ESCOLA DE DOUTORAMENTO
INTERNACIONAL DE LA USC

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PhD Thesis

The role of the Nigerian petroleum industry within the global value chains and the capabilities of its innovation system for upgrading

Santiago de Compostela, 2024

Doctoral Program in Economics & Business

ESCOLA DE DOUTORAMENTO
INTERNACIONAL DA USC

DOCTORAL THESIS

THE ROLE OF THE NIGERIAN PETROLEUM INDUSTRY WITHIN THE GLOBAL VALUE CHAINS AND THE CAPABILITIES OF ITS INNOVATION SYSTEM FOR UPGRADING

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DOCTORAL PROGRAM IN ECONOMICS & BUSINESS

SANTIAGO DE COMPOSTELA
2024

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List of Abbreviations

AFDB	African Development Bank
CBN	Central Bank of Nigeria
CIS	Community Innovation Survey
DPR	Department of Petroleum Resource
EU	European Union
FDI	Foreign Direct Investment
GCC	Global Commodity Chains
GIS	Global Innovation Index
GVCs	Global Value Chains
GPVCs	Global Petroleum Value Chains
GPN	Global product network
GDP	Gross Domestic Product
IS	Innovation Systems
IC	Innovation capabilities
ICT	Information Technology
IP	Innovation policies
IMF	International Monetary funds
IEA	International Energy Agency
MIP	Ministry of Petroleum
MNCs	Multinational Oil Companies
NACETEM	National Center for Technology Management
NBS	National Bureau of Statistics
NIS	National Innovation Systems
NNIS	Nigeria National Innovation Systems
NPI	National Petroleum Industry
NP	National Policy
OPEC	Organization of Petroleum Exporting Countries

R&D	Research &Development
STI	Science Technology and Innovation
UC	University Collaboration
UNIDO	United Nations International Development Organization
US	United States of America
WTO	World Trade Organization

AKNOWLEDGEMENTS

Completing this doctoral thesis felt like navigating a lengthy, challenging, and occasionally obscure journey, but it has finally been accomplished. My passion for research and the concerns I sought to address led to a life-altering change in direction, a shift I embraced with enthusiasm. This process was made possible through the grace of Almighty God. I am deeply grateful to the thesis journey for imparting invaluable life lessons, along with the cognitive knowledge I gained.

To begin, I would like to express my gratitude to Prof Oscar Rodil, the immediate past secretary of the Academic Doctorate Commission in the Doctorate program in Economics and Business for the unwavering support, knowledge and effort extended from the first day of my arrival. To Ines, sharing these years with you has been essential, and I am grateful for the wealth of knowledge I've gained through knowing you. Special thanks for your prompt assistance in accessing library resources from the Biblioteca Intercentros, USC-Lugo Campus. Also, I extend my heartfelt thanks to Dra Carmela Sanchez, my thesis tutor, for the dedicated work, effort and understanding she has provided. I have learnt immensely from her professionalism and poise. To my supervisor & thesis Director, Prof Manuel, words cannot adequately express my gratitude. I am deeply appreciative of the wealth of knowledge gained through your critical thinking, professionalism, human quality, flexibility, and affection despite busy schedules throughout the years.

On a personal note, numerous individuals have walked alongside me on this journey, each unknowingly contributing in various ways to this process. Navigating this complex path has underscored the significance of health breaks and the role of the people around. I appreciate all those who played this relevant role and if I inadvertently overlooked anyone, I extend my LO-SIENTOS in advance. Special mention and appreciation to Dr. Betty for her encouragement, comforting presence and companionship during challenging moments, always being a steadfast support; to Pepe, your understanding, organizational prowess, proactive advice and patient guidance have been instrumental in helping me gain perspectives; to Aniebiet, thank you for the joy of comedy and your uplifting spirit and to Elio, you've been a significant reference point in many aspects – our conversation in 2018, has enriched me personally and professionally. Additionally, a heartfelt thanks to Ahmed and Bose for helping me clear my head, sharing leisure time and always willing to listen and understand. Your collective contributions have made this journey more meaningful.

I extend my gratitude to Marco and Ana for the love and spirited support they have shown me throughout these years. Additionally, I would like to mention Alexandra, a friend, research collaborator and an exceptional worker. Being research mates with your kind guidance from my first day in this program has fueled my critical thinking and sharpened my focus. For the future, I wish you all the best.

To Dr. Affiong at the Liquefied Natural Gas Company (LNG) & Prof. Ugen (Shell Petroleum Development Company), a big thank you for your professional fit on energy &

innovation matters. My special thanks to Obas my husband and Graham my son for making the final stage of the thesis a smoother journey. Your understanding, help, and encouragement, despite my absence from home, have meant a great deal to me. I also extend my heartfelt gratitude to my godmother, Dr. Becky-Enenche, for consistently being there during delicate moments, offering a listening ear and unwavering support. You’ve been a key support and a companion during the darkest times, and much of who I am today is thanks to you. I admire my siblings for their unwavering support; I am particularly grateful to my parents for the right upbringing, values and love they provided from the cradle. Blessings to all of you and Glory to the Almighty God.

ABSTRACT

With globalization, firms have adapted their trade methods and interactions, supported by diverse knowledge in science and technologies. This study examines the role of the Nigerian Petroleum Industry (NPI) within the Global Value Chains (GVCs) and the capabilities of its innovation system for upgrading this industry. Oil is the mainstay of Nigeria's economy, yet despite being the largest producer and supplier of crude oil in Africa and one of the top 10 global exporters with approximately 38 billion barrels of proven oil reserves, Nigeria imports nearly all its refined petroleum. The country has four refineries with a combined capacity of 455,000 barrels, but declining refining capacity has led to high import values and insufficient local supply. Multinational corporations (MNCs) dominate Nigeria's oil industry, focusing on upstream activities within the country and downstream activities abroad, resulting in inadequate refining capabilities and challenges such as limited foreign exchange liquidity, environmental degradation, and technology transfer deficits. Additionally, socio-political issues like corruption and ethnic tension hinder sector development.

To explore how the National Innovation System (NIS) can facilitate innovation in the oil sector, the study utilized secondary data from the Global Innovation Index (GII) and primary data from a questionnaire based on Community Innovation Survey (CIS). The GII data revealed poor outcomes in institutions, human resources, R&D capacity, intellectual property, political environment, and education, with Nigeria's average ranking being 110th out of 140 countries from 2011 to 2020. The CIS results indicated structural weaknesses in the NIS, with limited R&D involvement by domestic firms and poor collaboration between oil companies and scientific institutions. The study recommends enhancing domestic refining activities, fostering partnerships between MNCs and national oil companies, and incrementally upgrading NPI through rehabilitating existing refineries and integrating new modular petroleum refining schemes. Structural reforms, including effective implementation of the Petroleum Industry Act (2021), adopting modern technology, and improving management practices, are essential. Encouraging cross-functional collaboration, effective communication, and investing in skill development within scientific and technological systems will further strengthen NIS, improve R&D capacity, and drive value addition for NPI in the GPVCs.

Keywords: Global Value Chains (GVCs), National Innovation Systems (NIS), National Petroleum Industry (NPI), Product fragmentation, Globalization, Nigeria's National Innovation Systems (NNIS), Research &Development (R&D), Global Petroleum Value Chains.

RESUMEN

Con la globalización, las empresas han adaptado sus métodos e interacciones comerciales, respaldados por diversos conocimientos en ciencia y tecnología. Este estudio examina el papel de la Industria Nacional del Petróleo (NPI) dentro de las Cadenas Globales de Valor del Petróleo (CGV) y las capacidades del sistema de innovación para mejorar esta industria. El petróleo es el pilar de la economía de Nigeria; Sin embargo, a pesar de ser el mayor productor y proveedor de petróleo crudo de África y uno de los 10 principales exportadores mundiales con aproximadamente 38 billones de barriles de reservas probadas de petróleo, Nigeria importa casi todo su petróleo refinado. El país tiene cuatro refinerías con una capacidad combinada de 455.000 barriles, pero la disminución de la capacidad de refinación ha provocado altos valores de importación y un suministro local insuficiente. Las corporaciones multinacionales (CMN) dominan la industria petrolera de Nigeria, centrándose en actividades upstream dentro del país y downstream en el extranjero, lo que resulta en capacidades de refinación inadecuadas y desafíos como liquidez limitada en divisas, degradación ambiental y déficits de transferencia de tecnología. Además, cuestiones sociopolíticas como la corrupción y las tensiones étnicas obstaculizan el desarrollo del sector.

Para explorar cómo el Sistema Nacional de Innovación (SNI) puede facilitar la innovación en el sector petrolero, el estudio utilizó datos secundarios del Índice Global de Innovación (GII) y datos primarios de un cuestionario basado en la encuesta de Innovación Comunitaria (CIS). Los datos del GII revelaron malos resultados en instituciones, recursos humanos, capacidad de I+D, propiedad intelectual, entorno político y educación, y la clasificación promedio de Nigeria ocupó el puesto 110 entre 140 países entre 2011 y 2020. Los resultados de la CEI indicaron debilidades estructurales en los NEI, con participación limitada en I+D por parte de las empresas nacionales y escasa colaboración entre las compañías petroleras y las instituciones científicas. El estudio recomienda mejorar las actividades de refinación nacionales, fomentar asociaciones entre multinacionales y compañías petroleras nacionales y mejorar gradualmente el NPI mediante la rehabilitación de refinerías existentes y la integración de nuevos esquemas modulares de refinación de petróleo. Las reformas estructurales, incluida la implementación efectiva de la Ley de la Industria Petrolera (2021), la adopción de tecnología moderna y la mejora de las prácticas de gestión, son esenciales. Fomentar la colaboración interfuncional, la comunicación efectiva y la inversión en el desarrollo de habilidades dentro de los sistemas científicos y tecnológicos fortalecerá aún más los NIS, mejorará la capacidad de I+D e impulsará la adición de valor para las NPI en los GPVC.

Palabras clave: Cadenas de valor globales (CGV), Sistemas nacionales de innovación (NIS), Industria nacional del petróleo (NPI), Fragmentación de productos, Globalización, Sistemas nacionales de innovación de Nigeria (NNIS), Investigación y desarrollo (I+D), Cadenas globales de valor del petróleo (GPVC).

RESUMO

Coa globalización, as empresas adaptaron os seus métodos e interaccións comerciais, apoiándose en coñecementos diversos en ciencia e tecnoloxía. Este estudo examina o papel da Industria Nacional do Petróleo (NPI) dentro das cadenas globales de valor do petróleo (CGV) e as capacidades do sistema de innovación para mellorar esta industria. O petróleo é o pilar da economía de Nixeria, aínda que a pesar de ser o maior produtor e provedor de cru de África e un dos 10 principais exportadores mundiais con aproximadamente 38 millóns de barrís de reservas probadas de petróleo, Nixeria importa case todo o seu petróleo refinado. O país conta con catro refinerías cunha capacidade combinada de 455.000 barrís, pero a diminución da capacidade de refino provocou altos valores de importación e abastecemento local insuficiente. As corporacións multinacionais (MNC) dominan a industria petroleira de Nixeria, centrándose nas actividades ascendentes dentro do país e nas actividades posteriores no estranxeiro, o que orixina capacidades de refino inadecuadas e desafíos como a liquidez de divisas limitada, a degradación ambiental e os déficits de transferencia de tecnoloxía. Ademais, problemas sociopolíticos como a corrupción e a tensión étnica dificultan o desenvolvemento do sector.

Para explorar como o Sistema Nacional de Innovación (SNI) pode facilitar a innovación no sector petroleiro, o estudo utilizou datos secundarios do Índice de Innovación Global (GII) e datos primarios dun cuestionario baseado na Enquisa de Innovación Comunitaria (CIS). Os datos do GII revelaron malos resultados en institucións, recursos humanos, capacidade de I+D, propiedade intelectual, ambiente político e educación, sendo a clasificación media de Nixeria no posto 110 de 140 países entre 2011 e 2020. Os resultados do CIS indicaron debilidades estruturais no NIS, con participación limitada en I+D das empresas nacionais e escasa colaboración entre compañías petroleiras e institucións científicas. O estudo recomenda mellorar as actividades de refino nacionais, fomentar asociacións entre as multinacionais e petroleiras nacionais e mellorar progresivamente o NPI mediante a rehabilitación das refinerías existentes e a integración de novos esquemas modulares de refino de petróleo. As reformas estruturais, incluíndo a aplicación efectiva da Lei de Industria do Petróleo (2021), a adopción de tecnoloxía moderna e a mellora das prácticas de xestión, son esenciais. Fomentar a colaboración interfuncional, a comunicación eficaz e o investimento no desenvolvemento de habilidades dentro dos sistemas científicos e tecnolóxicos fortalecerán aínda máis os NIS, mellorarán a capacidade de I+D e impulsarán a adición de valor ao NPI nos GPVC.

Palabras clave: cadeas de valor globais (CVM), sistemas nacionais de innovación (NIS), industria nacional do petróleo (NPI), fragmentación de produtos, globalización, sistemas nacionais de innovación de Nixeria (NNIS), investigación e desenvolvemento (I+D), cadeas de valor do petróleo globais (GPVC).

EXTENDED ABSTRACT

This study explores the role of the Nigerian petroleum industry within Global Value Chains (GVCs) and evaluates the capabilities of its National Innovation System (NIS) for upgrading the sector. It provides a comprehensive analysis of the Nigerian oil industry's processes within the frameworks of GVCs and NIS, delving into theoretical and empirical facets crucial for understanding and enhancing the performance of Nigeria's oil sector. Discovered in the 1950s, petroleum has significantly influenced Nigeria's economy, becoming a major source of revenue and foreign exchange. Over the decades, oil has been the backbone of Nigeria's economic structure, contributing substantially to the nation's GDP and government revenues. Despite this, Nigeria faces significant challenges within its oil sector. The country has established four refineries to process crude oil, yet these refineries currently operate at a mere 20% of their capacity. This inefficiency leads to the paradox of Nigeria being a net exporter of crude oil while importing a large proportion of its refined petroleum products. This reliance on imported refined oil not only represents a substantial economic inefficiency but also highlights gaps in the national policy and infrastructure. This research aims to examine this paradox in depth, providing insights into the achievements and ongoing challenges of the Nigerian oil industry. Furthermore, it offers recommendations for leveraging GVCs and NIS to enhance the performance of Nigeria’s oil sector and promote sustainable economic development.

The introduction outlines the research objectives, significance, and methodology. It begins by exploring Global Value Chains (GVCs), explaining their concepts, mappings, governance structures, and upgrading processes. The aim is to understand how Nigeria's petroleum industry fits into and can benefit from GVCs. Following this, the concept of the National Innovation System (NIS) is discussed, focusing on its role in fostering innovation and economic growth within the oil sector. The study then examines the integration of GVC and NIS approaches, highlighting the potential synergies and contributions to the Nigerian oil industry. The core objectives of this study are to examine why the country imports refined fuel despite being a net exporter of crude oil, analyze the integration of Nigeria’s petroleum sector within global markets, assess the NIS's support for the sector, and identify pathways for economic upgrading through improved innovation capabilities and strategic participation in GVCs.

The literature review on GVCs provides a comprehensive overview of their development, relevance, and application in the oil industry. It traces the historical evolution of GVCs and their impact on global trade and production networks. The review integrates key concepts and frameworks, such as value chain mapping and governance structures, to set a foundation for analyzing the global positioning of Nigeria’s oil sector. Understanding GVCs is crucial for grasping the intricacies of global market dynamics and their impact on national industries. The review highlights the importance of GVCs in driving competitiveness and

economic growth, emphasizing their relevance to Nigeria's oil industry. GVCs offer significant benefits to developing countries by providing access to international markets, fostering technological transfer, and encouraging investment and employment opportunities. These value chains can help developing nations like Nigeria integrate into the global economy, enhancing productivity and innovation.

However, the study also underscores the challenges faced by developing countries in fully capitalizing on GVCs, including dependency on primary products, limited value-added activities, and vulnerability to global market fluctuations. A case study within the review indicates that while developing countries participate in GVCs, they often remain confined to the lower end of the value chain, focusing on primary product extraction and exportation. This situation results in a disproportionate share of the gains accruing to more developed countries, which dominate the higher value-added segments of the chains. The gaps identified in GVC participation expose the necessity to extend the analysis to innovation theory, introducing the concept of the National Innovation System (NIS) as a framework for enhancing the oil sector and its global competitiveness.

In exploring the concept of innovation systems, the study delves into the challenges of defining and implementing NIS within Nigeria's unique socio-economic context. Various interpretations of innovation systems, including national, regional, and sectoral systems, are examined for their relevance to economic policies. The study highlights the fluidity in the interpretation of innovation systems and the need for a clear, consensus-driven understanding to effectively harness their potential.

The analysis underscores the role of NIS in fostering innovation, knowledge creation, and technological advancement, which are essential for upgrading Nigeria's oil sector. The concept of National Innovation Systems (NIS) is crucial for understanding the broader context within which Nigeria's oil industry operates. This study delves into the various types of NIS, distinguishing between narrow and broad interpretations. The narrow NIS focuses on institutions and policies directly related to innovation activities, such as research and development institutions, universities, and technology policies. In contrast, the broad NIS encompasses a wider array of elements that influence innovation, including social, cultural, and economic factors, along with educational systems, labor markets, and financial institutions.

In the context of developing countries, NIS takes on additional complexity. Developing countries often face unique challenges in establishing and maintaining effective NIS. These challenges include limited financial resources, inadequate infrastructure, and insufficient human capital. Moreover, developing countries may lack the institutional frameworks and governance structures necessary to support robust innovation systems. The difficulties in defining NIS within these contexts stem from the need to tailor the concept to fit diverse socio-economic realities and development stages. For instance, while developed countries might focus on advanced technological innovations, developing countries might prioritize incremental innovations and adaptations of existing technologies.

Implementing NIS within Nigeria's unique socio-economic context presents specific challenges. Nigeria's socio-economic landscape is characterized by significant disparities in wealth, education, and infrastructure between urban and rural areas. Additionally, political instability, corruption, and bureaucratic inefficiencies further complicate the establishment of a cohesive NIS. The country's educational and research institutions often suffer from underfunding and lack of resources, limiting their ability to contribute effectively to innovation. Furthermore, there is frequently a disconnect between academic research and industry needs, leading to a misalignment of priorities and a gap in practical applications of research findings.

These challenges highlight the necessity of combining GVC and NIS frameworks to address the shortcomings in not only Nigeria's innovation capacity but globally**.** By integrating the insights from GVC analysis with the principles of NIS, the study aims to provide a more comprehensive approach to enhancing trade competitiveness. The combination of these frameworks helps to identify strategic interventions that leverage developing countries' participation in global value chains while simultaneously strengthening their national innovation capabilities. This integrated approach is to facilitate the development of a more resilient and dynamic oil industry that is better positioned to contribute to the Nigeria's economic growth and development.

Two central research questions guide the study:

(1) "Why Nigeria, which is a net exporter of crude oil, is also a net importer of refined oil?"

(2) "To what extent can the Nigeria's NIS be used to upgrade the National Petroleum Industry in the Global Petroleum Value Chains?"

These questions are crucial in addressing the dichotomy between Nigeria's crude oil exports and its dependence on imported refined petroleum products.

The research methodology adopts a mixed-method approach, combining qualitative and quantitative methods to offer a comprehensive analysis of the Nigerian oil industry. This approach facilitates a holistic understanding of the complex dynamics within the industry, allowing for both numerical comparisons and deeper insights into motivations, perceptions, and contextual factors. The primary data collection is conducted using a questionnaire based on the Community Innovation Survey (CIS), chosen for its relevance in capturing innovation activities and capabilities within firms operating in the oil sector. CIS provides a standardized framework for data collection, ensuring consistency and comparability across respondents. By administering the CIS questionnaire to key stakeholders in the oil sector, including government agencies and oil companies, the research aims to capture diverse perspectives and insights from those directly involved in shaping industry processes.

The selection of oil companies as a primary population for data collection is strategic. Oil companies are significant players in the Nigerian oil industry, influencing production, investment, and innovation trends. Moreover, they possess valuable expertise and firsthand insights into industry challenges, opportunities, and innovation practices. By targeting oil companies, the research ensures representation from various segments of the industry, including exploration, production, refining, and distribution especially those with commitments in host communities.

The secondary data sources, including the Global Innovation Index, OPEC data, Trade in Value-Added (TIVA) data, and information on Nigeria's National Innovation System (NIS), were also utilized to provide additional insights into the industry's performance and global positioning. TIVA data offers valuable insights into the role of global value chains in shaping the Nigerian oil sector's competitiveness and innovation performance.

The research findings on the first research question underscore the dominance of multinational corporations (MNCs) in Nigeria's oil industry, with significant influence over production, investment, and refining activities. However, a noteworthy observation is that these MNCs often possess refining capacities in more developed countries rather than within Nigeria itself. This phenomenon highlights the country's reliance on foreign-owned entities for downstream refining processes, despite its status as a major oil producer.

When considering the implications of this trend, several pros and cons emerge. On the positive side, partnering with MNCs with refining capacities in developed countries offers access to advanced refining technologies and expertise that may not be readily available domestically. This can enhance efficiency, product quality, and safety standards within the refining process. Additionally, leveraging the refining capacities of MNCs allows Nigerian oil products to access global markets more easily, diversifying revenue streams and mitigating risks associated with fluctuations in local demand or regulatory changes. Furthermore, collaborating with established MNCs spreads the risks associated with refining operations, including capital investment, regulatory compliance, and market volatility. MNCs may have greater financial resources and risk management capabilities to navigate these challenges effectively.

However, there are significant drawbacks to this reliance on MNCs for refining activities. Outsourcing refining activities limits the extent of value addition and economic benefits that Nigeria can derive from its oil resources. The lack of domestic refining capacity perpetuates the country's dependence on imported refined products, undermining efforts to achieve self-sufficiency and industrial development. Additionally, relying on MNCs for refining exposes Nigeria to vulnerabilities associated with geopolitical tensions, trade disputes, and supply chain disruptions in the countries hosting these facilities. Any disruptions in refining operations abroad could have significant ramifications for Nigeria's energy security and economy. Moreover, the absence of significant refining capacities within Nigeria hampers the transfer of advanced refining technologies and skills to the domestic workforce, perpetuating a cycle of technological dependency and inhibiting the development of local expertise and innovation in the oil sector.

