WILLOWER, D.J., 1998. Fighting the fog: A criticism of postmodernism. Journal of School Leadership, 8(5), pp.448-463.

WILSON, B. 1990. Systems, concepts, methodologies, and applications, Wiley.

WORLD BANK, 2018. Nigeria. The world bank data. Online. Available from: https://data.worldbank.org/country/nigeria

WYNN JR, D. and WILLIAMS, C.K., 2012. Principles for conducting critical realist case study research in information systems. MIS quarterly, pp.787-810.

YAZAN, B., 2015. Three approaches to case study methods in education: Yin, Merriam, and Stake. The qualitative report, 20(2), pp.134-152.

YIN, R.K., 2003. Designing case studies. Qualitative Research Methods, 5, pp.359-386.

YIN, R. K. 2009. How to do better case studies. The SAGE Handbook of Applied Social Research Methods, 2, 254–282.

ZABBEY, N., GIADOM, F.D. and BABATUNDE, B.B., 2019. Nigerian Coastal Environments. In World Seas: an Environmental Evaluation (pp. 835-854). Academic Press.

ZACH, L., 2006. Using a multiple-case studies design to investigate the information-seeking behavior of arts administrators. Library trends, 55(1), pp.4-21.

ZHAO, H.R.; GUO, S. 2014. Selecting Green Supplier of Thermal Power Equipment by Using a Hybrid MCDM Method for Sustainability. Sustainability, 6, 217–235

ZHU, P., LIYANAGE, J.P., PANESAR, S.S. AND KUMAR, R., 2020. Review of workflows of emergency shutdown systems in the Norwegian oil and gas industry. Safety science, 121, pp.594-602.

APPENDICES

Appendix 1 Request Letter for Data Collection from NNPC

ROBERT GORDON UNIVERSITY ABERDEEN

THE SCOTT SUTHERLAND SCHOOL OF BUILT ENVIRONMENT
Robert Gordon University
The Sir Ian Wood Building
Riverside East
Garthdee Road
Aberdeen AB10 7GJ
UK
Tel: 01224 263700
Email: sss@rgu.ac.uk

21st December 2020

The Zonal Director
Department of Petroleum Resources
No. 4-9, Moscow Road
Port Harcourt
Rivers State, Nigeria.

Dear Sir,

REQUEST FOR DATA COLLECTION FROM PORT HARCOURT REFINERY AND NLNG FOR AN ACADEMIC RESEARCH STUDY

I am writing to request for data collection from Port Harcourt refinery and NLNG. This data will help me to successfully carry out my PhD research study on the performance challenges of the refineries. One of the key objectives of this study is to extract vital lessons from similar local and international organizations with standard practice in order to inform Nigeria's policymakers while seeking to address the challenges of the refineries.

Listed below are the details of the information that I require:

From Port Harcourt refinery:

- The process units at the refineries as well as the Nelson complexity index
- Any documents that will point to the nature of construction contracts used to build the refineries
- Summary of production data from the refineries in the last five years
- Operating costs of the refineries for the last five years
- Major maintenance operations carried out in the refineries since year 2000
- Records of downtime in the refineries in the last five years
- Any national/international laws/regulations binding on the refinery operations?
- Any compensation claims against the refineries in the last ten years

INVESTOR IN PEOPLE

From NLNG:

- A brief history of the NLNG, including information on the construction projects for the LNG Trains 1 – 7. I'm particularly interested in the major participating companies for the construction of the Trains 1- 7 and the overall project award value for each train.
- Information on the type of construction contracts used to build the LNG trains 1 – 7. This is to learn the kind of contractual relationships that exists between NLNG and their original equipment manufacturers (OEMs), which assures the continuous support of the OEMs on the operations of the LNG plants.
- Summary records of some of the major maintenance operations carried out in the plants in the last five years.
- The software the company uses for asset performance management for the LNG plants.

I will appreciate any information the companies can oblige me on the listed requirements. Additionally, can I request that this information be sent to me (where possible) through my school email: o.e.iheukwumere@rgu.ac.uk

Thank you for your kind assistance in anticipation.