Additionally, findings from the CIS and secondary data sources shed light on Nigeria's status as a net importer of refined fuel despite being a major oil exporter. The analysis highlights factors such as infrastructure constraints, inadequate domestic refining capacity, and policy bottlenecks that contribute to this paradoxical situation. Additionally, the research employs Trade in Value-Added (TiVA) analysis to examine the interconnectedness of global value chains (GVCs) and the Nigerian oil industry, providing insights into value distribution, competitiveness, and opportunities for domestic value addition. TiVA analysis traces the flow of value-added across different countries and industries, offering a comprehensive perspective on the sector’s position within GVCs.

The findings from TiVA analysis reveal key aspects of Nigeria's oil sector. Firstly, the analysis highlights significant backward linkages, with a heavy reliance on imported inputs for production and refining activities. This dependence underscores challenges related to domestic technological capabilities, value retention, and industrial development. Secondly, TiVA analysis sheds light on the distribution of value-added along the oil value chain, identifying opportunities to enhance downstream refining capabilities and capture more value domestically. Moreover, the analysis examines the role of multinational corporations (MNCs) and their affiliates in the sector, tracing how value-added flows through MNCs' global operations. This perspective reveals both opportunities for technology transfer and challenges related to limited local value addition.

Overall, while partnering with MNCs for refining activities offers advantages such as access to advanced technology and global market integration, it also presents challenges, including vulnerability to external factors, barriers to technology transfer, and constraints on innovation. Addressing these challenges requires strategic interventions aimed at promoting domestic refining capacity, fostering technology transfer, and enhancing the competitiveness of Nigeria's oil industry. By integrating insights from TiVA analysis with mixed-method approaches, this research provides a nuanced understanding of the complexities shaping Nigeria's fuel import dependence and offers strategic recommendations for increasing local content, industrial development, and value retention.

Considering the second research question about the capabilities of Nigeria's National Innovation System (NIS) to support the oil industry for upgrading a multifaceted analysis is essential. The NIS encompasses various institutions, policies, and mechanisms that facilitate innovation and technological development within a country. Assessing its capacity to support the oil industry for upgrading involves evaluating the institutional framework, policy initiatives, research and development infrastructure, and collaboration mechanisms with industry stakeholders. Nigeria's NIS holds promise but also faces challenges in effectively supporting the oil industry's technological advancement and innovation.

On one hand, Nigeria has made strides in establishing institutions and policies to foster innovation and technology transfer. Initiatives such as the National Agency for Science and Engineering Infrastructure (NASENI) and the Nigerian Content Development and Monitoring Board (NCDMB) aim to promote local content participation and technological advancement in strategic sectors like oil and gas. Additionally, efforts to strengthen research and development infrastructure through partnerships with universities, research institutes, and industry players demonstrate a commitment to enhancing indigenous technological capabilities. However, significant gaps remain, including limited funding for research and development, inadequate infrastructure, and fragmented coordination among stakeholders. Addressing these challenges requires concerted efforts to bolster the NIS's capacity, foster collaboration between academia and industry, and incentivize innovation within the oil sector to support upgrading and competitiveness in the global market.

In addition, the study integrates the Global Innovation Index (GII) analysis to provide a comprehensive understanding of innovation dynamics and competitiveness within the Nigerian oil industry. The GII analysis offers insights into the country's innovation ecosystem, technological capabilities, and global positioning, complementing primary data collected through the Community Innovation Survey (CIS) and secondary data sources such as Trade in Value-Added (TiVA) analysis and OPEC data. By synthesizing findings from diverse sources, this research aims to inform strategic interventions for enhancing competitiveness, sustainability, and innovation in the Nigerian oil sector.

The study's examination of the Global Innovation Index reveals that Nigeria's innovation performance lags other oil-producing countries. The index scores indicate deficiencies in key areas such as research and development (R&D) investment, technological infrastructure, and human capital development. These weaknesses constrain the sector's ability to innovate and upgrade within GVCs. The analysis suggests that enhancing Nigeria's NIS through increased R&D funding, capacity building, and improved institutional support is critical for driving innovation and economic growth in the oil sector. The analysis of findings further reveals several key insights into Nigeria's innovation terrain and its implications for the oil industry. Firstly, the analysis assesses Nigeria's performance in key innovation indicators such as institutions, human capital, research and development, infrastructure, market sophistication, and business sophistication. This assessment highlights areas of strength, such as market size and business sophistication, as well as areas requiring improvement, such as institutional quality and research and development investment. Secondly, the GII analysis benchmarks Nigeria's innovation performance against regional and global peers, providing valuable comparative insights into the country's innovation competitiveness and identifying strategic priorities for policy interventions.

Furthermore, the study emphasizes the importance of institutional diversification and integrating new entrants into the federal government's modular petroleum refining scheme. This approach can promote competition, innovation, and investment within the oil sector, contributing to its overall growth and development. By addressing the structural and operational challenges within the industry, Nigeria can better leverage its oil resources for sustainable economic development.

In conclusion, this study highlights the critical role of Nigeria’s petroleum industry within Global Value Chains (GVCs) and evaluates the capabilities of its National Innovation System (NIS) for upgrading the sector. Generally, the findings underscore the importance of enhancing local content, improving innovation capabilities, and fostering strategic partnerships to drive economic growth. The research contributes to the understanding of the dynamics influencing Nigeria’s oil sector and provides actionable recommendations for leveraging GVCs and NIS to enhance performance and achieve sustainable development. By addressing the identified challenges and opportunities, Nigeria can strengthen its position within the global oil market and realize its full economic potential.

Keywords: Global Value Chains, National Innovation System, Nigerian Petroleum Industry, Oil Sector Upgrading, Innovation Capabilities, Community Innovation Survey,

Global Innovation Index, Economic Development, Multinational Corporations, Refining Capacity, Local Content, Technology Transfer, Policy Recommendation.

RESUMEN EXTENDIDO

Este estudio explora el papel de la industria petrolera de Nigeria dentro de las cadenas de valor globales (CGV) y evalúa las capacidades de su Sistema Nacional de Innovación (NIS) para mejorar el sector. Proporciona un análisis integral de los procesos de la industria petrolera nigeriana dentro de los marcos de las CGV y los NEI, profundizando en facetas teóricas y empíricas cruciales para comprender y mejorar el desempeño del sector petrolero de Nigeria. Descubierto en la década de 1950, el petróleo ha influido significativamente en la economía de Nigeria, convirtiéndose en una importante fuente de ingresos y divisas. A lo largo de décadas, el petróleo ha sido la columna vertebral de la estructura económica de Nigeria y ha contribuido sustancialmente al PIB y a los ingresos gubernamentales del país. A pesar de esto, Nigeria enfrenta importantes desafíos dentro de su sector petrolero. El país ha establecido cuatro refinerías para procesar petróleo crudo, pero estas refinerías actualmente operan a apenas el 20% de su capacidad. Esta ineficiencia lleva a la paradoja de que Nigeria sea un exportador neto de petróleo crudo e importe una gran proporción de sus productos petrolíferos refinados. Esta dependencia del petróleo refinado importado no sólo representa una ineficiencia económica sustancial sino que también pone de relieve lagunas en la política y la infraestructura nacionales. Esta investigación tiene como objetivo examinar esta paradoja en profundidad, proporcionando información sobre los logros y los desafíos actuales de la industria petrolera nigeriana. Además, ofrece recomendaciones para aprovechar las cadenas de valor mundiales y los NEI para mejorar el desempeño del sector petrolero de Nigeria y promover el desarrollo económico sostenible.

La introducción describe los objetivos, la importancia y la metodología de la investigación. Comienza explorando las Cadenas de Valor Globales (CGV), explicando sus conceptos, mapeos, estructuras de gobernanza y procesos de actualización. El objetivo es comprender cómo la industria petrolera de Nigeria encaja en las cadenas de valor mundiales y cómo puede beneficiarse de ellas. A continuación, se analiza el concepto de Sistema Nacional de Innovación (SNI), centrándose en su papel en el fomento de la innovación y el crecimiento económico dentro del sector petrolero. Luego, el estudio examina la integración de los enfoques de CGV y NEI, destacando las posibles sinergias y contribuciones a la industria petrolera de Nigeria. Los objetivos principales de este estudio son examinar por qué el país importa combustible refinado a pesar de ser un exportador neto de petróleo crudo, analizar la integración del sector petrolero de Nigeria en los mercados globales, evaluar el apoyo de los NEI al sector e identificar vías para la mejora económica a través de mejores capacidades de innovación y participación estratégica en las cadenas de valor mundiales.

La revisión de la literatura sobre las CGV proporciona una visión integral de su desarrollo, relevancia y aplicación en la industria petrolera. Se rastrea la evolución histórica de las CGV y su impacto en el comercio global y las redes de producción. La revisión integra conceptos y marcos clave, como el mapeo de la cadena de valor y las estructuras de gobernanza, para sentar las bases para analizar el posicionamiento global del sector petrolero de Nigeria. Comprender las cadenas de valor mundiales es crucial para comprender las complejidades de la dinámica del mercado global y su impacto en las industrias nacionales. El estudio destaca la importancia de las cadenas de valor mundiales para impulsar la competitividad y el crecimiento económico, destacando su importancia para la industria petrolera de Nigeria. Las cadenas de valor mundiales ofrecen importantes beneficios a los países en desarrollo al proporcionar acceso a los mercados internacionales, fomentar la transferencia tecnológica y fomentar la inversión y las oportunidades de empleo. Estas cadenas de valor pueden ayudar a países en desarrollo como Nigeria a integrarse en la economía global, mejorando la productividad y la innovación.

Sin embargo, el estudio también subraya los desafíos que enfrentan los países en desarrollo para capitalizar plenamente las cadenas de valor mundiales, incluida la dependencia de los productos primarios, las actividades de valor agregado limitado y la vulnerabilidad a las fluctuaciones del mercado global. Un estudio de caso incluido en el estudio indica que, si bien los países en desarrollo participan en las CGV, a menudo permanecen confinados al extremo inferior de la cadena de valor, centrándose en la extracción y exportación de productos primarios. Esta situación resulta en que una parte desproporcionada de las ganancias recaiga en los países más desarrollados, que dominan los segmentos de mayor valor agregado de las cadenas. Las brechas identificadas en la participación en las CGV exponen la necesidad de extender el análisis a la teoría de la innovación, introduciendo el concepto de Sistema Nacional de Innovación (SNI) como marco para mejorar el sector petrolero y su competitividad global.

Al explorar el concepto de sistemas de innovación, el estudio profundiza en los desafíos de definir e implementar NIS dentro del contexto socioeconómico único de Nigeria. Se examinan varias interpretaciones de los sistemas de innovación, incluidos los sistemas nacionales, regionales y sectoriales, para determinar su relevancia para las políticas económicas. El estudio destaca la fluidez en la interpretación de los sistemas de innovación y la necesidad de una comprensión clara y basada en el consenso para aprovechar eficazmente su potencial.

El análisis subraya el papel de los NEI en el fomento de la innovación, la creación de conocimientos y el avance tecnológico, que son esenciales para mejorar el sector petrolero de Nigeria. El concepto de Sistemas Nacionales de Innovación (NIS) es crucial para comprender el contexto más amplio dentro del cual opera la industria petrolera de Nigeria. Este estudio profundiza en los distintos tipos de NIS, distinguiendo entre interpretaciones estrechas y amplias. El NIS estrecho se centra en instituciones y políticas directamente relacionadas con actividades de innovación, como instituciones de investigación y desarrollo, universidades y políticas tecnológicas. Por el contrario, el SNI amplio abarca una gama más amplia de elementos que influyen en la innovación, incluidos factores sociales, culturales y económicos, junto con los sistemas educativos, los mercados laborales y las instituciones financieras.

En el contexto de los países en desarrollo, los NEI adquieren una complejidad adicional. Los países en desarrollo a menudo enfrentan desafíos únicos a la hora de establecer y mantener SNI eficaces. Estos desafíos incluyen recursos financieros limitados, infraestructura inadecuada y capital humano insuficiente. Además, los países en desarrollo pueden carecer de los marcos institucionales y las estructuras de gobernanza necesarios para respaldar sistemas de innovación sólidos. Las dificultades para definir los NEI en estos contextos surgen de la necesidad de adaptar el concepto a diversas realidades socioeconómicas y etapas de desarrollo. Por ejemplo, mientras los países desarrollados podrían centrarse en innovaciones tecnológicas avanzadas, los países en desarrollo podrían priorizar innovaciones incrementales y adaptaciones de tecnologías existentes.

La implementación de NIS dentro del contexto socioeconómico único de Nigeria presenta desafíos específicos. El panorama socioeconómico de Nigeria se caracteriza por importantes disparidades en riqueza, educación e infraestructura entre las zonas urbanas y rurales. Además, la inestabilidad política, la corrupción y las ineficiencias burocráticas complican aún más el establecimiento de un SNI cohesivo. Las instituciones educativas y de investigación del país a menudo sufren de falta de financiación y recursos, lo que limita su capacidad para contribuir eficazmente a la innovación. Además, con frecuencia existe una desconexión entre la investigación académica y las necesidades de la industria, lo que lleva a una desalineación de prioridades y una brecha en las aplicaciones prácticas de los resultados de la investigación.

Estos desafíos resaltan la necesidad de combinar los marcos de CGV y SNI para abordar las deficiencias no solo en la capacidad de innovación de Nigeria sino a nivel mundial. Al integrar los conocimientos del análisis de las cadenas de valor mundiales con los principios de los NIS, el estudio pretende proporcionar un enfoque más integral para mejorar la competitividad comercial. La combinación de estos marcos ayuda a identificar intervenciones estratégicas que aprovechen la participación de los países en desarrollo en las cadenas de valor globales y al mismo tiempo fortalezcan sus capacidades nacionales de innovación. Este enfoque integrado tiene como objetivo facilitar el desarrollo de una industria petrolera más resiliente y dinámica que esté mejor posicionada para contribuir al crecimiento económico y el desarrollo de Nigeria.

Dos preguntas de investigación centrales guían el estudio:

(1) "¿Por qué Nigeria, que es un exportador neto de petróleo crudo, es también un importador neto de petróleo refinado?"

(2) "¿Hasta qué punto se puede utilizar el SNI de Nigeria para mejorar la industria petrolera nacional en las cadenas mundiales de valor del petróleo?"

Estas preguntas son cruciales para abordar la dicotomía entre las exportaciones de petróleo crudo de Nigeria y su dependencia de los productos petrolíferos refinados importados.

La metodología de investigación adopta un enfoque de métodos mixtos, combinando métodos cualitativos y cuantitativos para ofrecer un análisis completo de la industria petrolera de Nigeria. Este enfoque facilita una comprensión holística de la compleja dinámica dentro de la industria, permitiendo tanto comparaciones numéricas como conocimientos más profundos sobre las motivaciones, percepciones y factores contextuales.

La recopilación de datos primarios se realiza mediante un cuestionario basado en la Encuesta de Innovación Comunitaria (CIS), elegida por su relevancia para capturar actividades y capacidades de innovación dentro de las empresas que operan en el sector petrolero. CIS proporciona un marco estandarizado para la recopilación de datos, garantizando coherencia y comparabilidad entre los encuestados. Al administrar el cuestionario CIS a partes interesadas clave en el sector petrolero, incluidas agencias gubernamentales y compañías petroleras, la investigación tiene como objetivo capturar diversas perspectivas y conocimientos de aquellos directamente involucrados en la configuración de los procesos industriales.

La selección de compañías petroleras como población primaria para la recopilación de datos es estratégica. Las compañías petroleras son actores importantes en la industria petrolera nigeriana e influyen en las tendencias de producción, inversión e innovación. Además, poseen experiencia valiosa y conocimientos de primera mano sobre los desafíos, oportunidades y prácticas de innovación de la industria. Al centrarse en las compañías petroleras, la investigación garantiza la representación de varios segmentos de la industria, incluida la exploración, la producción, la refinación y la distribución, especialmente aquellos con compromisos en las comunidades anfitrionas.

Las fuentes de datos secundarios, incluido el Índice de Innovación Global, los datos de la OPEP, los datos del Comercio de Valor Agregado (TIVA) y la información sobre el Sistema Nacional de Innovación (NIS) de Nigeria, también se utilizaron para proporcionar información adicional sobre el desempeño y el posicionamiento global de la industria. Los datos de TIVA ofrecen información valiosa sobre el papel de las cadenas de valor globales en la configuración de la competitividad y el desempeño de la innovación del sector petrolero nigeriano.

Los resultados de la investigación sobre la primera pregunta de investigación subrayan el predominio de las corporaciones multinacionales (CMN) en la industria petrolera de Nigeria, con una influencia significativa sobre la producción, la inversión y las actividades de refinación. Sin embargo, una observación digna de mención es que estas multinacionales a menudo poseen capacidades de refinación en países más desarrollados y no dentro de la propia Nigeria. Este fenómeno pone de relieve la dependencia del país de entidades de propiedad extranjera para los procesos de refinación posteriores, a pesar de su condición de importante productor de petróleo. Al considerar las implicaciones de esta tendencia, surgen varios pros y contras. En el lado positivo, asociarse con multinacionales con capacidades de refinación en países desarrollados ofrece acceso a tecnologías de refinación avanzadas y experiencia que pueden no estar fácilmente disponibles a nivel nacional. Esto puede mejorar la eficiencia, la calidad del producto y los estándares de seguridad dentro del proceso de refinación. Además, aprovechar las capacidades de refinación de las empresas multinacionales permite que los productos petroleros nigerianos accedan más fácilmente a los mercados globales, diversificando los flujos de ingresos y mitigando los riesgos asociados con las fluctuaciones en la demanda local o los cambios regulatorios. Además, la colaboración con multinacionales establecidas distribuye los riesgos asociados con las operaciones de refinación, incluida la inversión de capital, el cumplimiento normativo y la volatilidad del mercado. Las empresas multinacionales pueden tener mayores recursos financieros y capacidades de gestión de riesgos para afrontar estos desafíos de manera efectiva.

Sin embargo, esta dependencia de las empresas multinacionales para las actividades de refinación tiene importantes inconvenientes. La subcontratación de las actividades de refinación limita el grado de valor agregado y los beneficios económicos que Nigeria puede obtener de sus recursos petroleros. La falta de capacidad de refinación interna perpetúa la dependencia del país de productos refinados importados, socavando los esfuerzos por lograr la autosuficiencia y el desarrollo industrial. Además, depender de las multinacionales para la refinación expone a Nigeria a vulnerabilidades asociadas con tensiones geopolíticas, disputas comerciales e interrupciones en la cadena de suministro en los países que albergan estas instalaciones. Cualquier interrupción en las operaciones de refinación en el extranjero podría tener ramificaciones significativas para la seguridad energética y la economía de Nigeria. Además, la ausencia de capacidades de refinación significativas en Nigeria obstaculiza la transferencia de tecnologías y habilidades avanzadas de refinación a la fuerza laboral nacional, lo que perpetúa un ciclo de dependencia tecnológica e inhibe el desarrollo de experiencia e innovación locales en el sector petrolero.

Además, los resultados de la CEI y de fuentes de datos secundarios arrojan luz sobre la situación de Nigeria como importador neto de combustible refinado a pesar de ser un importante exportador de petróleo. El análisis destaca factores como las limitaciones de infraestructura, la capacidad inadecuada de refinación interna y los obstáculos políticos que contribuyen a esta situación paradójica. Además, la investigación emplea el análisis del Comercio de Valor Agregado (TiVA) para examinar la interconexión de las cadenas de valor globales (CGV) y la industria petrolera nigeriana, brindando información sobre la distribución del valor, la competitividad y las oportunidades para la adición de valor nacional. El análisis de TiVA rastrea el flujo de valor agregado entre diferentes países e industrias, ofreciendo una perspectiva integral sobre la posición del sector dentro de las CGV.

Los hallazgos del análisis TiVA revelan aspectos clave del sector petrolero de Nigeria. En primer lugar, el análisis destaca importantes vínculos hacia atrás, con una fuerte dependencia de insumos importados para las actividades de producción y refinación. Esta dependencia subraya los desafíos relacionados con las capacidades tecnológicas nacionales, la retención de valor y el desarrollo industrial. En segundo lugar, el análisis TiVA arroja luz sobre la distribución del valor agregado a lo largo de la cadena de valor del petróleo, identificando oportunidades para mejorar las capacidades de refinación y capturar más valor a nivel nacional. Además, el análisis examina el papel de las corporaciones multinacionales (CMN) y sus filiales en el sector, rastreando cómo el valor agregado fluye a través de las operaciones globales de las CMN. Esta perspectiva revela tanto oportunidades para la transferencia de tecnología como desafíos relacionados con la limitada adición de valor local.

En general, si bien asociarse con multinacionales para actividades de refinación ofrece ventajas como el acceso a tecnología avanzada y la integración del mercado global, también presenta desafíos, incluida la vulnerabilidad a factores externos, barreras a la transferencia de tecnología y limitaciones a la innovación. Para abordar estos desafíos se requieren intervenciones estratégicas destinadas a promover la capacidad de refinación nacional, fomentar la transferencia de tecnología y mejorar la competitividad de la industria petrolera de Nigeria. Al integrar los conocimientos del análisis TiVA con enfoques de métodos mixtos, esta investigación proporciona una comprensión matizada de las complejidades que configuran la dependencia de las importaciones de combustible de Nigeria y ofrece recomendaciones estratégicas para aumentar el contenido local, el desarrollo industrial y la retención de valor.

Es esencial considerar la segunda pregunta de investigación sobre las capacidades del Sistema Nacional de Innovación (NIS) de Nigeria para apoyar a la industria petrolera en la mejora de un análisis multifacético. El NIS abarca varias instituciones, políticas y mecanismos que facilitan la innovación y el desarrollo tecnológico dentro de un país. Evaluar su capacidad para apoyar la modernización de la industria petrolera implica evaluar el marco institucional, las iniciativas políticas, la infraestructura de investigación y desarrollo y los mecanismos de colaboración con las partes interesadas de la industria. El NIS de Nigeria es prometedor, pero también enfrenta desafíos para apoyar eficazmente el avance tecnológico y la innovación de la industria petrolera.

Por un lado, Nigeria ha logrado avances en el establecimiento de instituciones y políticas para fomentar la innovación y la transferencia de tecnología. Iniciativas como la Agencia Nacional para la Infraestructura de Ciencia e Ingeniería (NASENI) y la Junta de Monitoreo y Desarrollo de Contenidos de Nigeria (NCDMB) tienen como objetivo promover la participación en el contenido local y el avance tecnológico en sectores estratégicos como el petróleo y el gas. Además, los esfuerzos para fortalecer la infraestructura de investigación y desarrollo a través de asociaciones con universidades, institutos de investigación y actores de la industria demuestran un compromiso para mejorar las capacidades tecnológicas locales. Sin embargo, persisten lagunas importantes, incluida una financiación limitada para la investigación y el desarrollo, una infraestructura inadecuada y una coordinación fragmentada entre las partes interesadas. Abordar estos desafíos requiere esfuerzos concertados para reforzar la capacidad de los NEI, fomentar la colaboración entre la academia y la industria e incentivar la innovación dentro del sector petrolero para apoyar la mejora y la competitividad en el mercado global.

Además, el estudio integra el análisis del Índice de Innovación Global (GII) para proporcionar una comprensión integral de la dinámica de la innovación y la competitividad dentro de la industria petrolera de Nigeria. El análisis del GII ofrece información sobre el ecosistema de innovación, las capacidades tecnológicas y el posicionamiento global del país, complementando los datos primarios recopilados a través de la Encuesta de Innovación Comunitaria (CIS) y fuentes de datos secundarios como el análisis del Comercio de Valor Agregado (TiVA) y los datos de la OPEP. Al sintetizar los hallazgos de diversas fuentes, esta investigación tiene como objetivo informar intervenciones estratégicas para mejorar la competitividad, la sostenibilidad y la innovación en el sector petrolero de Nigeria.

El examen del estudio del Índice Global de Innovación revela que el desempeño en innovación de Nigeria va a la zaga de otros países productores de petróleo. Las puntuaciones del índice indican deficiencias en áreas clave como la inversión en investigación y desarrollo (I+D), la infraestructura tecnológica y el desarrollo del capital humano. Estas debilidades limitan la capacidad del sector para innovar y mejorar dentro de las cadenas de valor mundiales. El análisis sugiere que mejorar el NEI de Nigeria a través de una mayor financiación de I+D, desarrollo de capacidades y un mejor apoyo institucional es fundamental para impulsar la innovación y el crecimiento económico en el sector petrolero. El análisis de los hallazgos revela además varias ideas clave sobre el terreno de la innovación en Nigeria y sus implicaciones para la industria petrolera. En primer lugar, el análisis evalúa el desempeño de Nigeria en indicadores clave de innovación, como instituciones, capital humano, investigación y desarrollo, infraestructura, sofisticación del mercado y sofisticación empresarial.

Esta evaluación destaca áreas de fortaleza, como el tamaño del mercado y la sofisticación empresarial, así como áreas que requieren mejora, como la calidad institucional y la inversión en investigación y desarrollo. En segundo lugar, el análisis del GII compara el desempeño en innovación de Nigeria con el de sus pares regionales y globales, proporcionando valiosos conocimientos comparativos sobre la competitividad en innovación del país e identificando prioridades estratégicas para las intervenciones políticas.

Además, el estudio enfatiza la importancia de la diversificación institucional y la integración de nuevos participantes en el esquema modular de refinación de petróleo del gobierno federal. Este enfoque puede promover la competencia, la innovación y la inversión dentro del sector petrolero, contribuyendo a su crecimiento y desarrollo generales. Al abordar los desafíos estructurales y operativos dentro de la industria, Nigeria puede aprovechar mejor sus recursos petroleros para el desarrollo económico sostenible.

En conclusión, este estudio destaca el papel fundamental de la industria petrolera de Nigeria dentro de las cadenas de valor globales (CGV) y evalúa las capacidades de su Sistema Nacional de Innovación (NIS) para mejorar el sector. En general, los hallazgos subrayan la importancia de mejorar el contenido local, mejorar las capacidades de innovación y fomentar asociaciones estratégicas para impulsar el crecimiento económico. La investigación contribuye a la comprensión de la dinámica que influye en el sector petrolero de Nigeria y proporciona recomendaciones prácticas para aprovechar las CGV y los NEI para mejorar el desempeño y lograr el desarrollo sostenible. Al abordar los desafíos y oportunidades identificados, Nigeria puede fortalecer su posición dentro del mercado petrolero mundial y aprovechar todo su potencial económico.

Palabras clave: cadenas de valor globales, sistema nacional de innovación, industria petrolera de Nigeria, mejora del sector petrolero, capacidades de innovación, encuesta de innovación comunitaria, índice de innovación global, desarrollo económico, corporaciones multinacionales, capacidad de refinación, contenido local, transferencia de tecnología, recomendación de políticas.

RESUMO AMPLIADO

Este estudo explora o papel da industria petroleira nixeriana dentro das cadeas de valor globais (CVM) e avalía as capacidades do seu Sistema Nacional de Innovación (NIS) para mellorar o sector. Proporciona unha análise completa dos procesos da industria petroleira de Nixeria nos marcos das GVC e NIS, afondando en facetas teóricas e empíricas cruciais para comprender e mellorar o rendemento do sector petroleiro de Nixeria. Descuberto na década de 1950, o petróleo influíu significativamente na economía de Nixeria, converténdose nunha importante fonte de ingresos e divisas. Ao longo das décadas, o petróleo foi a columna vertebral da estrutura económica de Nixeria, contribuíndo substancialmente ao PIB do país e aos ingresos do goberno. A pesar diso, Nixeria enfróntase a importantes desafíos no seu sector petroleiro. O país estableceu catro refinerías para procesar petróleo cru, pero estas refinerías operan actualmente a un 20% da súa capacidade. Esta ineficiencia leva ao paradoxo de que Nixeria sexa un exportador neto de cru mentres importa unha gran parte dos seus produtos petrolíferos refinados. Esta dependencia do petróleo refinado importado non só representa unha ineficiencia económica substancial senón que tamén pon de relevo as lagoas na política e infraestrutura nacional. Esta investigación ten como obxectivo examinar este paradoxo en profundidade, proporcionando información sobre os logros e os retos en curso da industria petroleira nixeriana. Ademais, ofrece recomendacións para aproveitar as GVC e os NIS para mellorar o rendemento do sector petroleiro de Nixeria e promover o desenvolvemento económico sostible.

A introdución describe os obxectivos da investigación, a importancia e a metodoloxía. Comeza explorando as cadeas de valor globais (CVM), explicando os seus conceptos, mapeamentos, estruturas de goberno e procesos de actualización. O obxectivo é entender como a industria petroleira de Nixeria encaixa e pode beneficiarse das GVC. A continuación, fálase do concepto de Sistema Nacional de Innovación (SNI), centrándose no seu papel no fomento da innovación e do crecemento económico no sector petroleiro. A continuación, o estudo examina a integración dos enfoques GVC e NIS, destacando as posibles sinerxías e contribucións á industria petroleira nixeriana. Os obxectivos fundamentais deste estudo son examinar por que o país importa combustible refinado a pesar de ser un exportador neto de petróleo cru, analizar a integración do sector petroleiro de Nixeria nos mercados globais, avaliar o apoio do NIS ao sector e identificar vías para a mellora económica a través da mellora das capacidades de innovación e da participación estratéxica nas CGV.

A revisión da literatura sobre as GVC ofrece unha visión xeral do seu desenvolvemento, relevancia e aplicación na industria petrolífera. Traza a evolución histórica das CGV e o seu impacto no comercio global e nas redes de produción. A revisión integra conceptos e marcos clave, como o mapeo da cadea de valor e as estruturas de goberno, para establecer as bases para analizar o posicionamento global do sector petroleiro de Nixeria. Comprender as GVC é fundamental para comprender as complejidades da dinámica do mercado global e o seu impacto nas industrias nacionais. A revisión destaca a importancia das CGV para impulsar a competitividade e o crecemento económico, facendo fincapé na súa relevancia para a industria petroleira de Nixeria. As CGV ofrecen importantes beneficios aos países en desenvolvemento ao proporcionar acceso aos mercados internacionais, fomentar a transferencia tecnolóxica e fomentar o investimento e as oportunidades de emprego. Estas cadeas de valor poden axudar ás nacións en desenvolvemento como Nixeria a integrarse na economía global, mellorando a produtividade e a innovación.

Non obstante, o estudo tamén subliña os desafíos aos que se enfrontan os países en desenvolvemento para capitalizar plenamente as CGV, incluíndo a dependencia dos produtos primarios, as actividades de valor engadido limitado e a vulnerabilidade ás flutuacións do mercado global. Un estudo de caso dentro da revisión indica que, aínda que os países en desenvolvemento participan nas CGV, a miúdo permanecen confinados ao extremo inferior da cadea de valor, centrándose na extracción e exportación de produtos primarios. Esta situación dá lugar a unha parte desproporcionada das ganancias dos países máis desenvolvidos, que dominan os segmentos de maior valor engadido das cadeas. As lagoas identificadas na participación das CGV expoñen a necesidade de estender a análise á teoría da innovación, introducindo o concepto de Sistema Nacional de Innovación (SNI) como marco para potenciar o sector petroleiro e a súa competitividade global.

Ao explorar o concepto de sistemas de innovación, o estudo afonda nos desafíos de definir e implementar NIS no contexto socioeconómico único de Nixeria. Examínanse diversas interpretacións dos sistemas de innovación, incluídos os sistemas nacionais, rexionais e sectoriais, pola súa relevancia para as políticas económicas. O estudo destaca a fluidez na interpretación dos sistemas de innovación e a necesidade dunha comprensión clara e consensuada para aproveitar eficazmente o seu potencial.

A análise subliña o papel de NIS no fomento da innovación, a creación de coñecemento e o avance tecnolóxico, que son esenciais para mellorar o sector petroleiro de Nixeria. O concepto de Sistemas Nacionais de Innovación (NIS) é crucial para comprender o contexto máis amplo no que opera a industria petroleira de Nixeria. Este estudo afonda nos distintos tipos de NIS, distinguindo entre interpretacións estreitas e amplas. O NIS estreito céntrase en institucións e políticas directamente relacionadas coas actividades de innovación, como institucións de investigación e desenvolvemento, universidades e políticas tecnolóxicas. Pola contra, o NIS amplo abarca unha gama máis ampla de elementos que inflúen na innovación, incluíndo factores sociais, culturais e económicos, xunto cos sistemas educativos, os mercados de traballo e as institucións financeiras.

No contexto dos países en desenvolvemento, os NIS adquiren unha complexidade adicional. Os países en desenvolvemento adoitan enfrontarse a desafíos únicos para establecer e manter NIS eficaces. Estes retos inclúen recursos financeiros limitados, infraestruturas inadecuadas e capital humano insuficiente. Ademais, os países en desenvolvemento poden carecer dos marcos institucionais e das estruturas de goberno necesarios para apoiar sistemas sólidos de innovación. As dificultades para definir os NIS nestes contextos derivan da necesidade de adaptar o concepto para adaptarse a diversas realidades socioeconómicas e etapas de desenvolvemento. Por exemplo, mentres os países desenvolvidos poden centrarse nas innovacións tecnolóxicas avanzadas, os países en desenvolvemento poden priorizar as innovacións incrementais e as adaptacións das tecnoloxías existentes.

A implementación do NIS no contexto socioeconómico único de Nixeria presenta desafíos específicos. O panorama socioeconómico de Nixeria caracterízase por importantes disparidades en materia de riqueza, educación e infraestruturas entre as zonas urbanas e as rurais. Ademais, a inestabilidade política, a corrupción e as ineficiencias burocráticas complican aínda máis o establecemento dun NIS cohesionado. As institucións educativas e de investigación do país adoitan sufrir unha falta de financiamento e de recursos, o que limita a súa capacidade de contribuír de forma eficaz á innovación. Ademais, a miúdo hai unha desconexión entre a investigación académica e as necesidades da industria, o que leva a un desaxuste das prioridades e unha brecha nas aplicacións prácticas dos resultados da investigación.

Estes desafíos destacan a necesidade de combinar marcos GVC e NIS para abordar as deficiencias non só na capacidade de innovación de Nixeria senón a nivel mundial. Ao integrar os coñecementos da análise da GVC cos principios do NIS, o estudo pretende ofrecer un enfoque máis completo para mellorar a competitividade comercial. A combinación destes marcos axuda a identificar intervencións estratéxicas que potencian a participación dos países en desenvolvemento nas cadeas de valor globais ao mesmo tempo que reforzan as súas capacidades nacionais de innovación. Este enfoque integrado é facilitar o desenvolvemento dunha industria petroleira máis resistente e dinámica que estea mellor posicionada para contribuír ao crecemento e desenvolvemento económico de Nixeria.

Dúas preguntas centrais de investigación guían o estudo:

(1) "Por que Nixeria, que é un exportador neto de petróleo cru, é tamén un importador neto de petróleo refinado?"

(2) "Ata que punto se pode usar o NIS de Nixeria para mellorar a Industria Nacional do Petróleo nas cadeas de valor do petróleo global?"

Estas preguntas son cruciais para abordar a dicotomía entre as exportacións de cru de Nixeria e a súa dependencia dos produtos petrolíferos refinados importados.

A metodoloxía de investigación adopta un enfoque de método mixto, que combina métodos cualitativos e cuantitativos para ofrecer unha análise completa da industria petroleira nixeriana. Este enfoque facilita unha comprensión holística da dinámica complexa dentro da industria, permitindo tanto comparacións numéricas como coñecementos máis profundos sobre motivacións, percepcións e factores contextuais. A recollida de datos primarios realízase mediante un cuestionario baseado na Enquisa de Innovación Comunitaria (CIS), escollida pola súa relevancia para captar actividades e capacidades de innovación dentro das empresas que operan no sector petroleiro. CIS proporciona un marco estandarizado para a recollida de datos, que garante a coherencia e a comparabilidade entre os entrevistados. Ao administrar o cuestionario do CIS ás principais partes interesadas do sector petroleiro, incluídas as axencias gobernamentais e as compañías petrolíferas, a investigación ten como obxectivo captar diversas perspectivas e coñecementos das persoas directamente implicadas na configuración dos procesos da industria.

A selección das compañías petroleiras como poboación principal para a recollida de datos é estratéxica. As compañías petroleiras son actores importantes na industria petroleira nixeriana, e inflúen nas tendencias de produción, investimento e innovación. Ademais, posúen unha valiosa experiencia e coñecementos de primeira man sobre os desafíos da industria, as oportunidades e as prácticas de innovación. Ao dirixirse ás compañías petroleiras, a investigación garante a representación de varios segmentos da industria, incluíndo a exploración, produción, refino e distribución, especialmente aqueles con compromisos nas comunidades de acollida. As fontes de datos secundarias, incluíndo o Índice de Innovación Global, os datos da OPEP, os datos do Comercio de Valor Engadido (TIVA) e a información sobre o Sistema Nacional de Innovación (NIS) de Nixeria, tamén se utilizaron para proporcionar información adicional sobre o rendemento e o posicionamento global da industria. Os datos de TIVA ofrecen información valiosa sobre o papel das cadeas de valor globais na configuración da competitividade e do rendemento da innovación do sector petroleiro nixeriano.

Os resultados da investigación sobre a primeira pregunta de investigación subliñan o dominio das corporacións multinacionais (MNC) na industria petroleira de Nixeria, cunha influencia significativa sobre as actividades de produción, investimento e refino. Non obstante, unha observación digna de mención é que estas multinacionais adoitan posuír capacidades de refino nos países máis desenvolvidos en lugar de dentro da propia Nixeria. Este fenómeno pon de relevo a dependencia do país de entidades de propiedade estranxeira para os procesos de refino posterior, a pesar da súa condición de gran produtor de petróleo.

Ao considerar as implicacións desta tendencia, xorden varios pros e contras. No lado positivo, asociarse con empresas multinacionais con capacidades de refino nos países desenvolvidos ofrece acceso a tecnoloxías de refino avanzadas e coñecementos que poden non estar dispoñibles no país. Isto pode mellorar a eficiencia, a calidade do produto e os estándares de seguridade dentro do proceso de refino. Ademais, aproveitar as capacidades de refino das multinacionales permite que os produtos petrolíferos nixerianos accedan aos mercados globais con máis facilidade, diversificando os fluxos de ingresos e mitigando os riscos asociados ás flutuacións na demanda local ou aos cambios normativos. Ademais, colaborar coas multinacionais establecidas difunde os riscos asociados ás operacións de refino, incluíndo o investimento de capital, o cumprimento da normativa e a volatilidade do mercado. As multinacionais poden ter maiores recursos financeiros e capacidades de xestión de riscos para afrontar estes desafíos de forma eficaz.

Non obstante, esta dependencia das multinacionais para as actividades de refino presenta inconvenientes significativos. A externalización das actividades de refino limita o valor engadido e os beneficios económicos que Nixeria pode obter dos seus recursos petrolíferos. A falta de capacidade de refino doméstica perpetúa a dependencia do país dos produtos refinados importados, socavando os esforzos para acadar a autosuficiencia e o desenvolvemento industrial. Ademais, confiar nas multinacionales para refinar expón a Nixeria a vulnerabilidades asociadas a tensións xeopolíticas, disputas comerciais e interrupcións na cadea de subministración nos países que acollen estas instalacións. Calquera interrupción nas operacións de refino no estranxeiro pode ter ramificacións significativas para a seguridade enerxética e a economía de Nixeria. Ademais, a ausencia de capacidades de refino significativas en Nixeria dificulta a transferencia de tecnoloxías e habilidades de refino avanzadas á forza de traballo doméstica, perpetuando un ciclo de dependencia tecnolóxica e inhibindo o desenvolvemento de coñecementos e innovación locais no sector petroleiro.

Ademais, os descubrimentos do CIS e fontes de datos secundarias arroxan luz sobre o estado de Nixeria como importador neto de combustible refinado a pesar de ser un gran exportador de petróleo. A análise destaca factores como as limitacións de infraestruturas, a inadecuada capacidade de refino doméstica e os pescozos de botella das políticas que contribúen a esta situación paradoxal. Ademais, a investigación emprega a análise do comercio de valor engadido (TiVA) para examinar a interconexión das cadeas de valor globais (CVM) e a industria petroleira nixeriana, proporcionando información sobre a distribución de valor, a competitividade e as oportunidades de adición de valor doméstico. A análise de TiVA rastrexa o fluxo de valor engadido en diferentes países e industrias, ofrecendo unha perspectiva completa sobre a posición do sector dentro das CGV.

Os resultados da análise de TiVA revelan aspectos clave do sector petroleiro de Nixeria. En primeiro lugar, a análise destaca importantes conexións cara atrás, cunha gran dependencia dos insumos importados para as actividades de produción e refino. Esta dependencia subliña os desafíos relacionados coas capacidades tecnolóxicas domésticas, a retención de valor e o desenvolvemento industrial. En segundo lugar, a análise de TiVA arroxa luz sobre a distribución do valor engadido ao longo da cadea de valor do petróleo, identificando oportunidades para mellorar as capacidades de refino posterior e capturar máis valor no país. Ademais, a análise examina o papel das corporacións multinacionais (MNC) e as súas filiais no sector, rastrexando como o valor engadido flúe a través das operacións globais das MNC. Esta perspectiva revela tanto oportunidades para a transferencia de tecnoloxía como desafíos relacionados co limitado valor agregado local. En xeral, aínda que a asociación con empresas multinacionais para actividades de refino ofrece vantaxes como o acceso a tecnoloxía avanzada e a integración do mercado global, tamén presenta desafíos, incluíndo vulnerabilidade a factores externos, barreiras á transferencia de tecnoloxía e limitacións á innovación. Abordar estes desafíos require intervencións estratéxicas dirixidas a promover a capacidade de refino doméstica, fomentar a transferencia de tecnoloxía e mellorar a competitividade da industria petroleira de Nixeria. Ao integrar os coñecementos da análise TiVA con enfoques de métodos mixtos, esta investigación proporciona unha comprensión matizada das complexidades que configuran a dependencia das importacións de combustible de Nixeria e ofrece recomendacións estratéxicas para aumentar o contido local, o desenvolvemento industrial e a retención de valor.

Considerar a segunda pregunta de investigación sobre as capacidades do Sistema Nacional de Innovación (NIS) de Nixeria para apoiar a industria petroleira para actualizar unha análise multifacética é esencial. O NIS engloba varias institucións, políticas e mecanismos que facilitan a innovación e o desenvolvemento tecnolóxico dentro dun país. Avaliar a súa capacidade para apoiar a industria petroleira para a súa modernización implica avaliar o marco institucional, as iniciativas políticas, a infraestrutura de investigación e desenvolvemento e os mecanismos de colaboración coas partes interesadas da industria. O NIS de Nixeria é prometedor, pero tamén afronta desafíos para apoiar eficazmente o avance tecnolóxico e a innovación da industria petrolífera.

Por unha banda, Nixeria avanzou no establecemento de institucións e políticas para fomentar a innovación e a transferencia de tecnoloxía. Iniciativas como a National Agency for Science and Engineering Infrastructure (NASENI) e a Nigerian Content Development and Monitoring Board (NCDMB) teñen como obxectivo promover a participación do contido local e o avance tecnolóxico en sectores estratéxicos como o petróleo e o gas. Ademais, os esforzos para fortalecer a infraestrutura de investigación e desenvolvemento mediante asociacións con universidades, institutos de investigación e axentes da industria demostran o compromiso de mellorar as capacidades tecnolóxicas autóctonas. Non obstante, quedan lagoas importantes, incluíndo financiamento limitado para investigación e desenvolvemento, infraestruturas inadecuadas e coordinación fragmentada entre as partes interesadas. Abordar estes desafíos require esforzos concertados para reforzar a capacidade do NIS, fomentar a colaboración entre a academia e a industria e incentivar a innovación no sector petroleiro para apoiar a mellora e a competitividade no mercado global.