Yours faithfully,

Obinna Iheukwumere
BEng, MSc, AFHEA, PhD Candidate
Robert Gordon University,
The Sir Ian Wood Building, Scott Sutherland School
Riverside East, Garthdee Road, Aberdeen,
AB10 7GJ
United Kingdom.
Email: o.e.iheukwumere@rgu.ac.uk
Mobile: +44 (0)7459808807

Appendix 2 Student Confirmation letter for NNPC

ROBERT GORDON UNIVERSITY ABERDEEN

THE SCOTT SUTHERLAND SCHOOL OF BUILT ENVIRONMENT

Robert Gordon University
The Sir Ian Wood Building
Riverside East
Garthdee Road
Aberdeen AB10 7GJ
UK
Tel: 01224 263700
Email: sss@rgu.ac.uk

21st December 2020

The Zonal Director
Department of Petroleum Resources
No. 4-9, Moscow Road
Port Harcourt
Rivers State, Nigeria.

RE: MR. OBINNA IHEUKWUMERE'S REQUEST FOR DATA COLLECTION

This is to confirm that Mr. Obinna Iheukwumere is a registered doctoral student of this school. As his supervisor, I can confirm that his PhD research work investigates the performance challenges of NNPC refineries with a view of understanding the factors that may impact on future practice across the Nigerian refining industry. One of the main objectives of Mr Iheukwumere's research work is to extract key lessons from similar local and international organizations with best practices that can inform policymakers in Nigeria while seeking to resolve the challenges of the refineries.

As such, Mr Iheukwumere will be happy to respond to any queries you may have concerning the above and, subject to being allowed to collect relevant data, share the findings of his research work with your organization upon completion.

Signed:

DRMoore

David Moore, PhD
Research Supervisor
Robert Gordon University,
The Sir Ian Wood Building, Scott Sutherland School
Riverside East, Garthdee Road, Aberdeen,
AB10 7GJ
United Kingdom.
Email: d.moore2@rgu.ac.uk

INVESTOR IN PEOPLE

Appendix 3 Approval Letter from NNPC

MINISTRY OF PETROLEUM RESOURCES
DEPARTMENT OF PETROLEUM RESOURCES
PORT HARCOURT ZONAL OFFICE
4-9 MOSCOW ROAD, PORT HARCOURT

P.M.B. 5103
Website: www.dpr.gov.ng

Ref. No: DPR/PH.UPS/2371/S.1/932
Date: 26th February, 2021

The General Manager,
Port Harcourt Refinery Company (PHRC),
Alesa, Eleme
Rivers state.

Dear Sir,

REQUEST FOR ACADEMIC DATA/ASSISTANCE

OBINNA EMMANUEL IHEUKWUMERE is a PhD student at Robert Gordon University, Aberdeen, Scotland.

He has applied for permission to obtain data/assistance required for his research project.

Based on the above, approval is hereby granted you to please provide **OBINNA EMMANUEL IHEUKWUMERE** with the necessary data/assistance to enable him to fulfill the academic requirement of the university.

He has been advised to handle the data/assistance with very strict confidentiality and to submit a copy each of his report to this office and your organization.

If you need further clarification, please contact the above-named student through his email: o.e.iheukwumere@rgu.ac.uk or telephone number: +44(0)7459808807.

Yours faithfully,

U.Bassey Nkanga FEnv
Zonal Operations Controller, DPR, PH

Appendix 4 Correspondence with UKPIA for Information Request

Re: Request for Information

Jamie Baker <Jamie.Baker@ukpia.com>
Tue 8/24/2021 5:01 PM
To: OBINNA IHEUKWUMERE (0817622) <o.e.iheukwumere@rgu.ac.uk>

Good afternoon Obinna,

Thank you for contacting us and I hope I can be of some help, although I should make clear that UKPIA does not hold detailed information on individual refinery projects or policies beyond what is available in the public domain.

- What is the general approach of UK refineries towards best practices regarding refinery maintenance and management?

  The major oil companies who own and operate the 6 UK refineries all have long-established corporate policies and standards for refinery management including maintenance activities, with most also having established global functions for major project management and technology sourcing (see for example, *https://corporate.exxonmobil.com/About-us/Business-divisions/Upstream/Global-projects* and *https://www.shell.com/business-customers/catalysts-technologies.html*). Internal benchmarking and global cost databases are also used to share best practice and cost information.