Ademais, o estudo integra a análise do Índice de Innovación Global (GII) para proporcionar unha comprensión completa das dinámicas de innovación e da competitividade na industria petroleira nixeriana. A análise do GII ofrece información sobre o ecosistema de innovación do país, as capacidades tecnolóxicas e o posicionamento global, complementando os datos primarios recollidos a través da Enquisa de Innovación Comunitaria (CIS) e fontes de datos secundarias como a análise do Comercio de Valor Engadido (TiVA) e os datos da OPEP. Ao sintetizar achados de diversas fontes, esta investigación ten como obxectivo informar as intervencións estratéxicas para mellorar a competitividade, a sustentabilidade e a innovación no sector petroleiro nixeriano.

O estudo do Índice de Innovación Global revela que o rendemento de innovación de Nixeria está por detrás doutros países produtores de petróleo. As puntuacións do índice indican deficiencias en áreas clave como o investimento en investigación e desenvolvemento (I+D), infraestrutura tecnolóxica e desenvolvemento do capital humano. Estas debilidades limitan a capacidade do sector para innovar e actualizarse dentro das CGV. A análise suxire que a mellora do NIS de Nixeria mediante o aumento do financiamento de I+D, o desenvolvemento de capacidades e o apoio institucional mellorado é fundamental para impulsar a innovación e o crecemento económico no sector petroleiro. A análise dos resultados revela ademais varias ideas clave sobre o terreo de innovación de Nixeria e as súas implicacións para a industria petroleira. En primeiro lugar, a análise avalía o rendemento de Nixeria en indicadores clave de innovación, como institucións, capital humano, investigación e desenvolvemento, infraestruturas, sofisticación do mercado e sofisticación empresarial.

Esta avaliación destaca áreas de fortaleza, como o tamaño do mercado e a sofisticación empresarial, así como áreas que requiren melloras, como a calidade institucional e o investimento en investigación e desenvolvemento. En segundo lugar, a análise do GII compara o rendemento en innovación de Nixeria fronte aos pares rexionais e globais, proporcionando información comparativa valiosa sobre a competitividade da innovación do país e identificando prioridades estratéxicas para as intervencións políticas.

Ademais, o estudo subliña a importancia da diversificación institucional e da integración de novos participantes no esquema modular de refino de petróleo do goberno federal. Este enfoque pode promover a competencia, a innovación e o investimento no sector petroleiro, contribuíndo ao seu crecemento e desenvolvemento global. Ao abordar os desafíos estruturais e operativos da industria, Nixeria pode aproveitar mellor os seus recursos petrolíferos para un desenvolvemento económico sostible.

En conclusión, este estudo destaca o papel crítico da industria petroleira de Nixeria dentro das cadeas de valor globais (GVC) e avalía as capacidades do seu Sistema Nacional de Innovación (NIS) para mellorar o sector. En xeral, os resultados subliñan a importancia de mellorar o contido local, mellorar as capacidades de innovación e fomentar asociacións estratéxicas para impulsar o crecemento económico. A investigación contribúe á comprensión da dinámica que inflúe no sector petroleiro de Nixeria e ofrece recomendacións viables para aproveitar as GVC e os NIS para mellorar o rendemento e lograr un desenvolvemento sostible. Ao abordar os desafíos e oportunidades identificados, Nixeria pode fortalecer a súa posición no mercado mundial de petróleo e realizar todo o seu potencial económico.

Palabras clave: cadeas de valor globais, sistema nacional de innovación, industria petroleira nixeriana, mellora do sector petrolífero, capacidades de innovación, enquisa de innovación comunitaria, índice de innovación global, desenvolvemento económico, empresas multinacionais, capacidade de refino, contido local, transferencia de tecnoloxía, recomendación de políticas.

PART 1.
INTRODUCTION

Chapter 1.
Introduction

The Nigerian oil industry stands at a critical juncture, characterized by its paradoxical status as a leading exporter of crude oil while remaining a significant importer of refined petroleum products. This dichotomy underscores the complex interplay between Nigeria's participation in Global Value Chains (GVCs) and the effectiveness of its National Innovation Systems (NIS). The primary objective of this study is to explore the reasons behind this paradox and assess how integrating GVCs with a robust NIS can facilitate Nigeria's economic transformation. Specifically, the study addresses two key research questions: (1) Why does Nigeria, a net exporter of crude oil, import refined oil instead of refining it domestically? (2) To what extent can the Nigerian National Innovation System (NIS) facilitate upgrades or innovations in the oil sector? By addressing these questions, the study aims to provide actionable insights for policymakers and industry stakeholders to foster sustainable economic development and improve global competitiveness in petroleum products.

1.1. BACKGROUND OF THE STUDY

The quest for economic development, globalization, and the modularization of production processes has significantly enhanced value-added manufacturing in various industries across the globe. Numerous refined products have synthesized inputs from multiple supply and demand chains situated in different geographical locations (Nielson, 2018). Among other governing factors, GVCs are identified by numerous researchers as a controlling economic factor that largely determines a firm's entry, continuity, and exit in the value chain, as well as the spatial configuration of production arrangement (Pietrobelli & Robelliti, 2011; Sweet & Eterovic, 2019).

By simply opening borders and attracting investments, countries can jump-start trade and maximize the absorption potential of their domestic economies, to foster growth and interconnections across diverse geographies. GVCs serve as catalysts for economic development, particularly in less developed nations by offering pathways for integration into the global economy and opportunities for industrial upgrading. In addition, it leverages increasing skills and the availability of materials at competitive costs and quality, thus enabling nations to integrate into established supply chains rather than building from scratch. The concept is beneficial as it reduces the necessity for countries to achieve comparative advantage across a wide range of domestic production stages, instead encouraging specialization and leveraging comparative advantages in specific stages within the GVCs (Baldwin & Lopez-Gonzalez, 2015). The remarkable rise of China exemplifies this approach, where the direction and productivity flows align with traditional trade theory, emphasizing offshoring, learning externalities, and technology spillovers (Khorana, 2022).

In many less developed (LD) nations, new low-cost manufacturers can venture into the global market, intensifying competition, especially in labor-intensive products. The strategic integration of local industries into GVCs enables countries to capitalize on their comparative advantages and foster economic growth (Carlsson & Westermark, 2016). However, participation in GVCs also reveals significant gaps in a country's ability to fully capitalize on global economic integration. These gaps include limited technological capabilities, inadequate infrastructure, dependencies, insufficient investment in research and development, and weak institutional frameworks. Such deficiencies hinder a nation's ability to move up the value chain and capture higher value-added activities.

Recognizing these gaps has led to the realization that merely participating in GVCs is insufficient; there must be a robust system to support and enhance a country's innovation and technological capabilities. National Innovation Systems (NIS) play a pivotal role in this context by providing the necessary framework for innovation and technological advancement. NIS encompasses policies, institutions, and practices that enable a country to develop, diffuse, and utilize innovations. The strength and effectiveness of NIS determine how well a country can leverage its participation in GVCs to achieve sustainable economic development. By fostering collaboration among government agencies, research institutions, industries, and universities, NIS ensures that innovation becomes a driving force for economic development.

Recent studies highlight the transformative role of National Innovation Systems (NIS) in enhancing economic development, particularly in emerging markets. NIS, defined by Richard Nelson as the institutions shaping a nation's innovation capabilities, play a crucial role in facilitating technology transfer and fostering local innovation (Nelson, 1993). However, challenges persist, especially in Less Developed Countries (LDCs), where NIS often face gaps in infrastructure, technological capability, and institutional support. Multinational Corporations (MNCs) significantly influence NIS dynamics by bringing advanced technology, managerial expertise, and global market access. These partnerships can accelerate local innovation and knowledge transfer, benefiting domestic firms. Yet, the influx of MNCs also poses risks, such as dependency on foreign technology and potential exploitation of local resources without sufficient local value creation (Tayauova, 2012).

The integration of GVCs with NIS emerges as a strategic imperative to address these gaps and maximize benefits. By combining GVCs and NIS, countries can leverage their comparative advantages, access global markets, and attract higher-value activities. This symbiotic relationship enhances technological capabilities through learning and innovation, thus driving sustainable and economic growth (Na et al., 2024).

This sets the stage for a comprehensive exploration of Nigeria's oil industry within the context of GVCs and NIS capability for upgrading. By delving into the complexities of Nigeria's position as a major crude oil exporter yet a net importer of refined fuel, this study seeks to uncover the underlying reasons and potential pathways for the country's economic transformation, illustrated through relevant GVC and NIS examples. The research objectives underscore the importance of understanding how GVC participation and NIS capabilities intersect in shaping Nigeria's economic trajectory. Through empirical analysis and theoretical frameworks, this study aims to provide actionable insights for policymakers, industry stakeholders, and scholars. By elucidating the role of GVCs and NIS in the context of the oil industry, this study seeks to pave the way for informed decision-making and strategic interventions aimed at upgrading the Nigeria's Petroleum Industry (NPI), increase her participation in global value chains and the achievement of sustainable economic development.

1.2. MOTIVATION

Nigeria is one of the top crude oil exporters globally and ranks as the largest oil and gas producer in Africa. The country's advantageous geographical position, large population, and workforce, combined with the potential for preferential oil trade agreements, position it strategically for significant involvement in Global Petroleum Value Chains (GPVCs) and deeper integration into the global economy. Several characteristics make Nigeria attractive to foreign investors, including low labor costs, substantial quantities of unprocessed petroleum products, a huge population, and access to the global market through its membership in OPEC.

At the nexus of global economic forces, Nigeria's oil industry finds itself at a crossroads, balancing the imperatives of global trade with the need to foster indigenous technological advancement and economic diversification. This paradoxical situation calls for a deeper examination of the underlying factors, thus motivating a complex and multifaceted inquiry into why Nigeria, despite being a large crude oil exporter, remains a net importer of refined oil.
Many hypotheses attempt to explain this phenomenon. Some attribute it to the Dutch disease, where resource wealth undermines other economic sectors. Others point to geopolitical factors, the so-called "oil curse," or socio-political issues, including governance challenges and infrastructure deficits. These diverse explanations highlight the multifaceted nature of the problem and prompt a thorough inquiry into the underlying causes.

This research has two main contributions, firstly: it seeks to add to the empirical literature on oil industry-level participation in GVCs by investigating why Nigeria, which is a net exporter of crude oil, is also a net importer of refined oil. Secondly, it assesses the potential of the Nigerian innovation system to upgrade NPI position in the global petroleum value chain. In this context and as a major contribution, we have designed a questionnaire based on the Community Innovation Survey (CIS) type, which has enabled the collection of information to examine the oil sector in the Nigerian NIS. The findings are expected to remain relevant even when accounting for potential linkages between oil industry productivity and NIS participation, an area that has been underexplored.

1.3 RESEARCH QUESTIONS

Nigeria is rated as the largest producer and exporter of crude oil in Africa. It also holds the 10th largest proven oil reserve in the world. Despite the huge crude oil production, the

country imports nearly all its fuel oil; thus, assuming the status of both a net exporter of crude oil and a net importer of refined petroleum products.
To address this complex phenomenon, the research questions arise on:
(i) Why Nigeria, which is a net exporter of crude oil, is also a net importer of refined oil?
(ii) To what extent can the Nigeria's NIS be used to upgrade the National Petroleum Industry in the Global Petroleum Value Chains?

1.4. OBJECTIVES OF THE STUDY

The main objective of this study is to investigate how the Nigerian petroleum industry is situated in the global petroleum value chain and to assess the potential of the Nigerian innovation system to upgrade the NPI position in the global petroleum value chain.

The objectives of this study include the following:
I. to identify the NPI in the global petroleum value chain.
II. to map-out the value chain in petroleum industry and evaluate the effect of Nigeria's import of refined fuel on economy.
III. to characterize the NIS and particularly, its relation, with the NPI
IV. to assess the potential of the NIS to upgrade the NPI position in the global petroleum value chain.

1.5 RESEARCH METHODOLOGY

This study employs a mixed-methods approach, integrating both qualitative and quantitative research methods to comprehensively examine the innovativeness of Nigeria's National Innovation System (NNIS) in the oil sector and investigate Nigeria's dual role as a major exporter of crude oil and a significant importer of refined petroleum products instead of refining it themselves.

a) Secondary Data and Analysis

The secondary research component of this study primarily utilizes Trade in Value-Added (TiVA) measurements to conduct a quantitative analysis of Nigeria's participation in Global Value Chains (GVCs). TiVA metrics are instrumental in capturing the value added by each country in the production of goods and services that are traded internationally, providing insights into the extent of Nigeria's integration into global trade networks. Data sourced from the OECD TiVA database for 2023, spanning the period from 1995 to 2020, were analyzed to assess Nigeria's involvement in GVCs through backward, forward, and total participation measures. The findings indicate that Nigeria's participation in GVCs is predominantly characterized by backward integration, where the country primarily exports raw materials, such as crude oil, and imports higher value-added products, such as refined petroleum. This scenario underscores the paradox of Nigeria being a major crude oil exporter while simultaneously importing refined oil products, highlighting the critical need for strategic interventions to enhance Nigeria's position and promote its advancement up the value chains.

In addition to TiVA analysis, the study also focuses on examining the structural elements and dynamics of Nigeria's National Innovation System (NIS) through the Global Innovation Index (GII) reports. The GII data, covering the period from 2011 to 2020, provide metrics across various pillars, including institutions, human capital and research, infrastructure, market sophistication, business sophistication, knowledge, technology, and creative outputs. By analyzing these pillars, the research offers a comprehensive evaluation of Nigeria's innovation performance in comparison to other countries, identifying areas of strength as well as opportunities for improvement. The insights gained from this analysis are intended to inform strategic policy recommendations aimed at strengthening Nigeria’s innovation system and enhancing its overall economic competitiveness.

The study further analyzed external datasets to provide a comprehensive understanding of Nigeria’s oil sector and its global interactions. This included data from OPEC on Nigeria’s oil production and trade, information from the Nigerian National Petroleum Corporation (NNPC) on the activities of multinational corporations (MNCs) in the country, and economic data from the Central Bank of Nigeria (CBN), National Bureau of Statistics (NBS), and the African Development Bank (AfDB). These sources offered a detailed view of the oil industry’s performance, its role in global value chains, and its interaction with the national innovation framework

b) Primary Research and Data Collection

Primary data were collected through a self-structured questionnaire adapted from the Community Innovation Survey (CIS) 2018. The questionnaire was tailored to assess the innovation activities, sources, and outcomes within Nigeria’s petroleum sector. It was distributed to 30 Nigerian oil firms, collecting data on their innovation practices between 2020 and 2022. The CIS questionnaire provided valuable insights into the sources, drivers and barriers of innovation, types of innovations pursued, and their impact on firm performance and competitiveness. This primary data collection aimed to fill gaps in existing research by offering a detailed understanding of how Nigerian oil firms innovate and the challenges they face. The research also incorporated supplementary data to enrich the analysis of Nigeria’s innovation landscape. This included data on literacy levels from 2000 to 2019, university student enrollments, academic staff complements, budgetary expenses for education and industry-university collaboration from the National University Commission (NUC) database. These additional data points helped to contextualize the educational and research environment, which are critical components of the NIS, providing a broader understanding of the factors influencing innovation in Nigeria.

To strengthen the statistical rigor of this study, Chi-square analysis was incorporated as an additional analytical tool. This method was employed to examine the relationships between firm characteristics, innovation activities, and the influence of multinational corporations

(MNCs) on local oil firms in Nigeria. The inclusion of Chi-square analysis enhances the reliability of findings by allowing statistical validation of observed trends in innovation behavior, investment in research and development (R&D), and technology adoption within the sector. By integrating this statistical test, the study provides a more robust empirical foundation for assessing the disparities between multinational and indigenous firms in terms of innovation capacity and technological investment. Additionally, the Chi-square analysis helps to quantify the structural weaknesses within Nigeria's National Innovation System (NIS), offering insights that support more data-driven policy recommendations. This methodological enhancement complements the existing Trade in Value-Added (TiVA) analysis, Global Innovation Index (GII) evaluation, and Community Innovation Survey (CIS)-based questionnaire, ensuring a comprehensive approach to investigating Nigeria's participation in the global petroleum value chain and the effectiveness of its innovation ecosystem.

1.6 RESEARCH STRUCTURE

While the research stream and theoretical lenses appear complementary, the rest of the study follows an organized framework premised on inclusive theoretical coverage from multiple literatures. The study outlines the structure of the research by dividing it into 4 parts and 8 chapters. The first part covers chapter 1 which involves the background, motivation, research question, objectives, and methodology. The second part delves into the literature review and theoretical foundation, encompassing chapters on Global Value Chains (GVCs), National Innovation System (NIS), and the combination of GVCs and NIS. The third part termed Empirical Analysis, includes chapters on the oil industry in Nigeria, the Nigeria Innovation Systems and the interactions between the Nigerian Petroleum Industry and the NIS. The fourth and final part is the conclusion, summarizing the key findings and insights derived from the research. Structurally, the thesis begins with:

- Chapter 1, which represents an introduction and general background, motivation, research questions and objectives of the thesis.
- Chapter 2 presents a comprehensive review of the Global Value Chain (GVC) framework, exploring its origins, conceptual developments, and the various factors influencing participation in GVCs. It discusses different market governance structures and upgrading strategies within GVCs, highlighting how firms and countries can enhance their roles in global production networks. The chapter also examines key measurement approaches, including Trade in Value Added (TiVA), to assess Nigeria's integration into GVCs. A significant focus is placed on the role of multinational corporations (MNCs) in shaping GVC dynamics and their impact on developing economies, with particular emphasis on their dominance in the oil sector. The chapter then narrows down to the petroleum industry within the GVC framework, analyzing its importance, challenges, and potential for upgrading. It further provides an overview of the status of oil and gas in global context, the position of Nigeria in GPVCs, reserves, consumption, and oil trading. Additionally, the chapter discusses how GVC participation affects domestic institutions and policies, shaping innovation and

industrial development in resource-rich economies like Nigeria. The chapter concludes with a summary, setting the stage for subsequent discussions on National Innovation Systems (NIS).

- Chapter 3 discusses the National Innovation Systems. It explores the concept of NIS, providing definitions, types, and key components. It examines the role of NIS in developing countries, emphasizing the transition from NIS to innovation capabilities in these economies. The chapter further analyzes the relevance of NIS in the petroleum sector, highlighting the role of petroleum clusters in fostering innovation and the challenges to effective NIS. By assessing NIS and the oil industry, the chapter provides insights into how nations can leverage their innovation systems to enhance technological progress in the petroleum sector. It concludes with a summary of key findings.
- Chapter 4 examines the combination of GVC and NIS, exploring their integration and co-evolution. It provides an overview of policies and best practices, highlighting different perspectives on their integration. The chapter outlines the stages of GVC-NIS co-evolution, discussing the foundational elements, linkages, and illustrative trajectories that shape their interaction. Additionally, it identifies opportunities and challenges in their linkages, emphasizing the complementary features that can enhance innovation in industry upgrading. The chapter concludes with a summary of key insights.
- Chapter 5 shifts the focus from the global perspective of Chapter 2 to an in-depth examination of Nigeria’s oil industry and its position within the Global Value Chain (GVC). It begins with a brief historical background, assessing the industry's structure, key drivers, and its significance in Nigeria’s economy. The chapter analyzes Nigeria’s participation in GVCs using Trade in Value-Added (TiVA) measurements, evaluating global trade, imports, and the role of multinational corporations (MNCs) in shaping the sector. It also explores the state's involvement in the industry, highlighting its influence on governance, policies, and local content development. Finally, the chapter discusses the benefits of the oil sector, along with the risks and barriers limiting its potential, before concluding with a chapter summary.
- Chapter 6 discusses the Nigeria’s National Innovation System (NNIS). It shifts the focus from the global perspective of NIS in Chapter 3 to an in-depth analysis of NNIS. It begins with a brief overview of the origin and recent developments in Nigeria’s NIS, followed by an evaluation of the country’s innovation performance using the Global Innovation Index (GII). The chapter examines the integration and assessment of key NIS pillars, comparing Nigeria’s innovation landscape with other oil-rich nations. Additionally, it explores the role of NNIS agents, universities, industry, and government, highlighting their linkages, challenges, and contributions to technological advancement. The government’s efforts in developing NNIS are analyzed alongside the benefits and persistent challenges that hinder innovation-driven growth. Finally, the chapter offers suggestions on technological frameworks for economic recovery, setting the stage for Chapter 7, which delves into the Nigerian oil industry in the NNIS, thus, ending with a summary.

- Chapter 7 empirically analyzes Nigeria's oil industry within the NNIS framework**.** Using a self-structured questionnaire based on the Community Innovation Survey (CIS) methodology, the study investigates innovation sources, firm turnover, R&D investment, product innovation, and external knowledge flows**.** To enhance statistical analysis, Chi-square testing was employed to assess firm-level innovation disparities between multinational corporations (MNCs) and indigenous firms. The chapter highlights key challenges, including MNC dominance, limited local R&D investment, weak university collaboration, and policy inefficiencies**,** offering strategic insights into improving Nigeria's innovation performance in the oil sector. Finally,
- Chapter 8 wraps-up the thesis with conclusions by synthesizing key findings from Chapters 1-7 and providing policy recommendations to enhance NNIS effectiveness, improve GVC participation, and achieve sustainable economic development. It also outlines research limitations, future research directions, and the need for stronger data frameworks to support empirical modeling. The chapter emphasizes the importance of addressing structural weaknesses, strengthening domestic innovation capacity, and fostering industry-university collaboration to enhance Nigeria's position in the global petroleum industry. The highlight of the basic elements that underscore the study's conceptual approach/framework is in table 1.

Table 1: Research Framework

Study's Conceptual Approach as framework

	Theoretical Strand	Analytical Grouping	Dimensions	Object for examination
1	GVC	Power Coordination	Complexities	NPI & Government NPI &MNC NPI & Illegal refiners
2	Global Commodity Chains (GCC), Gereffi et al., (1994)	Institutions	Formal Institutions Informal Institutions	Local Content Reforms Conventions & practices
3	Global production Network (GPN)	Power	Resource-based, capabilities	Producers & lead firms
4	Upgrading in GPVCs	Product Sophistication Upgrading	Process, product & functional upgrading	Crude Oil & Refining
5	Innovation Systems	Technology, Learning & Knowledge transfer	Research & Education	NIS
6	***Combining GVC & National Innovation System***	***Perspectives***	***Developing economies***	***Technology***

Source: Own Elaboration

PART 2.
LITERATURE REVIEW AND THEORETICAL FOUNDATION

Chapter 2.
Global Value Chains (GVCs)

This chapter reviews the literature and theoretical frameworks relevant to the study, focusing on Global Value Chains (GVCs). GVCs refer to the full range of activities that firms and workers perform to bring a product from its conception to end use and beyond. These activities include design, production, marketing, distribution, and support to the final consumer. The section explores the origins, concepts, governance structures, and upgrading processes within GVCs. It then examines the experiences of developing countries with GVCs, highlighting both the gains and challenges. The aim is to provide a comprehensive understanding of how the concept of GVCs contributes to the economic dynamics observed in emerging economies such as Nigeria.

2.1. BIRTH OF LITERATURE

The Birth of GVCs emerged from the increasing globalization of production processes and the fragmentation of manufacturing across different geographical locations. As multinational corporations sought to optimize their operations and reduce costs, they began to distribute various stages of production across multiple countries. This shift was driven by advancements in transportation, communication technologies, and trade liberalization, which facilitated the coordination of complex production networks. With this development, researchers and policymakers started to recognize the significance of GVCs in shaping global trade patterns and influencing economic development.

Highlighting the interconnectedness of global production and the interdependence of economies and making them a critical area of study for comprehending modern economic globalization has progressed through three distinct stages, mirroring shifts in global trade dynamics and economic paradigms.

Initially, it relied on traditional trade statistics, which provided a simplistic view of trade flows by focusing solely on the destination of goods and services. However, as trade patterns became more fragmented and production processes dispersed globally, these traditional statistics proved inadequate for capturing the intricacies of GVCs. Thus, during the mid-20th century, the mapping of GVCs entered a new phase characterized by the development of input-output tables and other advanced modeling techniques. These tools allowed researchers to trace the flow of intermediate goods and services across countries and industries, providing a more comprehensive understanding of how production processes were integrated across borders.

The third and final stage in the evolution of GVC mapping, as described by Richard Baldwin and Javier Lopez-Gonzalez and further re-appraised by Maria Savona, saw a notable shift towards a more holistic approach (Savona, 2015). This stage incorporated information on governance structures, power dynamics, and upgrading opportunities within GVCs, thus providing a comprehensive understanding of how value is created and distributed across global value chains. By examining these elements, the section sets the stage for the emergence of GVC and explores how Nigeria can leverage its participation to enhance its economic development.

2.2. GVC CONCEPT

Global Value Chains (GVCs) represent the international dispersion of production processes across different countries, with each stage of production adding value to a final product. This concept emerged as a response to globalization, technological advancements, and changes in trade policies, which facilitated the fragmentation and outsourcing of production activities. In GVCs, various firms and countries specialize in specific stages of production based on their comparative advantages and then trade intermediate goods and services to create a final product.

It involves analyzing the entire value chain, from the extraction of raw materials to the delivery of finished goods to consumers. Each stage of production contributes to value addition, and firms strategically position themselves within these chains to optimize efficiency, reduce costs, and access global markets. GVCs highlight the interconnectedness of the global economy, with goods often crossing multiple borders during the production process.

In terms of viewing the foundational concepts of GVCs with details of scholars' contribution with shifts that position countries for competitiveness and sustained economic growth, one prominent figure in this field is Gary Gereffi, who has extensively studied GVCs and their implications for global trade and economic development. Gereffi's work emphasizes the interconnectedness of production processes across different countries and highlights the role of leading firms in orchestrating these chains.

Another influential scholar in the field of GVC research is Richard Baldwin, whose contributions shed light on the evolution of global trade and the emergence of GVCs in the modern economy. Baldwin's work emphasizes the role of technology, particularly information and communication technologies (ICT), in facilitating the fragmentation of production processes and the integration of global supply chain.

Additionally, scholars like Stefano Ponte and Timothy Sturgeon have contributed valuable insights into the governance structures of GVCs and the power dynamics between lead firms and suppliers. Their research highlights the importance of governance mechanisms in shaping the distribution of value along the chain and the implications for labor standards and environmental sustainability.

The concept of 'Global Commodity Chains' was introduced by Gereffi (1996), relating value-added chains to the global organization of industries. Similarly, the concepts and procedures in GVC involve the international production of goods and services with a view to the growing occurrences in the global product fragmentation unveiling. It recognizes aspects of design, production, and distribution of products involved in various activities of the chains among firms located at different geographies. Murat et al. (2018) described this stage as the employment of foreign components of imported intermediate inputs largely used to produce outputs for exports. Since then, research has explored various typologies, determinants, and impacts of integrating into GVCs, culminating in the proposal of specific terminology by Jones and Kierzkowski (2004) for the phenomenon of globalization, termed International Fragmentation of Production.

Many literatures indicate that more advanced patterns in global businesses are characterized by organizational and spatial dispersion, leading to terminologies such as offshoring, international sharing of production, and outsourcing. Today, developing nations with linkages across lead-firms, strategic suppliers, and major consumers tend to provide various skills to support this phenomenon, prompting new and estranged splits in global trade transmissions. This conglomeration has been the subject of investigations, especially among Development Economists, Social Sciences, and general Commerce, extending to disciplines like international political economy and regional development.

The early works in global value chains also highlight the governance structure along commodity chains particularly in labor intensive and high-tech industries. These acts as testaments that identifies the typology of buyer-driven and producer or service-driven Global Commodity chains with related market power and control relationships (Gereffi, 1994). Understanding the perspectives in buyer-supplier relationships delineates the market relationship and enhances each power position for effective procurement and supply strategies, (Kähkönen & Lintukangas, 2022). Between the year 1996-2000, GVC expansion raised income trade elasticity and accelerated the role of individual European countries with the notion for higher tech investment transformations and upgrades (Zhan, 2021). However, in the year 2000, the processes heralded further enormous and rapid growth in GVC with large-scale research-based from the Rockefeller Foundation convention (Gereffi et al., 2005).

Today, findings show that Global investment and trade are inextricably inter-twined through various international production networks and upgrading along GVCs has moved from 30% to over 40% according to (Rabellotti, 2014). Firms now invest in productive assets globally through cross-border value chains of various degrees of input and output complexities. Thus, exposing the value chains whether inter-firm or intra-firm, regional, or global in nature towards sharpening with consensus building and providing technical assistance especially to developing countries, including TNCs with over 80% of global trade (Rabellotti, 2014).

Another concept that is directly close to GVC is the Global Production Network (GPN). Developed in the 1990s, by researchers in the field of geography, GPN came into limelight after the growing dissatisfaction with existing theories of Economic developments based on increase in network nature across geographies (Chi et al., 2022).

However, various events have shown that the concept of global trade has changed, especially within the atmosphere of final products crossing from one nation to another. These changes tend to have given rise to complex and sophisticated formation of finished goods across different national borders that transact primary products and intermediate goods to become final goods. GVCs is viewed along this process as a network of interconnected markets for products and services where commodities are re-generated to add value outside of the “primary production” and firm's limits. These networks have concepts that support the unbundling, or the slicing of tasks from various stages of production/manufacturing and service as they progress into the intermediate and more final stages of production (Kano et al., 2020). In development studies, the global trade was previously used to analyze a concept that depicts the activities of an entire manufacturing process in a product or service, from raw materials to assembly, marketing, sales, and distribution, to the final client/consumers within a sphere coordinate but this phase has changed and has now involved new patterns of trade that require specialization, cost effectiveness and benefits to be determined differently from what was obtained in the past.

In the case of manufacturing, primary and support operations are streamlined in the activities of large multinational corporations to allow specializations and competitive advantages to count through random checking of the number of times that the goods travel abroad. For the petroleum sector, it encompasses a highly intricate and interconnected network of activities that span across multiple countries and regions. This process involves various stages, from exploration and extraction to refining and distribution, each requiring specialized technologies and global collaboration. The globalization of these production processes has allowed for the efficient management and transport of petroleum, though it also introduces challenges that relate to geopolitical risks, double counting, environmental concerns, and market volatilities. Understanding the complexities of GVCs in petroleum is crucial for navigating the evolving landscape of the global energy market. network fosters the alignment of key factors within global organizations and theoretical frameworks, all underpinned by policies designed for operational checks and improvements (Gibbon et al., 2005). Figure 1 presents a schematic representation of the global trade process, showcasing the interconnected geographies of production and market procedures.

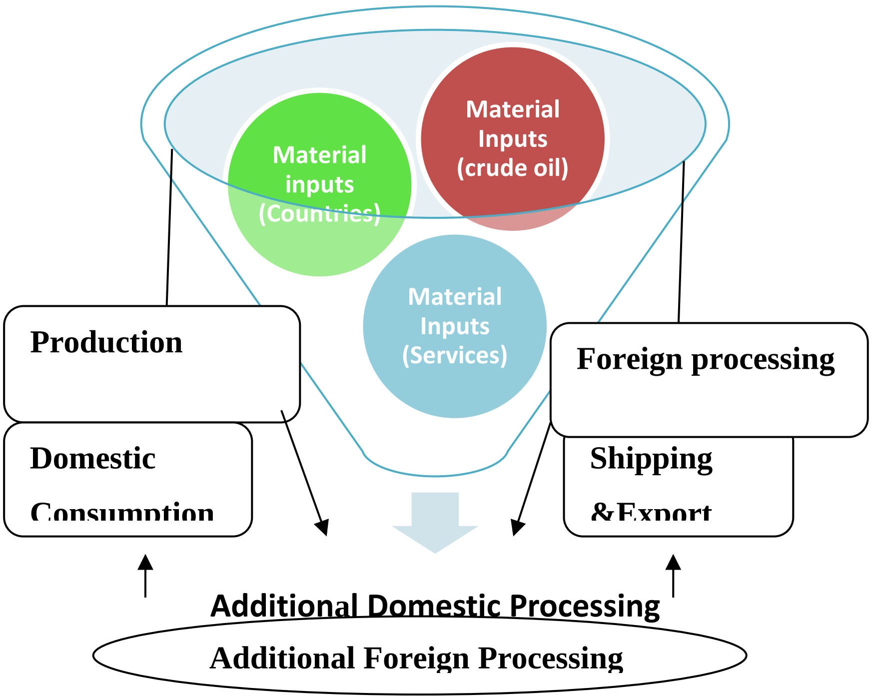

Figure 1: Production Processes & Geographic Scope for petroleum product fragmentation

Source: Own Elaboration

Table 2. Key terms for Understanding GVC Definitions

Terms	Implicit	Key Associated terms	Authors
Global Value chains	Added value content in an economy's export	Task capability trading	Gereffi (1994); Coe & Yeung (2015); Humphrey & Sturgeon (2001, 2005)
Global Production network	Capture of domestic Value for primary production coordination	Logistics from service links	Neilson (2014); Yeung (2016)
Outsourcing	Network analysis for delegation of tasks	Contracting outside the firm internal workers	Tayauova (2012); Barrientos (2013); Kleibert (2016); Strange et al. (2017)
Vertically integrated Supply-chains	Acquisition of key components of supply chain that was otherwise contracted	taking advantage of low-cost goods	Guan & Rehme (2012)
Off-shoring	Restructuring operations internationally	Sourcing at arm's length boundaries	OECD. (2018); Henderson et al., (2002)

Source: Own Elaboration

2.3. Mapping the development of GVC from the 1970s to the contemporary

The emergence of Global Value Chains (GVCs) signifies a crucial transformation in global trade dynamics, originating in the 1970s. During this period, the traditional premise of competitive markets operating at constant returns to scale was disrupted, leading producers to reconsider their operational strategies. In the 1980s, this shift gave rise to a new school of thought known as the new trade theory. This theory introduced the concept of production technology with increasing returns to scale, fundamentally challenging the conventional models of international trade.

While the new trade theory allowed for endogenous selection of market entry and exit by firms, the focus remained primarily on moving final goods across borders. However, scholars like Jones and Kierzkowski in 1990 began to explore the idea of product fragmentation and trade in intermediate goods, laying the groundwork for the GVC paradigm (Blyde, 2014). In the mid-1990s, the concept began to gain significant attention with scholars like Gary Gereffi pioneering its exploration. Gereffi's work sought to explain the process of natural learning inherent in the success of the 'Asian Tigers,' as highlighted in the export-led World Bank's 'East Asian Miracle report' (Gereffi, 1994). This initial focus on the upgrading prospects for developing countries laid the foundation for further research into the nature and growth of vertical specialization, as formalized by Hummel and Yi in 2001 Yi, 2001).

This concept gained further attraction in the 2000s, with a more comprehensive examination of product distribution structures and components, culminating in the term 'Global Value Chains' (Gereffi et al., 2005). In subsequent years, institutions such as the World Trade Organization (WTO) and IDE/Japan External Trade Organization (Jetro) began to recognize the economic significance of GVCs, broadening its scope into wider limelight (Fally, 2012). The concept emphasized how firms could leverage their core competencies and strategically decide which activities to outsource, thereby facilitating cross-border linkages and increasing GVC participation. This evolution spurred the integration of emerging economies into world trade, with a notable increase in the number of non-OECD countries transitioning from primary level production to intermediate production.

The contributions of GVCs trade encompasses both forward and backward linkages, experiencing significant growth during the early 1990s to 2000s. In the mid-2000s, there was a notable surge in Foreign Direct Investment (FDI) flows, skyrocketing from $200 billion to $2.0 trillion by 2007. This surge in investment triggered deeper trade policies and more stringent negotiations, that reshaped the terrain of global trade. As a result, a more complex GVC framework emerged, prompting a shift in terminology towards the concept of Global Value Networks (GVNs) in 2007 (Yeung & Coe, 2015).

In 2011, GVCs became broadening into wider limelight in a condition that allows the World Trade Organization (WTO) and IDE/Japan External Trade Organization (Jetro) to sight the new reality in a GVC-driven economic perspective of value-added analysis from various business records (Fally, 2012). The concept also emphasizes how a firm or industry aside from participating in global trade can decide on which activities that they have core competences and which of them should be outsourced to provide the needed links geographically. These cross-border linkage attempts to allow series of unprecedented increases in GVC participation as they evolve, and this has basically spurred the integration of emerging economies into world trade. Although OECD nations have advanced especially in manufacturing within GVC enclave, records show that there is significant increase in the number of non-OECD countries with primary level products but working towards intermediate production.

Prior to the introduction of GVCs, trade theories evolved from modernization to dependency in the mid-20th century, as outlined by scholars like Yeung & Coe (2015). The emergence of new trade theories, notably highlighted by Hopkins and Wallerstein in 1986 marked the genesis of international networks, setting the stage for the emergence of GVCs in subsequent decades.

Porter's Value Chain analysis, introduced in 1985, further contributed to the development narrative by emphasizing the tasks performed to create value in a business context. This analytical framework provided insights into how firms could strategically manage their operations to gain a competitive advantage. As trade policies shifted towards liberalization in the mid-1990s, many developing economies, previously resistant to trading or investing, began to embrace international production sharing. Scholars like Gereffi (1996) shed light on how these economies capitalized on liberalization policies to integrate themselves into global value chains, with East Asian countries experiencing significant growth in manufacturing sector competencies between 1995 and 2007 (Fan et al., 2021). Additionally, pro-supply chain agreements, coupled with unilateral concessions and Bilateral Investment Treaties, accelerated the integration of developing economies into global value chains, attracting investments from developed nations.

Two transformational changes have refined the phase of global production and trade within GVCs. Firstly, the increasing integration of world markets through trade liberalization, Regional Integrations and Agreements (RIAs), and advances in technology have facilitated the disintegration of production processes and the influx of intermediate goods in global markets (Hernández & Pedersen, 2017). However, despite the significant growth of GVCs trade from the early 1990s to the 2000s, recent decades have seen declines, attributed in part to the global wave of events, such as the financial crisis of 2008, which disrupted the fragmented production processes within GVCs, exposing vulnerabilities and leading to a reevaluation of global production strategy (Cattaneo et al., 2013).

Whereas 20th-century trade primarily involved final goods crossing borders, 21st-century trade has evolved to encompass the fragmentation of inputs and the assembly of goods across multiple countries, adding value at each step of the production process. This shift reflects a departure from traditional manufacturing processes, where goods were typically produced in a single factory.

However, opinions among experts diverge regarding the trajectory of GVC development, particularly considering recent global crises and geopolitical tensions. While some argue that GVCs represent a fundamental aspect of 21st-century industry globalization, with intensified connections among global firms, trade, investments, production, and consumers, others caution against overestimating their resilience, especially given recent challenges. Kano (2018) projected that future GVCs will require significant transformation, particularly in terms of enhancing supply chain resilience to navigate the complexities of global fragmentation in production and trade service.

Scholars have identified various evolutional stages of GVCs, each characterized by distinct phenomena. Kaplinsky, (2019) categorizes the primary phase as outsourcing, while Gereffi, (1996) refers to it as Global Commodity Chains. While Jones & Kierzkowski, (2004) describe it as the Disintegration of Production Chains, while Chen, Bart, Los, Marcel, Timmer et al. (2018) introduce the concept of Global Production Sharing with factor incomes, emphasizing the role of factors such as labor and capital in shaping global production networks. Finally, Baldwin & Okubo, (2018) describe later stages of GVCs as the industrialization and de-industrialization phase of the second unbundling, focusing on the transformation of manufacturing processes and the emergence of Global Supply Chain.

The concept of Global Value Chains (GVCs) has evolved over the past three decades from a theoretical research framework into applied research fields, gaining significant attention from policymakers. This progression highlights the importance of bridging theoretical frameworks with practical applications. Various analyses and approaches have emerged to reveal the dynamics of GVCs, reflecting their continuous evolution and adaptability. These changes are often driven by the networks formed between policies within International Organizations (IOs) at different stages of economic development. Figure 2 illustrates the different stages of the evolution of GVCs, providing a visual framework for understanding perspectives on GVC engagements as captured by contemporary development research frameworks.

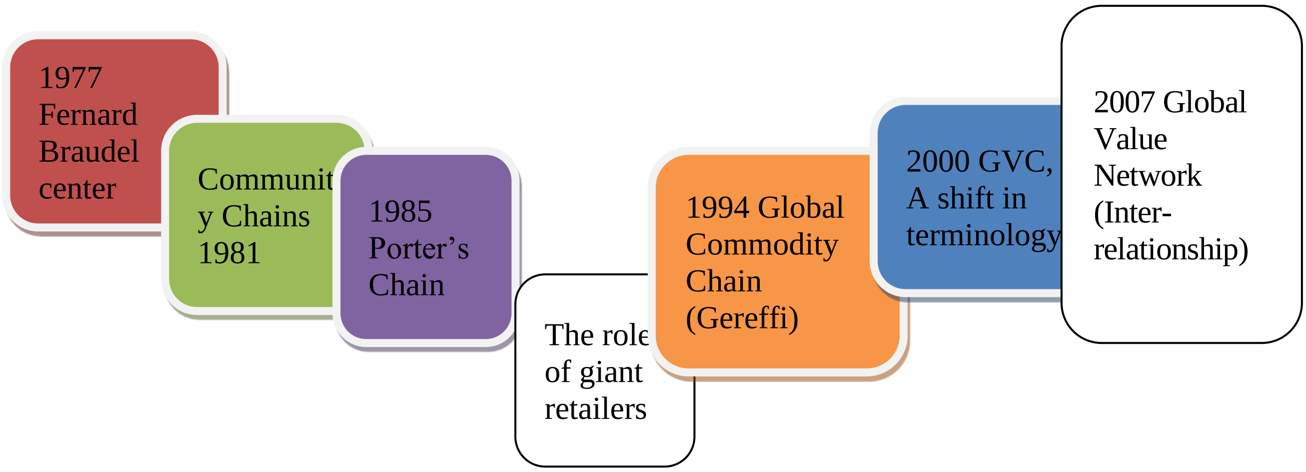

Figure 2: Mapping GVCs Evolution in transformation

Source: Own Elaboration

2.4. PARTICIPATING IN GVC AND THE DETERMINANTS

Participation in Global Value Chains (GVCs) has become increasingly crucial for countries aiming to enhance their economic development and integration into the global economy. As the world becomes more interconnected, understanding how countries engage in GVCs offers insights into their competitiveness, trade patterns, and opportunities for growth. This section examines the concept of GVC participation, exploring its significance, drivers, and implications for both developed and developing economies. This participation ranges from low to high levels, depending on the extent of a country's engagement in various stages of the production and supply chain. Higher participation typically implies a greater integration into GVCs, allowing countries to benefit from opportunities for specialization, efficiency gains, and access to global markets while the reverse is the case in lower engagements.

All countries engage in GVCs at various stages of production, contributing to the global economy in different ways. Gereffi (1996) explains that participating in GVCs does not necessarily involve directly trading goods and services; instead, it involves a company's integration into the process of value creation across geographical borders. Countries participate in GVCs based on the activities they perform or the extent of their contributions. This engagement can be grouped into categories such as (i) low participation with limited commodities, (ii) limited manufacturing, (iii) advanced manufacturing, (iv) services, or (v) innovation. Literature indicates an increasing number of countries progressively participating in GVCs, yielding diverse results. Rodrik (2018) identifies two crucial levers that spur participation in GVCs. The first is the transformative impact, exemplified by the Asian Tigers and the benefits they reaped from the production of mobile phones, which significantly enhanced financial inclusion. Secondly, investing in development strategies that better connect developing countries to global economies is crucial. This trend has been facilitated by technological innovations in transport, information, and communication, which have lowered coordination costs. However, these benefits are not automatic; they tend to favor countries capable of producing at global standards in terms of quality and efficiency. Notably, developing economies are rapidly emerging as significant participants in GVCs, yet they predominantly trade in primary goods. In contrast, advanced countries are more heavily involved in services, thus benefiting more from advanced technologies. This trend highlights the evolving dynamics of global economic integration, where developing economies play a crucial role in producing and exporting raw materials, while advanced nations focus on high-value-added services and technology-driven sectors within GVCs. This shift has contributed to significant economic milestones, such as the record-breaking 14.5% surge in export volumes in 2010 and the productivity-enhancing movement of labor from agriculture to manufacturing and services.