  For over 30 years, UK refinery operators have also subscribed to the Solomon Associates benchmarking services (see *https://www.solomoninsight.com/services/benchmarking/refining* and *https://www.solomoninsight.com/industries/refining/*), which provide assessment of refinery performance across a wide range of criteria against its peer group refineries. Typically, a UK refinery will allocate 1-2 FTEs to this activity to maintain competitiveness against their peer group or competing local refineries.

- Are there any existing or planned strategies to reduce the carbon footprint of the UK's refining industry? If so, what are they?
- What future can be foreseen for the UK refining industry given the imminent transition of the UK transport sector to electric vehicles and alternative fuels?

  Regarding both questions, and as noted above, UKPIA does not hold detailed information on the plans of individual refinery plans or policies, however, the two publications from UKPIA linked below have both been endorsed by the UKPIA Council on which sit representatives of all 6 UK refineries.

  The first, the *UKPIA Future Vision*, assesses some of the technologies and new ways of working that could contribute to decarbonisation right across the downstream sector (i.e. from refineries, to terminals and pipelines, all the way down to petrol filling stations). Such strategies to reduce the carbon footprint of the industry, include the deployment of CCUS technologies and continued efficiencies in process and combustion plant at sites, but there is also the potential for significant decarbonisation from feedstock switching that has both the potential to reduce on-site emissions but also the lifecycle emissions of products of refineries.

  The second, *Transition, Transformation and Innovation* considers in particular the UK's commitment to Net-Zero. As your question suggests, there is expected to be a drop in demand for transportation fuels, however, there will be an ongoing requirement for aviation and marine fuels which themselves will need to be made sustainably. The report also considers the role of hydrogen where the UK refining sector is both the largest producer and consumer of the energy vector in the UK and could have a significant role in the expected growth in that sector – there are early examples of projects for both blue and green hydrogen where refineries will play a key role. The other item explored is one of a systemic decarbonisation, drawing on examples where non-fuel products from refining (bitumen for road building, lubricants for efficiencies across many sectors, and anode graphite used in EV batteries among others) will have a role in enabling the decarbonisation of other sectors as well as within the sector itself.

While it is now a little out of date, you may also find the link below of some use, as the reports there are of work delivered jointly by ourselves and the UK Department for Business Energy and Industrial Strategy (BEIS) around 5 years ag that looked at individual technologies that could decarbonise refining. https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050

I hope the above is of use in your work
All the best
Jamie

Director of External Relations, UKPIA, M: 07468694731 T: 02072697605

From: "OBINNA IHEUKWUMERE (0817622)" <o.e.iheukwumere@rgu.ac.uk>
Date: Thursday, 19 August 2021 at 05:17
To: Jamie Baker <Jamie.Baker@ukpia.com>
Subject: Request for Information

Dear Jamie Baker,

I was directed by an official at Grangemouth refinery, where I had solicited information, to contact the UKPIA. As such, I emailed one of your officials last week with this message and have not yet received any response.

I am a doctoral research student from Robert Gordon University, Aberdeen. My research is focused on investigating the performance challenges of state-owned refineries in Nigeria and as a part of my study, I am seeking to understand some factors that help UK's refineries operate at optimum levels. In addition, I am also seeking to understand the future challenges confronting the UK refining industry and what is being done to manage the situation.

This information is intended for benchmarking purposes by helping me to identify some best practices within the UK refining industry as well as any strategies to manage the future challenges of the industry. This will help inform some of my recommendations for best practices regarding refinery management within my study area - Nigeria.

In particular, I would appreciate any information regarding the following:

- What is the general approach of UK refineries towards best practices regarding refinery maintenance and management?
- Are there any existing or planned strategies to reduce the carbon footprint of the UK's refining industry? If so, what are they?
- What future can be foreseen for the UK refining industry given the imminent transition of the UK transport sector to electric vehicles and alternative fuels?

I look forward to receiving any information you may have regarding the above questions.

Thank you for your help in anticipation.

Obinna Iheukwumere

BEng, MSc, PMP, AFHEA, PhD Candidate

Appendix 5 Sample Questionnaire

Assessing the critical factors leading to performance challenges in government-owned refineries in Nigeria.

This questionnaire is designed as part of a doctoral research study to sample the expert opinions of industry practitioners across government-owned refineries in Nigeria. The intention is to identify and understand the impact of political, economic, social, technical, environmental and legal (PESTEL) factors leading to performance challenges across the refineries. The information gathered will be very useful for policy makers for addressing the challenges of the refineries. The results of this survey can also be shared with the organisation upon request.

* Required

1. **Which of the three government-owned refineries do you work with? ***
   Mark only one oval.
   - ◯ Port Harcourt Refining Company Limited (PHRC)
   - ◯ Warri Refining and Petrochemical Company Limited (WRPC)
   - ◯ Kaduna Refining and Petrochemical Company Limited (KRPC)

2. **How long have you worked in this organisation? ***
   Mark only one oval.
   - ◯ 0 - 2 years
   - ◯ 3 - 5 years
   - ◯ 6 - 8 years
   - ◯ 9+ years

3. **Which of the following categories best explains your role in the refinery operations? ***
   Mark only one oval.
   - ◯ Director/Senior Management
   - ◯ Junior Management
   - ◯ Accounting/Finance
   - ◯ HR/Administration
   - ◯ Engineering/Technical
   - ◯ Logistics
   - ◯ Other: ____________________

4. **What is your highest level of education?** *
Mark only one oval.

- ◯ Primary School Certificate
- ◯ Secondary School Certificate
- ◯ Vocational/Technical Education
- ◯ Bachelors Degree/Higher National Diploma
- ◯ Masters Degree
- ◯ Doctorate Degree
- ◯ Other: ____________________

5. **What do you think is the size of this refinery in terms of its total number of employees (Permanent & Contract staff)?**
Mark only one oval.

- ◯ 0 -250 persons
- ◯ 251 - 500 persons
- ◯ 501 - 750 persons
- ◯ 751 -1,000 persons
- ◯ 1,001 - 1,500
- ◯ 1,501 - 2,000 persons
- ◯ More than 2,000 persons
- ◯ Don't know

6. **How would you rank the importance of the following CRITERIA for measuring the performance of this refinery?** *
Mark only one oval per row.

	Least Important	Less Important	Moderately Important	Highly Important	Extremely Important
Capacity Utilisation	◯	◯	◯	◯	◯
Cost of Operation	◯	◯	◯	◯	◯
Downtime in Operation	◯	◯	◯	◯	◯

7. **How would you rank the level of impact of the following factors on the performance of this refinery?** *
Examples of each of these factors are listed in the questions that follow.
Mark only one oval per row.

	Least Impact	Less Impact	Moderate Impact	High Impact	Highest Impact
Political Factors	◯	◯	◯	◯	◯
Economic Factors	◯	◯	◯	◯	◯
Social Factors	◯	◯	◯	◯	◯
Technical Factors	◯	◯	◯	◯	◯
Environmental Factors	◯	◯	◯	◯	◯
Legal Factors	◯	◯	◯	◯	◯

8. **How would you rank the impact of the following POLITICAL FACTORS on the performance of this refinery? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Government interference	◯	◯	◯	◯	◯
Funding issues	◯	◯	◯	◯	◯
Political indecision	◯	◯	◯	◯	◯
Government commitment	◯	◯	◯	◯	◯
Managerial appointments	◯	◯	◯	◯	◯

9. **How would you rank the impact of the following ECONOMIC FACTORS on the performance of this refinery? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Cost of spare parts	◯	◯	◯	◯	◯
Operating capital	◯	◯	◯	◯	◯
Exchange rates	◯	◯	◯	◯	◯
Subsidy issues	◯	◯	◯	◯	◯
Profit margins	◯	◯	◯	◯	◯

10. **How would you rank the impact of the following SOCIAL FACTORS on the performance of this refinery? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Theft/Attacks on pipelines	◯	◯	◯	◯	◯
Illegal refining	◯	◯	◯	◯	◯
Security issues	◯	◯	◯	◯	◯
Compensations	◯	◯	◯	◯	◯
Collusion and sabotage	◯	◯	◯	◯	◯
Grievances & community disputes	◯	◯	◯	◯	◯
Stakeholder involvements	◯	◯	◯	◯	◯

11. **How would you rank the impact of the following TECHNICAL FACTORS on the performance of this refinery ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Maintenance issues	◯	◯	◯	◯	◯
Ageing refinery plants	◯	◯	◯	◯	◯
Limited plant capacity	◯	◯	◯	◯	◯
Feedstock supply	◯	◯	◯	◯	◯
Staff training	◯	◯	◯	◯	◯
Staff competence	◯	◯	◯	◯	◯