Gereffi et al. (2005) reveal that GVCs enhance investments in skills. This is often seen by researchers as crucial for improving competencies and employment in addition to boosting productivity. Although many studies question the mediating role of skill-biased technology change (SBTC) on the GVCs skill premium hike, H. Li et al. (2021), by examining China's service industry from 1995 to 2014, argue that participating in GVCs increases skills and serves as a dominant driver for knowledge transfer, especially for developing countries. Their findings further indicate that SBTC accounts for 75% to 82% of the total effects of gains across various sectors, making it a significant factor in strengthening GVC participation. GVCs are distributed across sectors based on areas of competence or specialization. For example, Antràs (2020), using data from the International Bank for Reconstruction and Development (IBRD), categorizes countries based on their specialization: Madagascar is specialized in agriculture, Norway and Nigeria focus on natural resources like petroleum, and India and Singapore are concentrated in services.

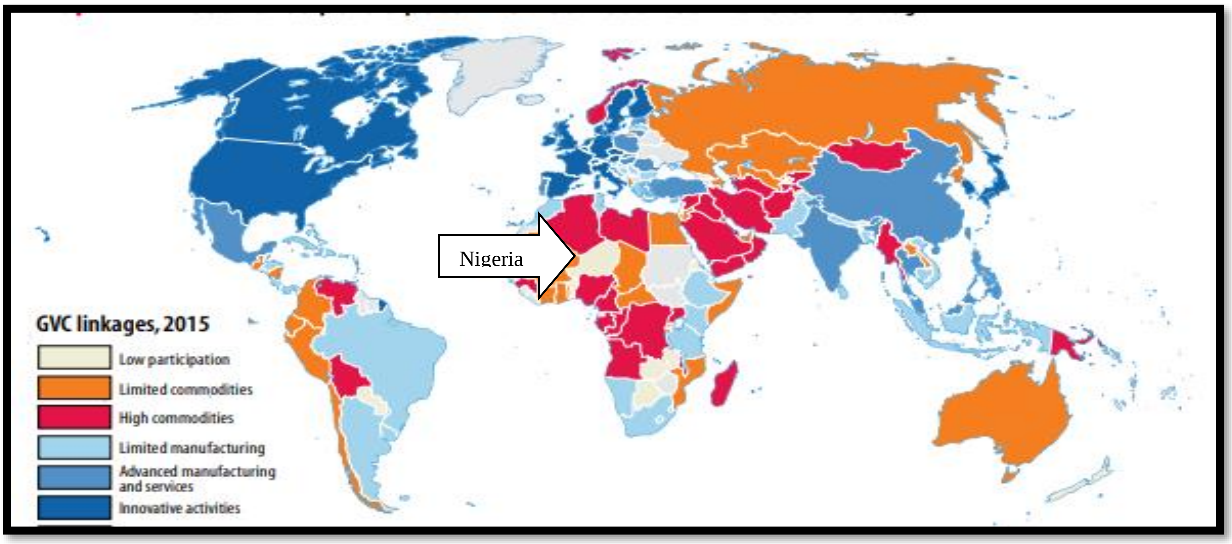

Figure 3: GVC Participation by country specialization

Source: Antràs (2020).

Unveiling a country's participation in GVCs is essential as it provides avenues for crucial policy guidance relevant to global trade. By identifying investment opportunities, barriers, or market inefficiencies, countries can mitigate risks and avoid significant losses. Additionally, leveraging GVC participation may necessitate new policies aimed at enhancing capabilities and facilitating knowledge transfer. For instance, Peter (2019) highlights the role of intermediate inputs in transferring knowledge across sectors and countries at various developmental stages. His research finds that GVC participation facilitates access to global markets and capital, particularly through technology transfer from high-income nations, with the greatest potential for knowledge spillovers occurring in countries at intermediate stages of development.

Similarly, Fuller (2022), in their study of interdependent development patterns among nations, reveals that large multinational corporations benefit disproportionately from participating in GVCs. This underscores the importance of creating policies that ensure more equitable benefits across different economic actors and development stages. By understanding these dynamics, countries can better position themselves within GVCs, enhancing their economic growth and development.

While there seems to be an on-going debate regarding the advantages and disadvantages of large multinational corporations, particularly in terms of market dominance in emerging markets, proponents argue that the advantages primarily arise from significant capital investments, advanced technology, and stronger negotiation power. These factors enable multinational corporations to secure favorable terms from smaller domestic firms. However, critics contend that the implications are broader and more complex. One notable concern is the potential for these dominant players to lock emerging markets into low-value-added GVC categories. This phenomenon could limit the capacity of domestic firms to move up the value chain and capture higher value-added activities, ultimately hindering economic development and diversification. As a result, domestic firms may face reduced incentives for efficiency improvements, product differentiation, and technological advancements. This limitation can diminish positive spillovers, such as knowledge transfer and innovation, which are essential for the sustainable growth of local industries. Therefore, while multinational corporations can bring immediate benefits through investments and technology, their dominance can also pose long-term challenges for the development of emerging markets.

On the other hand, GVC participation introduces several risks, such as heightened vulnerability to global business cycles and supply disruptions, as well as increased environmental costs, particularly for emerging nations (Global Center on Adaptation & African Development Bank, 2019).

In terms of measurement, GVCs also present challenges. While the gross value of trade in parts and components offers insight into GVC trade, standard gross trade flows tend to record the value of intermediate goods multiple times across the production network (Borin & Mancini, 2019). Moreover, the added value is sometimes allocated to countries involved in the final stage of production, leading to potential distortions and imbalances in GVC measurements.

Recognizing these limitations, modern research has focused on measuring trade in value-added terms. The OECD (2023) Trade in Value Added (TiVA) database exemplifies this approach, aiming to provide a more accurate and nuanced understanding of the contributions of different countries within global production networks. This method seeks to capture the real economic value generated by each country, thereby offering a clearer picture of global trade dynamics and the true economic contributions of nations.

Determinants of participation in GVC

The determinants of participation in Global Value Chains (GVCs) are multifaceted and reflect the complexity and diversity of global trade networks. These determinants can be broadly categorized into several key factors such as economic conditions, infrastructure, policy environments, human capital, institutional quality, technological capabilities, natural resources, and regional factors.

- **Economic Factors** play a significant role in GVC participation. Larger markets with higher demand attract more participation, as countries with significant consumer bases or industrial demand are more likely to be integrated into global supply chains. Additionally, cost competitiveness, which includes low labor costs, favorable exchange rates, and cost-effective raw materials, can enhance a country's attractiveness as a GVC participant. Countries that manage to keep production costs low while maintaining quality are better positioned to become integral parts of global supply chains
- **Infrastructure and logistics** are also crucial for effective GVC participation. Efficient transportation networks, such as ports, roads, railways, and airports, facilitate the smooth movement of goods, making a country more viable as a GVC participant. Similarly, advanced telecommunications and ICT infrastructure enable better coordination and management of GVC activities. Countries with well-developed logistical and digital networks can handle complex supply chain operations more effectively, enhancing their role in global value chains.
- **Human capital and skills** are essential for GVC participation. A skilled workforce capable of handling complex production processes and technologies is crucial. Investments in education and training, as well as innovation and research and development (R&D), help countries move up the value chain. Countries that prioritize building a knowledgeable and adaptable workforce are better equipped to meet the demands of modern GVCs, which increasingly require advanced technical skills and continuous innovation.
- **Technological capability** is increasingly important in GVC participation. Countries that are quick to adopt new technologies can more effectively participate in and benefit from GVCs. Access to and integration of digital technologies, such as automation and data analytics, are vital in modern GVCs. Technological advancements can streamline

production processes, enhance product quality, and reduce costs, making countries more competitive in the global market.

- **Institutional quality** is another key determinant. Stable political environments and strong governance structures provide the predictability and security needed for GVC investments. A robust legal framework that protects property rights and enforces contracts is essential. Good governance and reliable institutions help build investor confidence, ensuring that business operations can be conducted smoothly and that investments are protected.
- **Natural resources** also play a critical role in GVC participation. Countries with abundant natural resources often participate in GVCs, particularly in industries like mining, oil, and agriculture. Sustainable management of these resources is becoming a critical factor as global supply chains prioritize environmental and social governance (ESG) criteria. Ensuring that natural resource extraction and usage meets global sustainability standards can enhance a country's reputation and attractiveness as a GVC participation.
- **Geopolitical and regional factors** can impact GVC integration. Geographic proximity to large consumer markets or industrial hubs can enhance participation due to lower transportation costs and shorter lead times. Participation in regional economic blocs and initiatives can boost GVC integration through improved market access and regional cooperation. Countries that are strategically located and actively engage in regional trade agreements can leverage these advantages to enhance their GVC participation.

In developing economies, such as those within the Economic Community of West African States (ECOWAS), GVC integration is often characterized by backward integration. Factors such as trade openness, foreign direct investment (FDI), education, and infrastructure development are critical for these countries to enhance their GVC participation Mensah & Fofana (2018). Establishing preconditions like open trade and investment regimes, human capital development, infrastructure improvements, capital availability, and better institutional quality are essential for facilitating GVC integration (OECD, 2023).

Recent focus on the internationalization of industries and countries' participation in international production chains emphasizes the importance of measuring transactions in Trade in Value Added (TiVA) (OECD, 2023). Improved institutional quality, encompassing reforms in trade, investment, innovation, and skills, according to Kano et al. (2020), further supports GVC participation. Key determinants include the size and quality of education systems, domestic market size, per capita income, and industrial development levels, which collectively impact forward and backward linkages in GVCs (OECD, 2018).

2.5. GVC MARKET GOVERNANCE CONCEPT

Global Value Chains (GVCs) represent a sophisticated framework that orchestrates production and trade activities across international borders, leveraging competitive advantages in diverse locations. Market governance within GVCs encompasses the mechanisms and structures that harmonize these decentralized operations, ensuring smooth functioning across all stages of the chains. A crucial aspect of understanding GVC market governance lies in analyzing how economic agents interact within these expansive production networks. This interaction not only shapes economic development but also provides insights into the distribution of roles and responsibilities within the value chain.

Kano, (2018) emphasizes the role of information flow in enhancing production processes, highlighting its significance in coordinating activities among different stakeholders. Also, Barrientos et al. (2005, 2016) contribute further by identifying five distinct modes of governance that operate between lead firms and their suppliers. These modes elucidate how coordination and function dynamically unfold within GVCs, shedding light on the mechanisms through which decisions are made and resources are allocated across global production networks. Gereffi et al. (2005), distinguish between buyer-driven and producer-driven chains, underscoring the varying dynamics of governance structures based on the dominant role of lead firms in the value chains. Moreover, recent research byPananond et al. (2020) expands on these insights by introducing five models of governance structures. These models illustrate the evolving nature of governance mechanisms in response to market changes and technological advancements, reflecting the adaptive strategies of lead firms in managing global supply chains effectively, thus making GVC market governance pivotal for comprehending the intricate coordination mechanisms that underpin global production network as illustrated in figure 4.

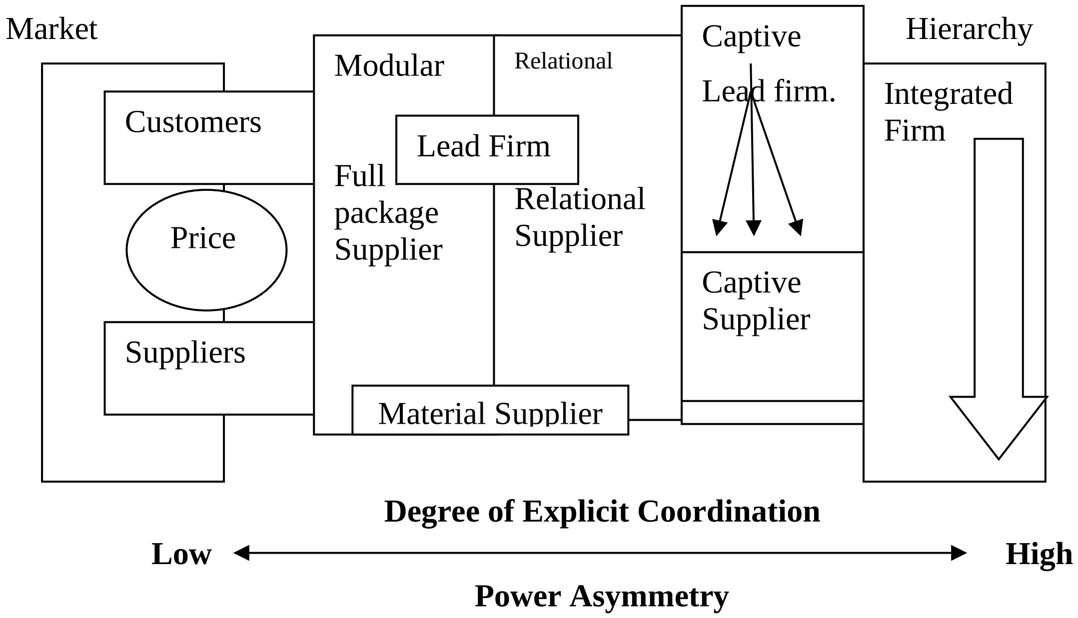

Figure 4: GVC Governance

Source: Gereffi et al. (2005)

2.5.1. Types of Market Governance

The governance structures within Global Value Chains (GVCs) are essential for understanding how value is created, distributed, and captured among the different actors involved in production. These governance types, identified by Gereffi, Sturgeon, et al. (2005) include market, modular, relational, captive, and hierarchical. Market governance is characterized by open-market transactions with minimal coordination, where suppliers and buyers operate independently. Modular governance involves suppliers producing to customer specifications using adaptable technology, while relational governance is based on mutual dependence and trust, often facilitated by long-term contracts. Captive governance sees small suppliers highly dependent on dominant buyers who exert significant control, and hierarchical governance involves vertical integration where the lead firm owns and controls most production processes.

According to Cattaneo et al. (2013), these governance types can be further extended into five distinct models, each offering unique insights into the management and coordination of activities within GVCs. Ponte & Sturgeon (2014) highlight that governance is determined by the ability to codify information, the supplier's capability, and transaction complexity. Building on Sturgeon, et al. (2005) it is noted that transactions tend to increase when lead firms place new demands on the value chain, such as just-in-time supply. Supplier capacity relates to product differentiation, while the ability to codify information is associated with establishing new technical demand.

(i) The "Market" type of GVC is characterized by open-market transactions with minimal coordination, where suppliers and buyers operate independently. Coordination and control among value chain actors primarily rely on market mechanisms such as price signals, contractual agreements, and competitiveness. Transactions between different actors are mediated by market forces, with limited direct intervention or coordination by any single actor or organization. This approach is often associated with industries characterized by relatively standardized products and services, low transaction costs, and intense competition (Hernández & Pedersen, 2017). While this model offers flexibility, efficiency, and adaptability, it can exacerbate power imbalances and inequalities among value chain actors, particularly when lead firms hold significant market power and can dictate terms to smaller suppliers. Additionally, relying solely on market mechanisms may limit opportunities for collaboration, innovation, and long-term relationship building within the value chain (Pananond et al. 2020).

(ii) In "modular" GVC governance model, lead firms focus on core activities such as product design, branding, and marketing, while outsourcing non-core activities, such as manufacturing or logistics, to specialized suppliers or contractors. This modularization of production allows firms to leverage external capabilities, access expertise and respond quickly to changes in market demand or technological advancement/s. Although information is also easy to codify particularly as it offers opportunities for firms to optimize their value chain operations, enhance competition and drive innovation through strategic outsourcing; Jones & Kierzkowski (2004) explain that it poses some challenges that relates to coordination, quality control, and supply chain resilience, particularly when managing complex networks of suppliers and contractors across different countries or regions. Additionally, reliance on external suppliers for critical components or modules may expose firms to risks of supplier reliability, supply chain disruptions, and intellectual property protection deficit.

(iii) But in the case of "relational" governance emphasis is more on long-term, collaborative relationships and partnerships among value chain actors, characterized by trust, mutual dependence, and shared objectives. In this classification, Gereffi et al. (2005) cited the improvement of capabilities through lead firms support as gains to emerging and developing countries, whereas in "modular" value chains, the exchange of information is between lead firms and first-tier suppliers thus, creating the risk of dominance. Furthermore, Niehoff et al. (2022) argue that the modular approach within GVCs can only be fully exploited when firms adopt it in both technology and organization. This implies that achieving the full benefits of modular governance requires not only technological modularity but also organizational modularity, where firms are structured in a way that facilitates flexibility, specialization, and collaboration across different modular components of the value chain. By aligning both technological and organizational aspects, firms can effectively leverage the modular approach to optimize their operations, enhance their capabilities, and adapt to changing market conditions within GVCs. Given the work of Gancarczyk et al. (2017) emphasize a shift in Global Value Chain (GVC) governance towards complexity, highlighting a transition from governance driven solely by market dynamics to governance as a strategic instrument for coordination. Their work underscores the role of innovation as a pivotal driver of development and growth within GVCs, signaling a shift towards more integrated and coordinated approaches to harnessing economic potential across global production networks.

(iv) In the other hand, the "captive" type of governance involves a hierarchical structure where lead firms have full control and ownership over all stages of the value chain, from production to distribution. In this model, the lead firm integrates vertically by internalizing various activities within the value chain, rather than outsourcing or collaborating with external suppliers or service provided. The advantage is that it allows the maintenance of high-level coordination, quality control and the capture of a larger share of the value created within the chain. However, experts argue that it poses challenges relating to high investment costs, inflexibility, and dependence on internal resources. In developing countries, the captive model tends to limit opportunities for innovation, knowledge sharing, and collaboration with external partners, which are essential for adapting to changing market conditions and driving of long-term competitiveness Ryan et al., (2022).

(v) In the case of the “hierarchy” type of GVC, governance involves a centralized and hierarchical structure where lead firms exercise significant control and coordination over value chain activities. In this model, lead firms maintain a dominant position within the value chain, thus dictating terms to suppliers and subcontractors, and exerting control over production processes, distribution channels, and market access. While the hierarchy GVC governance model offers advantages such as control, coordination, and efficiency, it may also pose challenges related to power imbalances, dependence on lead firms, and limited autonomy for suppliers and subcontractors. The structures provide a framework for analyzing how firms interact and coordinate within GVCs, shaping their roles and competitive strategies.

In comparing the captive and hierarchy levels sometimes compete to produce more satisfying results through detailed specifications. In this category, Gereffi et al. (2005) explains that without direct ownership, global buyers are not able to coordinate or control spatially dispersed manufacturing activities although the level of coordination may likely vary depending on the level of market/s. However, where power is in the middle-range, shaping the relationship could be in-between the actors. By highlighting the distinct coordination in separate chains and matching them with the relationship that contains the vertically integrated or producer driven chain, Gary Gereffi, the pioneer in value chain analysis, used the global commodity network that ties the concept of value-added to global industrial organizations to spur attention on the role of networks among cross-border co-evolution in industries (Dolan & Humphrey, 2004). Based on this degree of standardized supplier relationship, three types of relationships exist such as: a) the commodity, b) the capital and c) the turn-key types of supplier relationships, but the complexity of information and market relationships between them are streamlined. There is a lot of literature on these governance needs. While Gereffi et al. (2005) refer to those production systems that hirers are competent as turn-key suppliers in the category of modular, Humphrey & Schmitz, (2001)Humphrey and Schmitz (2001) distinguished between quasi-hierarchy relationships with buyers whose conditions correspond with the captive category.

The key determinants involved in the coordination within the hierarchy according to Gereffi (1994) is illustrated in the global apparel example as characterized by the captive governance between 1950s and 1980s, with that of the 1990s being characterized by relational governance with increased production and tasks in the geographical locations of Japan. This finally has created room for specifications of the type of suppliers’ relationship needed per time by global buyers, thus, the key determinant of GVC governance as highlighted in table 3.

Table 3 Important determinants of GPVC Governance

Type of Governance	Complexity of transaction	Ability to codify	Capability in the supply-base	Degree of distinct coordination
Market	Low	High	High	Low
Modular	High	High	High	
Relational	High	Low	High	
Captive	High	High	Low	
Hierarchy	High	High	Low	High

Source: Gereffi et al. (2005)

2.5.2. The Complexities in Market Governance

The complexities of market governance within Global Value Chains (GVCs) are multifaceted, involving dependency, governance issues, and policy mismatches. These complexities are most often due to the decentralized coordination among actors relying on price signals and contractual agreements. This model can lead to challenges in ensuring the alignment of incentives and managing risks across the chain. The decentralized approach often results in information asymmetries, varying standards, and potential power imbalances between lead firms and suppliers, which can significantly influence outcomes within the value chains. These complexities vary by institution and sector. For instance, in the oil sector, market governance involves coordination through price mechanisms and contractual agreements among various stakeholders, including oil producers, refiners, and distributors. This decentralized approach can lead to challenges such as fluctuating prices, differing quality standards across supply chains, and dependencies on market dynamics. Analyzing the oil price transmission in gasoline and diesel markets. Svetlana Maslyuk and Russel Smyth (2009) revealed that spot price for gasoline do show asymmetry in response to crude oil price changes and this often reflect levels of inventory adjustment effects. Similarly, Haliloglu, (2021) highlighted short-run market power among petroleum product retailers, noting asymmetrical responses of retail prices to wholesale price changes and their implications on exchange rates. Despite these complexities, market governance allows flexibility in adapting to global market shifts and optimizing efficiencies, highlighting its role in shaping the oil sector's resilience and competitiveness.