12. **How would you rank the impact of the following ENVIRONMENTAL FACTORS on the performance of this refinery, including the workers? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Adverse climatic conditions (High heat, wind and rainfall)	◯	◯	◯	◯	◯
Pollution (air, land and water)	◯	◯	◯	◯	◯
Health and safety issues	◯	◯	◯	◯	◯
State of infrastructure (offices, gadgets, toilets, eateries, communal areas etc)	◯	◯	◯	◯	◯
Organisation culture	◯	◯	◯	◯	◯

13. **How would you rank the impact of the following LEGAL FACTORS on the performance of this refinery? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Uncertainties of Petroleum Industry Bill (PIB)	◯	◯	◯	◯	◯
Legal actions	◯	◯	◯	◯	◯
Regulatory penalties	◯	◯	◯	◯	◯
Regulatory procurement issues	◯	◯	◯	◯	◯
Regulatory limitations on emissions	◯	◯	◯	◯	◯

14. **Overall, how would you rank the impact of the following factors on CAPACITY UTILISATION of this refinery? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Political Factors	◯	◯	◯	◯	◯
Economic Factors	◯	◯	◯	◯	◯
Social Factors	◯	◯	◯	◯	◯
Technical Factors	◯	◯	◯	◯	◯
Environmental Factors	◯	◯	◯	◯	◯
Legal Factors	◯	◯	◯	◯	◯

15. **How would you rank the impact of the following factors on COST OF OPERATION of this refinery? ***
Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Political Factors	◯	◯	◯	◯	◯
Economic Factors	◯	◯	◯	◯	◯
Social Factors	◯	◯	◯	◯	◯
Technical Factors	◯	◯	◯	◯	◯
Environmental Factors	◯	◯	◯	◯	◯
Legal Factors	◯	◯	◯	◯	◯

16. **How would you rank the impact of the following factors on DOWNTIME experienced in this refinery?** *

Mark only one oval per row.

	Very Low	Low	Moderate	High	Very High
Political Factors	⬭	⬭	⬭	⬭	⬭
Economic Factors	⬭	⬭	⬭	⬭	⬭
Social Factors	⬭	⬭	⬭	⬭	⬭
Technical Fcators	⬭	⬭	⬭	⬭	⬭
Environmental Factors	⬭	⬭	⬭	⬭	⬭
Legal Factors	⬭	⬭	⬭	⬭	⬭

17. **To what extent do you AGREE or DISAGREE that the following measures have been effectively undertaken by the government or management to address the performance challenges of this refinery in the last 10 years?** *

Mark only one oval per row.

	Strongly Disagree	Slightly Disagree	Neither agree nor disagree	Slightly agree	Strongly agree
Regular minor maintenance	⬭	⬭	⬭	⬭	⬭
Major overhaul (turnaround) maintenance	⬭	⬭	⬭	⬭	⬭
Special training for the staff	⬭	⬭	⬭	⬭	⬭

18. **Are there other government efforts made towards addressing some of the challenges? If so, what are they?**

____

____

____

____

____

Thank you so much for your time.

Powered by
Google Forms

Appendix 6 Z – Factor for Sample Selection

Desired confidence level	z-score
80%	1.28
85%	1.44
90%	1.65
95%	1.96
99%	2.58

Appendix 7 Semi-Structured Interview Questions

1. How do the various political factors in the questionnaire [Govt interference, funding issues, political indecision, political will, managerial appointments] affect the performance of your refinery?

2. What about the economic factors [spare parts cost, subsidy issues, operating capital, exchange rates, profit margins]?

3. What about the social factors [pipeline attacks, illegal refining, security issues, compensations, pollution & sabotage, grievances, and community disputes]?

4. And the technical factors [maintenance issues, ageing facilities, design, feedstock supply, staff training and competence issues]?

5. From the questionnaire findings, it appeared that environmental [pollution, health & safety issues, penalties & fines] and legal [PIB, legal actions, regulatory procurement, and emissions] factors do not affect the performance of the refineries as much. Why is that?

Prompt Questions

1. What do you think can be done to limit government interference on the refineries?

2. How effective is the organization's training regarding technical competence of its staff?