Beyond the oil sector, complexities in GVC market governance include issues related to codification, degree of coordination, dependency, and governance. Suppliers often require high capabilities due to the specialized nature of their products and services (Werner & Bair, 2019). Dependency and governance issues further complicate market governance, especially in developing countries. McAuslan (2019) highlighted that some suppliers exploit dysfunctional governance systems to evade taxes and engage in informal contracts. Carballa Smichowski et al. (2021) pointed out global policy-theory mismatches, where conceptual elaborations in theory are poorly reflected in practice. While Antras (2014) and Fernandes et al. (2020) emphasize the mis-leading terminological opposition, Verhoogen et al. (2018) argued that firms often operate in multiple value chains, each subject to different forms of governance both nationally and globally.

Looking further as researchers continue to explore the GVC-GDP relationship, critiques of the governance approach have emerged. Some argue that the analytical focus has shifted towards the meso level of sectoral dynamics and the micro level of firm upgrading, neglecting the programmatic formulation of buying objectives and practices in global trade. Ponte & Gibbo (2005) noted that findings in GVC analysis often reflect theoretical biases, suggesting a need for more comprehensive and empirical approaches. The concept of drivenness, along with Gereffi's buyer-driven versus producer-driven dichotomy, has faced criticism for not encompassing all chains neatly. The distinction between producer-driven and buyer-driven models, while insightful, may not capture the full spectrum of governance types present in various industries.

In analyzing each of Gereffi's governance models, the market, modular, relational, captive, and hierarchical reveals distinct advantages and challenges. The suitability of each model depends on industry characteristics, market dynamics, and the objectives of value chain actors. Market governance offers flexibility but can exacerbate power imbalances and limit collaboration opportunities. In the oil industry, which involves complex and capital-intensive operations, understanding and effectively managing market governance is crucial for enhancing stability, sustainability, and profitability across the value chain.

Modular governance facilitates specialization and innovation but poses coordination challenges. Relational governance builds trust and cooperation but requires significant investment in relationship management. Captive governance allows for efficiency and quality control but creates dependency issues, while hierarchical governance ensures control but limits flexibility. impact of these governance models on industries can be significant. Industries characterized by standardized products and intense competition may benefit from market governance, leveraging price signals and competitiveness to drive efficiency. High-tech industries might prefer modular governance to capitalize on specialized external capabilities and rapid innovation cycles. Industries requiring close cooperation and customized solutions may thrive under relational governance, fostering long-term partnerships. Sectors dependent on specific suppliers or facing complex supply chains might adopt captive governance for greater control, while industries with integrated operations may benefit from hierarchical governance for streamlined processes and consistent quality. Understanding these governance models can help industries including the oil sector to optimize their value chain strategies, thus enhancing their competitiveness and adaptability in global value chains.

2.6. UPGRADING IN GVC

Upgrading within Global Value Chains (GVCs) is a pivotal concept that encompasses the strategies and processes through which firms, industries, and economies enhance their positions and capabilities within the global trade terrain. It involves the advancement of production, technology, skills, and market access to achieve higher value-added activities and greater competitiveness.

It also refers to the process by which firms, industries, or countries move to higher-value activities in the value chain, enhancing their competitiveness and economic returns. Upgrading can take various forms, including product upgrading (shifting to more sophisticated products), process upgrading (improving production processes), functional upgrading (acquiring new functions within the value chain), and inter-chain upgrading (moving into new value chains). This process is crucial for firms in developing countries, as it enables them to capture more value from their participation in GVCs and move beyond low-value, labor-intensive activities. Humphrey & Schmitz, (2001) describe it as the process that typically entails improvements in product quality, innovation, efficiency, and competitiveness. It allows firms to move towards higher value segments of the value chain and facilitates the increase of their share of value creation.

One of the few choices open for countries to structurally upgrade their economy is in “moving up” as it tends to buffer increased participation in GVCs. According to Hua (2017) participating or moving horizontally to new GVCs through the production of higher value per unit of output with improved knowledge and skills can also be referred as Upgrading.

Giuliani (2005) noted that the importance of GVC upgrading lies in its potential to foster economic development, innovation, and skill acquisition. By engaging in higher-value activities, firms can increase their productivity, improve their capabilities, and gain better access to international markets. However, the path to upgrading is often fraught with challenges. Firms may face barriers such as lack of access to finance, technology, skilled labor, and the necessary institutional support. Additionally, governance structures within GVCs, such as buyer-driven or producer-driven chains, can influence the opportunities and constraints for upgrading. Successful upgrading often requires strategic interventions by governments, including investment in education, infrastructure, and supportive policies to create an enabling environment for firms to move up the value chains. Kaplinsky (2019) and Giuliani (2005), in their definition of upgrading proclaim “added value” as innovation, thus categorizing upgrading into four groups based on reviews. The discussion typically proceeds to explore different types or dimensions of upgrading within GVCs, including product, process, functional, inter-firm, inter-sector, social, and environmental upgrading, each representing distinct improvement aspects within the value chains.

2.6.1. Types of Upgrading

Global Value Chain upgrading types play a crucial role in advancing a firm's position within international markets by shifting towards higher value-added activities. This process encompasses diverse strategies through which economic entities can enhance their capabilities and outputs (Kano et al., 2020). Within value chains, various forms of upgrading distinguish firms based on their strategic functions. In the realm of industrial development, particularly in emerging economies, key types of upgrading include process, product, functional, and chain upgrading, as articulated by Kaplinsky (2019). These types of upgrading are closely linked to concepts identified by Humphrey and Hubert Schmitz (2001) such as functional and inter-sectoral upgrading.

- **(i) Product upgrading** takes place when the company can introduce new products, modify the design, improve the quality, and supply a product that has a higher value added, by virtue of the level of its sophistication. According to (Cui et al., 2024); and (Kaplinsky, 2019), it also involves moving the sophistication within an existing value chain with indicators such as: export growth and the share value of exports. While the authors suggest a combination of growth in the duo as having the tendency to provide a better product upgrade, (Chen Bart Los Marcel Timmer et al., 2018) argue that higher prices for the exported product can reflect an upgrade in view of improved quality of input/s. However, Ignatenko, (2019) in their analysis of upgrade suggests that the differences in product quality seem the overall strength of product upgrade as determined by consumers' preference.
- **(ii) Process upgrading:** This involves improving the efficiency and effectiveness of production processes, thereby enhancing productivity and reducing costs. Process upgrading often involves adopting new technologies, improving manufacturing techniques, or optimizing supply chain logistics.
- **(iii) Functional upgrading** as noted by Cattaneo, Gereffi, and Staritz (2021) means acquiring new, higher-value functions within the value chain, such as moving from manufacturing to design or marketing. In this case, the company can offer competitive products with greater value added depicted by higher capacities. It involves the increase in highly skilled workers which invariably tend to promote skill intensive activities; thus, allowing changes both in the upstream and downstream of the production process. However, some literature argues that this type of upgrading process has conditions that may hinder some forms of designs, marketing, and branding (e.g. the reluctance of transferring the core skills).
- **(iv) Chain upgrading** or "Inter-chain upgrading" corresponds with the connection or movement from one industry to another. It thus occurs when a company can refocus or position its activities in new GVCs with higher value added. Very often, chain upgrading could also be referred as "institutional upgrading" and tends to improve competitiveness as well as promote greater integration into the GVCs(Kaplinsky, 2019).
- **(v) Inter-sectoral upgrading:** This refers to the transit of a firm into higher value-added activities by moving across different sectors within the supply chain and contributing to increased competitiveness with expanded capabilities.
- **(vi) Social Upgrading**: This refers to the enhancement of wellbeing and working conditions of individuals involved in specific production processes of the chain especially in the context of wages, job security, better working hours, worker empowerment as well as access to training. It ensures that the benefits of participation in GVCs are not only economic but also entails the contributions towards the social aspects of communities and labor.
- **(vii) Environmental Upgrading**: This type of upgrading focuses on minimizing the negative impacts associated with supply chains and other production activities. It entails

the adoption of sustainable eco-friendly methods, reduction of carbon footprints, minimizing resource depletion and addressing issues of pollution and waste management. Environmental upgrading is therefore critical in the support and alignment of industries with global sustainability goals in view of its concerns on climate change and environmental degradations particularly in the oil industry.

GVC upgrading offers firms in developing countries pathways to enhance their competitive edge and economic standing by moving into higher value-added activities. However, this process presents several contradictions and implications. On one hand, upgrading can lead to increased efficiency, innovation, and access to new markets, boosting a firm's growth and profitability from low-skilled activities and then moving up the ladder of GVC through Learning-By-Doing, (Pietrobelli and Robellitti, 2011). On the other hand, it often requires substantial investments in technology, skills, and infrastructure, which can be challenging for resource-constrained firms(Humphrey, 2004), or firms entering new GVC segments, (Sampath & Ayitey, 2016). Additionally, the benefits of upgrading are not uniformly distributed; while some firms succeed in capturing more value, others struggle to compete or become dependent on volatile global markets according to Cattaneo et al. (2021). This dynamic can exacerbate inequalities within and between countries, thus raising questions about the equitable distribution of the gains from GVC participation. Upgrading within Global Value Chains (GVCs) is crucial for economic growth and development, particularly for developing countries. Section 2.6.2. has the key points highlighting the reasons and channels through which upgrading can be achieved:

2.6.2. Importance & Channels of Upgrading in GVC

(i) Easy route to industrialize.

Participation in Global Value Chains (GVCs) offers a relatively straightforward path to industrialization for developing countries. By integrating into these global networks, countries can specialize in specific stages of production that align with their existing capabilities and resources, allowing for gradual and sustainable economic development.

A prime example of this process is Bangladesh, which has successfully transitioned from a focus on jute mills before its independence to becoming a major player in the global garment industry. Since joining the garment GVC in the 1980s and 1990s, Bangladesh has seen exponential growth in the number of garment manufacturers, increasing from about 300 in the 1980s to around 6,000 by the 1990s. This growth translated into significant economic benefits, with garment exports rising from over US$25 billion in 2014 to US$34 billion in 2019, a remarkable 79% increase within five years. The garment sector now accounts for 80% of the country’s foreign exchange earnings (Sumon Hossain et al., 2022).

Bangladesh’s entry into the export-driven system began with the introduction of sewing machines by foreign suppliers, which allowed local women to assemble garments. This initial step into the GVC has since evolved into a comprehensive socio-economic driver, encompassing all aspects of garment manufacturing, including yarn production, sewing accessories, and textiles. The country's integration into the GVC has not only spurred industrialization but also significantly improved the socio-economic landscape, providing employment and driving economic growth.

Similarly, other countries such as Indonesia, Vietnam, and Cambodia have experienced substantial industrialization through their involvement in the clothing industry GVCs. These countries have leveraged their participation in GVCs to develop robust manufacturing sectors, enhance export performance, and achieve significant economic progress.

While the economic benefits of GVC participation are evident, it is crucial to also consider the environmental and social impacts. The dispersion of production fragments across multiple locations can lead to diverse environmental challenges, such as increased carbon emissions and resource depletion. However, it also presents opportunities for adopting sustainable practices and technologies that can mitigate these impacts. Socially, GVC participation can lead to improved labor standards and working conditions, especially when global companies adhere to strict regulatory frameworks and corporate social responsibility (CSR) policies.

Overall, the easy route to industrialization through GVC participation offers substantial benefits for developing countries. By engaging in global production networks, countries can achieve significant economic growth, enhance their industrial capacities, and improve socio-economic conditions. The example of Bangladesh highlights the transformative potential of GVCs, while the experiences of Indonesia, Vietnam, and Cambodia underscore the widespread applicability of this development strategy. As countries navigate the complexities of GVC participation, balancing economic gains with environmental and social considerations will be essential for sustainable and inclusive growth.

(ii) Competitiveness & product access

Xu & Luo (2018), discuss how the fragmentation of goods and services across multiple locations can yield significant advantages, particularly in terms of cost-effectiveness and competitive positioning. For instance, China imports iron ore from Australia, converts it into steel products, and exports these products to Germany for car manufacturing, primarily targeting consumers in the United States. This process not only highlights the interconnectedness of GVCs but also underscores the economic benefits derived from spatial fragmentation. According to Haliloglu (2021) the primary advantage is cost-effectiveness, as the products remain highly subsidized, which, in turn, supports employment and allows consumers to purchase goods at more affordable prices.

However, critics argue that the extensive fragmentation and separation of production and consumption have led to significant environmental and social challenges, particularly for China. This issue has sparked ongoing debates, especially regarding the ability to capture a higher share of value-added products within GVCs (OECD, 2013). Bolea et al. (2022) assert that learning and innovation are crucial determinants of competitiveness and growth for both firms and countries, enhancing efficiency and promoting structural transformation.

Ponte & Gibbon (2005) expand on the concept of upgrading, emphasizing the creation and control of value associated with the quality of technology and product attributes. They highlight the importance of product quality (intrinsic properties) and personal attributes/skills (technological upgrades and adaptability) in driving competitiveness and value creation.

In the petroleum industry, technological advancements have revolutionized operations, leading to more efficient and sustainable services. Rodrik (2018) explains that new technologies, such as cloud-based computing for oil and gas seismic exploration, enable high-precision exploration over a wide area of 2000 kilometers while simultaneously collecting vast amounts of data through high-density broadband. According to Bughin et al. (2017) by leveraging the works of McKinsey on investing in digital technologies posit that artificial intelligence can save oil and gas companies more than 20% on capital expenditures and 5% on upstream operating costs quarterly, thereby boosting profitability and facilitating technological upgrade.

Overall, the positive impact of product assessment on the petroleum industry for instance, can be evidenced in enhanced operational efficiency, improved competitiveness, and greater accessibility to high-quality products. Thus, technological advancements contribute to the sector's ability to meet consumer demands effectively while maintaining sustainable practices.

(iii) Skills upgrade and access to global best practice

The availability of highly devoted, talented, and inventive entrepreneurs has been identified as a critical requirement for Global Value Chains (GVCs) and process upgrading Gereffi et al. (2005) Consequently, many nations have structurally transformed their economies by leveraging GVC participation, utilizing locally available human and natural resources. These nations often rely on low-skilled workers willing to work for lower wages in exchange for the opportunity to develop their abilities during the production process. For instance, the revolution of Taiwan's computer industry in the early 1980s was centered on utilizing pre-existing basic production skills and design capabilities.

Integration into GVCs allows participants to interface with superior technology, nurturing domestic skills and facilitating skill upgrades. The inclusion of industry-specific skill upgrades and training that meet international standards can significantly enhance skills in oil production and refining processes, with extended benefits to other industries. Workers can also learn new "soft skills" that improve their efficiency in production and refining processes or in new and emerging production activities.

Despite success stories in Sub-Saharan Africa, where oil-rich countries have developed significant oil industries, these nations remain export-dependent. Countries like Angola and Nigeria, despite being rich in crude oil, are heavily dependent on this single commodity. For example, Nigeria, a significant exporter of petroleum products, still relies on oil imports due to limited refining capacity. This underscores the necessity for technology transfers to reduce dependency and facilitate upgrading opportunities.

Oil-rich countries in Sub-Saharan Africa, such as Angola and Nigeria, are heavily reliant on crude oil exports, with substantial potential for growth in the global hydrocarbon market. Achieving self-sufficiency by 2025 is a target for Nigeria, but it requires significant improvements in technological and vocational skills, organizational changes, and competitiveness. Developing local skills and promoting technology transfer are essential for these transitions. These involve costly strategies such as training, networking, and technology adoption, especially in the era of Industry 4.0, where automation, digitization, and AI play crucial roles in transforming the oil and gas sector and enhancing GVC participation.

Bridging skill gaps is crucial for successful technology transitions. For developing nations, this involves adopting global best practices through multiple channels: industry-specific training programs to upgrade skills, fostering collaborations between local firms and international technology leaders, investing in state-of-the-art equipment, and integrating advanced technologies in production processes. By focusing on these areas, developing nations can enhance their capabilities, improve productivity, and increase their share of value-added activities within GVCs. This will not only boost their economic resilience but also ensure sustainable growth and development.

(iv) Emergence of new and peripheral productive activities

Typically, nations at earlier stages of development often tend to export a narrower range of products while increasing their import volumes. One of the key benefits of participating in GVCs is the introduction of new peripheral activities that provide a wider range of options. Mitra (2020) in examining the drivers and benefits of enhancing GVC participation and upgrading, explains that GVCs allow for the integrated presentation of production for small firms through collaborations with sectors such as transport and logistics, banking and financial services, insurance, healthcare, education, and a variety of other support services. This lessens our high dependence on importing activities.

When primary products are processed locally, the economy not only expands but also dramatically loosens other structural transformation limits. Improved logistics services, for example, would dramatically lower trade expenses, which have been found to impede trade ten times more than tariffs on average (Egbetokun et al., 2017). This contributes to boosting productive activities and trade in diverse products and intermediate inputs along the value chains.

The emergence of new and peripheral products through GVC participation is particularly significant for developing nations. By integrating into GVCs, these countries can diversify their economies, reduce dependency on a limited range of exports, and stimulate the development of various sectors. This diversification leads to a more resilient economic structure, capable of withstanding global market fluctuations and fostering long-term sustainable growth. The importance of GVCs thus lies in their ability to promote economic diversification, enhance productivity, and create new avenues for industrial and economic development.

(v) Export diversification.

China's experience illustrates the benefits of export diversification through GVC integration. By importing raw materials like iron ore from Australia, converting them into steel products, and then exporting these products to countries like Germany for car manufacturing, China has positioned itself as a critical player in multiple stages of the value chain. This approach not only enhances China's economic resilience but also boosts its technological capabilities and employment.

It allows countries to move beyond primary products and develop a wider range of options, including peripheral activities that support various sectors. Improved logistics services, for instance, significantly lower trade costs, which can be more prohibitive than tariffs. This expansion facilitates trade in diverse products and intermediate inputs along the value chain, contributing to economic growth and structural transformation (Kayizzi-Mugerwa et al., 2021). Overall, export diversification is vital for all countries to achieve economic stability, growth, and resilience. Through channels such as GVC integration, infrastructure development, trade agreements, and innovation, nations can expand their export base, reduce dependency on limited commodities, and foster a more robust and dynamic global economy. This approach not only benefits individual countries but also contributes to a more balanced and integrated global trade system.

(vi) Inclusive growth through structural transformation, job creation, wealth spread and poverty reduction.

As previously mentioned, Global Value Chains (GVCs) catalyze increased economic activities across a diverse array of businesses involved in global trade and associated sectors. These activities generate numerous employment opportunities, helping to spread wealth and reduce income inequality. Job creation extends beyond activities directly linked to the oil sector, encompassing peripheral and support services, thus providing additional momentum for GVC participation in developing countries.

To achieve growth aspirations in Africa, as highlighted by the African Development Bank (AFDB) in 2019, the initial step involves reviewing the macroeconomic stability of nations. This entails ensuring that monetary policies (such as exchange rates), trade policies (including taxes and customs administration), and fiscal policies (covering oil revenues, overheads, and recurrent expenditures) are effectively aligned with industrial policies for coordinated implementation. For example, promoting the linkages between the oil industries of Nigeria, Angola, and Senegal, other sectors, and universities is crucial for overall economic growth in the regions.

Currently, many industries in developing countries face challenges in GVC upgrading due to foreign exchange shortages, poorly interconnected systems, and low competitiveness despite the high demand for intermediate-level oil production. Experts suggest that a revitalized oil sector could support job creation, stimulate foreign exchange earnings, and foster the growth of microservice firms and SMEs, contributing to poverty alleviation. However, while GVC upgrading is often cited as a critical pathway for developing countries to build productive capacities, adopt advanced technologies, and develop skills, certain disadvantages can make these gains appear challenging. These include higher production costs, the risk of untested products, evolving market competition, and unprotected employment among vulnerable workers (Verhoogen et al., 2018.)

GVC participation spurs inclusive growth through structural transformation by promoting job creation across various sectors and supporting wealth distribution. This growth is not confined to the oil industry but extends to a wide range of connected activities and support services, thereby broadening the economic base. The key to harnessing these benefits lies in achieving macroeconomic stability, fostering strong industrial policies, and enhancing linkages between industries and educational institutions.

Despite the challenges, the potential benefits of GVC participation are significant. By overcoming barriers such as foreign exchange shortages and poor infrastructure, developing countries can enhance their competitiveness and leverage GVCs for sustainable economic development. This requires strategic investments in technology, skill development, and infrastructure to facilitate smoother integration into global production networks.

Conclusion, the role of GVCs in promoting inclusive growth is multifaceted, involving structural transformation, job creation, wealth distribution, and poverty reduction. For developing countries, particularly those in Sub-Saharan Africa, integrating into GVCs offers a pathway to diversify their economies, reduce dependence on single commodities, and foster long-term sustainable development. By addressing the inherent challenges and maximizing the advantages of GVC participation, these countries can achieve significant economic and social progress.

2.7. MEASUREMENTS IN GVCS AND TRADE IN VALUE-ADDED (TIVA)

Understanding the economic dynamics of Global Value Chains (GVCs) requires accurate and comprehensive measurement tools. One such tool is Trade in Value Added (TiVA), which offers a more precise method for capturing the value-added contributions of different countries within GVCs. Traditional trade statistics often suffer from statistical bias by attributing the full commercial value of trade to the last country of origin, leading to issues such as "double counting." This becomes particularly apparent when inputs cross borders multiple times during the production process (Mattoo et al., 2013).

To address these challenges, TiVA accounts for the value added at each stage of production, providing a clearer picture of how value is created and distributed across countries. The approach, outlined by OECD (2023) involves decomposing gross exports into their domestic and foreign value-added components. This method allows for a more reliable and nuanced understanding of a country's role and contribution within the global production network.

By using TiVA, policymakers and researchers can better analyze the real economic impact of international trade, facilitating more informed decision-making and policy formulation. This measurement is crucial for evaluating the actual value added at each stage of the production process, using metrics such as Backward, Forward, and Total GVC participation.

With this methodology, a more nuanced understanding of a country's role in global value chains can be developed. This measurement is also crucial, especially for the evaluation of the actual

value added at each stage of the production process. The standard way to evaluate GVC through trade in intermediate inputs is either by using the Backward, Forward and/or Total GVC participation where:
(i) Backward GVC participation refers to the share of foreign value-added in total exports or the ratio of the foreign value-added content of gross exports measured per time for a country. The United Nations Conference on Trade and Development (UNCTAD), defines it as a country's engagement in upstream activities within global value chains, such as raw material extraction, component manufacturing, and initial processing, often associated with importing intermediate goods or components for further production or assembly. It helps to identify the foreign contributions or intermediates utilized in the production of exported goods, thus offering insights into the extent of a country's integration into global value chains.
(ii) Forward GVC Participation refers in this context to the connections and relationships that the oil industry has with downstream activities in the global value chain, primarily involving the processing and transformation of its outputs into final products that reach the global market. This is primarily based on the indicators provided by (OECD) TiVA database. This indicator considers only exports of domestic value-added embodied in foreign export as forward GVC linkage across at least two border nations. However, there is an alternative definition of forward GVC participation that includes all domestic value-added exported as intermediate products, but TiVA does not consider this option. The alternative can be defined as the share of domestic value-added of gross export of a country contained in foreign exports. It traces the value-added from the final exported product and downstream activities (processing, assembly, and distribution) back to its utilization in the production processes of other countries.

(iii) Total GVC participation involves the comprehensive involvement of a country into the entire global value chain, encompassing both forward and backward linkages, indicating the extent to which a nation integrates and contributes to the global production networks (Mattoo et al., 2013).

However, while the statistics are valuable for the assessment of a country's integration into global value chains, the limitation is that TiVA predominantly focuses on advanced economies, with limited coverage of developing and vulnerable nations. Nevertheless, Nigeria is among the countries recently included in the TiVA database. Following this inclusion by OECD, the backward, forward, and total Global Value Chain (GVC) participation is graphed and explained in Chapter 5, thus, providing insights into the country's role in the global production network.

2.8. GVC AND DEVELOPING COUNTRIES

Global Value Chains (GVCs) play a critical role in the economic development of countries, especially for developing nations seeking to integrate into the global economy. By participating in GVCs, developing countries can leverage their comparative advantages, such as lower labor costs, to become integral parts of global production networks. This integration can lead to increased employment opportunities, technology transfer, and improved industrial capabilities, all of which are essential for economic growth and development.

However, it seems that the economic integration of developing countries into global trade evolved significantly over the centuries. Starting from the late 18th century with barter trade in Africa, it progressed through slave trading and faced disruptions during the European colonial invasion. Post-World War I and II, international economic integration advanced through trade, finance, and foreign direct investment, primarily driven by European colonial powers (O'Brien, 2004). The discovery of petroleum in parts of Africa, including Nigeria, post-WWII, further opened international trade avenues. The 1960s brought decolonization efforts, leading to increased international trade participation, particularly between 1995 and 2007, marked by significant growth in the manufacturing sector (Medeiros & Trebat, 2017).

Today, Asia's growing middle class presents substantial opportunities for Africa to expand trade. Participation in GVCs has been shown to positively affect GDP per capita, especially when accompanied by investment reforms and institutional connectivity (Nadeem et al., 2020). Global trade, driven by liberalization and openness policies, has become a major economic dimension for many developing countries, evolving from national to global channels aimed at promoting economic growth and poverty reduction.

Moreover, the involvement in GVCs can help developing countries diversify their economies and reduce dependency on a limited number of export commodities, contributing to more sustainable and resilient economic structures. Global trade, driven by liberalization and openness policies, has become a major economic dimension for many developing countries, evolving from national to global channels aimed at promoting economic growth and poverty reduction.

Global trade has represented and represents a major dimension of many developing countries' economies. According to liberalization and other trade policies, the openness index, an economic metric calculated as the ratio of total trade, the sum of imports and exports, and the GDP, tends to capture the importance of trade over the economic activities in different geographical context in many developing countries as well as globally, including their GVC participation rates. It is important to note that participation in global trade has today evolved over time with diverse patterns and cutting across time and with diverse patterns, from national, regional, and colonial to global channels, from inter industry to intra industry goods and services exchanging hands; all aimed at promoting economic growth, development, and poverty reduction. Indeed, in its continuous evolution it tends to generate gains and losses for the countries differently depending on the extent of efficiency in GVC participation.

2.8.1. Gains of developing nations in GVC participation

Participation in Global Value Chains (GVCs) offers numerous benefits to developing countries, particularly in the realms of trade and investment reforms. OECD (2013) highlights that developing nations can leverage foreign trade to enhance their investment climate, moving beyond reliance solely on domestic markets.

Moreover, research by Borin & Mancini (2019) demonstrates a causal relationship between GVC participation and economic growth in countries like Seychelles, China, and India. Their findings underscore the positive impact of international trade on living standards, with an increase in the trade-to-GDP ratio correlating to higher income per person. For instance, a one percentage point rise in this ratio resulted in a half-percent increase in income per person in China, Seychelles, and Bangladesh.

Additionally, micro-level analyses, such as X. Wang et al. (2022), study on China's trade impact, reveal gains in areas like patent and IT, illustrating the benefits of technological advancement facilitated by GVC participation.

Participation in global trade, particularly through GVCs, has been shown to positively impact productivity in developing countries. Mitra (2020) conducted empirical research indicating that increased engagement in global trade has significantly enhanced productivity levels in developing nations, particularly post-2007. Their study, which measures "real openness" as the ratio of imports and exports to purchasing power parity GDP, demonstrates a robust and statistically significant effect on aggregate production and total factor productivity improvement across six developing countries.

Moreover,Gereffi (2001) highlight the importance of ensuring that the benefits of GVC participation are equitably distributed, emphasizing considerations for social and environmental protection. Ignatenko (2019) further underscores the role of GVCs as drivers of productivity and socioeconomic growth in emerging economies like Brazil and China. Their work suggests a strong correlation between global trade and economic efficiency in developing countries, with significant gains derived from participating in GVCs.

Participation in Global Value Chains (GVCs) offers significant benefits to developing countries, including the identification of inefficiencies and opportunities for knowledge transfer and training. Borin et al. (2021) highlights how countries like China, Bangladesh, and Vietnam have experienced substantial income growth through their participation in GVCs, with per capita income increasing by significant margins over the past few decades.

Moreover, GVC participation facilitates the dissemination of policies that guide trade and investment decisions, empowering developing nations to navigate global standards and regulations effectively. Kowalski et al. (2015) emphasizes the importance of understanding the roles and standards of GVCs to enhance competitiveness and interconnectedness in global markets. Additionally, participation in GVCs exposes developing economies to international markets, foreign competitors, and technology transfers, leading to various spillover effects such as access to best practices, intellectual property enhancement, and skill upgrading. These effects not only benefit firms directly engaged in GVCs but also have positive impacts on local firms and industries, fostering economic development and the emergence of spin-off firms.

Furthermore, GVCs enable firms to access more affordable inputs and economies of scale by sourcing components and materials from different locations, often from countries with lower production costs. This optimization of production processes allows firms to reduce costs and increase efficiency across the chain. For emerging economies, GVCs provide opportunities to leverage their comparative advantages in specific stages of production, facilitating rapid industrialization and integration into established supply chains. Gaál et al. (2023) underscores how the fragmentation inherent in GVCs allows developing nations to become part of established supply chains, thereby reducing the need to create their own and expanding their participation across domestic production stages. Overall, GVCs offer developing economies a pathway to enhance their global trade engagement and economic development.

2.8.2. GVCs & Risks in Developing Economies

While global trade presents considerable benefits for developing nations, it also poses risks and complexities. Studies emphasize concerns regarding the value of imports, the prevalence of low-skilled labor, low wages, and the quality and quantity of intermediate goods in overall trade from developing economies. These challenges necessitate strategic navigation of GVCs by developing countries to optimize gains and minimize potential drawbacks.

Trade liberalization policies, according to (Gay et al., 2021) often disadvantage developing countries by exposing them to competition from more advanced economies. Free trade agreements and global trade regulations can lead to deregulation of natural resources, loss of traditional livelihoods, and decreased local employment opportunities (Loonam & O'Regan, 2022). This situation creates complexity and threatens the economic efficiency of developing nations, as noted by Gereffi (1994) particularly in terms of global market governance.

Offshoring practices have been shown to negatively impact the labor demand for middle-class workers in developing countries, leading to reduced manufacturing employment(Ndubuisi & Owusu, 2023). Despite being labeled as important destinations for outsourcing activities, developing countries often experience smaller gains from offshoring compared to advanced economies, facing barriers such as time zone differentials, language barriers, political unrest, and job displacements. Additionally, Gay et al. (2021) highlight the risk of developing countries being confined to low-value segments of GVCs, limiting opportunities for innovation and technology transfer.

Over-reliance on international markets can lead to resource exhaustion, poor economic planning, and barriers to domestic industries, as indicated by (Loonam & O'Regan, 2022). Persistent adherence to post-war development strategies like import substitution and high protective barriers favoring primary goods production exacerbate these challenges. However, there is a growing recognition that developing countries must shift their focus towards increasing their share of intermediate production to enhance trade competitiveness and economic growth.

While many African countries participate in GVCs, their involvement primarily centers around primary goods, limiting opportunities for substantial reforms and profits (Marcato & Baltar, 2020). To overcome this, Africa must prioritize growth beyond primary commodity production and focus on increasing its proportion of intermediate production by value added. This transformation requires investments in technology and learning, as suggested by Jurowetzki et al. (2018) to deepen GVC participation, regional centrality, and trade openness.

In South Africa, there is debate about the effectiveness of Regional Value Chains (RVCs) as a short-term alternative measure to boost international trade prospects (Bolea et al., 2022). While some see potential in RVCs, others argue that they offer limited gains and constrain policy makers. Overall, Africa's participation in RVCs remains relatively low, with many imported inputs coming from outside the continent (Akanle & Shittu, 2022).

Despite these challenges, African countries have untapped domestic resources that could be leveraged through increased involvement in intermediate goods production and value addition. However, non-tariff trade costs and other intangible barriers, such as inefficient customs clearance and bureaucracy, pose significant challenges to realizing these opportunities for economic growth and development in the global marketplace.

2.8.3. GVCs and Developing country's Case Overview

In this case study shows the processes of Global Value Chains (GVCs) through the lens of specific regions. By focusing on this, we aim to illustrate how GVCs operate in real-world contexts, highlighting the complexities, challenges, and opportunities involved. Through a detailed examination of this case, we seek to uncover insights into the various factors influencing GVC participation, governance structures, upgrading processes, and overall economic impact. This case study serves as a practical application of theoretical frameworks and empirical research on GVCs, offering valuable lessons for policymakers, businesses, and stakeholders involved in global trade and production network.

The process of globalization has significantly increased global trade flows in recent years, leading to a restructuring of production systems. Developed countries, particularly lead firms, now rely on intricate networks of suppliers from various regions to manufacture goods. The African Development Bank's 2014 survey underscores the importance of intermediate goods in global trade and highlights the implications of this expansion for Africa. Figure 4 illustrates the growth of global trade from 1995 to 2011, showcasing the contributions of different regions. However, Africa's share remains relatively low at 1.4%, indicating limited participation in GVCs. Kaulich et al. (2015) highlight in their study of Africa that the region's lower participation in GVC is due to a decline in trade for intermediate goods. This suggests that Africa's engagement in GVCs is still minimal compared to other regions. Table 4 illustrates the regional participation levels in GVCs during the specified period, offering further insights into Africa's position within the global trade network.

Table 4 Share of GVCs by Regions

Region	1995	2011
Europe	57.5	50.9
East Asia	14.4	16.2
North America	13.1	11.8
Southeast Asia	6.0	6.8
Latin America	3.2	4.2
Middle East	2.0	3.0
Africa	**1.4**	**2.2**
Russia and Central Asia	0.9	2.0
South Asia	0.7	1.7
Oceania	0.9	1.3

Source: African Development Bank - AFDB (2016)

Table 4 presents a clear overview of the participation levels of ten different regions in GVCs, highlighting significant disparities. For instance, regions like Europe and East Asia contributed the most in 2011, accounting for 50.9% and 16.2% of GVC shares, respectively. In contrast, Africa's contribution stands at only 2.2% during the same period, despite being identified as a region with potential for GVC growth. This stark difference underscores the need for African policymakers to address various factors such as weak regulatory environments, reliance on primary goods production, low capital investment, and corruption, which have been identified as barriers to increased participation in GVCs. Urgent reassessment of options and policy interventions are necessary to enhance Africa's involvement in GVCs.

Kowalski et al, (2015) highlight the potential benefits of increased participation in GVCs, such as enhanced productivity, sophistication, and diversification of exports. However, factors like distance, market size, and level of development must be considered as they also influence participation. Table 4 also sheds light on Africa's limited role in GVCs compared to regions like Europe and East Asia which underscores the challenges African countries face in fully integrating into this chain and the potential hindrance to their economic development.

In recent years, there has been a slight decline in regional GVC linkages, particularly in Asia and Latin America, although supply chains remain clustered. Latin American countries have been working to strengthen linkages with other regions, including Africa, to enhance GVC integration. However, despite the initial potential advantage of not needing to establish entire industries from the scratch, African countries involved in GVCs often find themselves confined to low value-added segments, limiting opportunities for innovation and technology transfer.

This challenge is a significant concern raised in many studies, indicating the need for strategic interventions to enhance Africa's GVC participation and maximize its benefits.

This challenge is further illustrated in Figure 5, which shows the decline in regional GVC linkages, particularly noticeable in Asia and Latin America. Despite this decline, supply chains remain clustered, with Latin American countries seeking stronger connections with other regions, including Africa. However, the figure also underscores a critical issue: African countries involved in GVCs are often trapped in low value-added segments, limiting their ability to innovate and transfer technology. This issue highlights the importance of strategic interventions to boost Africa's GVC participation and unlock its full economic potential.

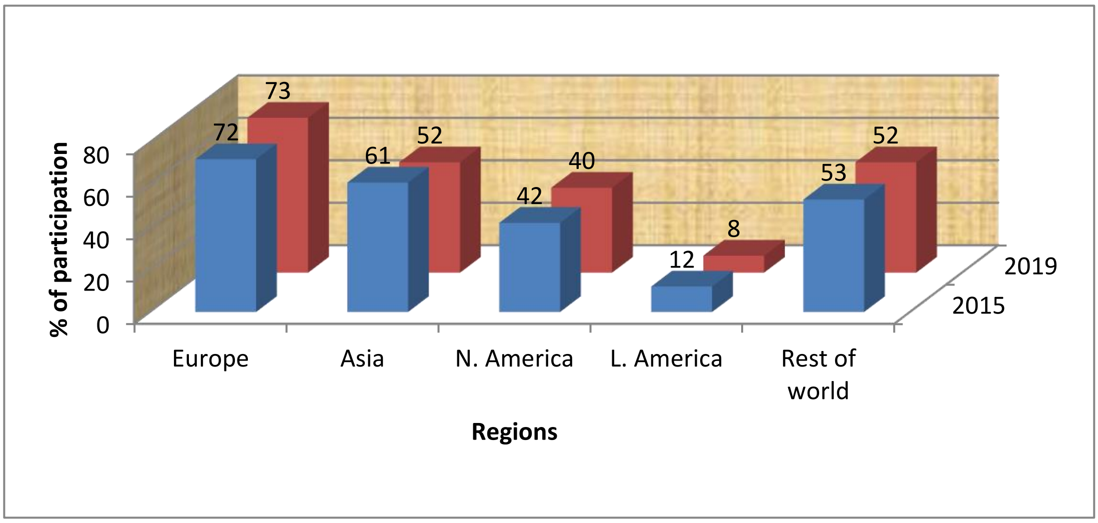

Figure 5: GVCs & Regional participation 2015-2019

Source: OECD (2022)

2.8.4. Options for developing countries to optimize GVCs.

The options for developing countries to navigate the complexities of Global Value Chains (GVCs) involve a multifaceted approach encompassing various aspects of trade policies, regulations, logistics, and investment strategies. Kowalski et al. (2015) highlight the significance of free trade agreements and policies in shaping the success of GVC participation, emphasizing the need for favorable conditions to foster integration into global networks. However, many developing countries face challenges such as discriminatory policies against their primary goods exports, leading to declines in market share and efficiency. To address these challenges, adjustments in trade policies, industrial development strategies, and investment frameworks are recommended. These adjustments aim to create an enabling environment for GVC participation, thereby enhancing economic growth and development. They include:

(i) Strategic Vision and Policies: Governments should formulate clear, outward-oriented policies focused on intermediate production, while also fostering coordination among

stakeholders, particularly in the private sector. This approach aligns with insights from scholars such as Balassa in 1984 and reports from organizations like the OECD in 2014 and 2023.
(ii) Market Expansion: By stimulating domestic and regional consumer demand, countries can create markets for their products, driving closer ties with global trade partners. Insights from reports by organizations like PricewaterhouseCoopers and African Development Bank (ADB) (2014) support this approach.
(iii) Investment in Human Capital: Prioritizing education, vocational training, urbanization, information technology, and infrastructure development can bolster skills, mobility, and connectivity, thus facilitating entry into GVCs. This approach is advocated by pioneer scholars like Gereffi et al. (2005), and reports from the OECD (2022).
(iv) Boarder Openness: Opening borders to trade can attract more partners and facilitate greater investment inflows, enhancing economic integration and participation in GVCs. This strategy is supported by many researchers.
(v)Meanwhile, PricewaterhouseCoopers in 2018, noted that developing countries' policymakers need to collaborate with institutions like the World Bank, IMF, and OECD to advocate for trade policies that serve their interests, aiming to reduce the existing imbalance between developed and developing nations.
However, Atkin et al. (2021) argue that for developing countries to ascend the economic ladder, they must transition to intermediate-level production and add value to their goods, thereby enhancing participation in more complex tasks within GVCs. Verhoogen et al. (2018.) further suggests that moving from resource-based activities to high-tech and knowledge-based endeavors, such as design, innovation, research and development, marketing, and branding, is essential for building robust cross-country linkages in developing country.

2.9. GVCS AND MULTINATIONALS (MNCS)

Global Value Chains (GVCs) and Multinational Corporations (MNCs) are closely intertwined concepts in the realm of international business and trade. GVCs refer to the network of activities involved in the production of goods and services that are coordinated across different countries. These activities often include various stages of production, such as design, manufacturing, assembly, and distribution, which are carried out by different firms located in different parts of the world.
MNCs play a central role in GVCs as they often oversee and coordinate these activities across borders. They establish subsidiaries, affiliates, and supply chain networks in multiple countries to leverage factors like cost, expertise, and market access. MNCs can be both lead firms, which drive the coordination of GVC activities, and suppliers, which contribute to specific stages of production within the chains.
The relationship between GVCs and MNCs is symbiotic. MNCs rely on GVCs to optimize their production processes, reduce costs, and access global markets efficiently. GVCs, in turn, rely on MNCs for investment, technology transfer, and market linkages. MNCs bring capital, expertise, and managerial skills to GVCs, while GVCs provide MNCs with opportunities for growth and expansion in increasingly interconnected markets.

To understand the dynamics of GVCs and MNC, it may be also essential to examine the various perspectives that shape their interactions and influence on the global economy. Multinational corporations are pivotal international entities engaged in controlling and operating value-added activities across multiple countries, international companies or enterprises (Mattoo et al., 2013). They represent dominant actors within GVCs, embodying the evolution of international business in a vertically integrated, multi-country context (Marcato & Baltar, 2020). Early records highlight that Spain and Portugal were governed by some of the world's earliest MNCs. Historical examples include the Swedish Africa Company established in 1646, M. Singer & Company in 1851, and the Hudson's Bay Company founded in the 17th century (Cadestin et al., 2018).

In developing nations, the study of MNCs and their investment decisions began in the 19th century and became more prominent during the 20th century particularly with the European gold merchant and settlers. Since then, MNCs have remained central actors in many developing economies. Foreign Direct Investment (FDI) by MNCs often forms the bulk of GVCs, decisively influencing the distribution of value added globally. Their contributions can be classified into two categories: vertical and horizontal. Horizontal investments are driven by market-seeking objectives, such as gaining direct market access and influencing trade policies and restrictions. Vertical investments, on the other hand, focus on production cost sensitivity. Both types of investments can have positive effects in the countries where these businesses are established (Chen, Bart, Los, Marcel, & Timmer, 2018).

Importantly, about four different modes of organizing the petroleum value chains tend to recognize MNCs and their functions. This includes tasks done in the upstream, midstream and downstream involving the in-house, outsourcing within the country or across nations. While many believe that MNCs are set up to grow customer base, others argue that they invest abroad for other strategic asset capture of value-added either downstream or towards basic technology and know-how for profits (Rodrik, 2018). Still, others argue that major international firms like Volkswagen Automobile and Shell Petroleum, tend to form major markets like the silicon valley in Israel and Oil & Gas Graduate/Technical Apprenticeship program in Nigeria and Oman liquefied Natural Gas joint venture programs in the Arabian peninsula to establish international learning portals that may not particularly aim at catching up internalization but to casually keep up with young leading enterprises in the industry with optimism of gaining access to wield phenomenal powers.

In Europe, some automotive firms have established startups abroad specifically for electronic vehicles, while local suppliers often integrate as general suppliers with their basic and non-functional technical components in manufacturing. This shift has generated various tensions, as small, midsize, and even large suppliers collaborate with MNCs, leading to numerous widespread challenges within their complex networks, affecting both environmental impacts and value-added computations. These concerns are particularly pertinent in the context of GVCs (Cadestin et al., 2018).

MNCs generate substantial profits through their local subsidiaries established via Foreign Direct Investments (FDI). These activities are often recorded as domestic in host economies, complicating the direct attribution of value-added within GVCs over time (Y. Li et al., 2022; G. Lin et al., 2018).

However, the study by Wang & Le, 2018) sheds light on the complexities of Global Value Chains (GVCs) involving Foreign Direct Investments (FDIs). It distinguishes between different types of GVCs: those driven by FDIs through local MNC affiliates, those driven by trade in intermediates by domestic firms, and those involving a combination of both. This differentiation underscores the substantial profits MNCs accrue through their operations, where value-added attribution can be complex and sometimes unclear due to the blending of local and international activities within GVCs.

Moreover, the analysis highlights that the impact of FDIs on economic growth varies based on factors such as the host country's capacity to absorb investments, the stage of financial development, and the institutional framework. Overall, it reveals a positive correlation, particularly in high-tech sectors and high-income countries. However, challenges associated with MNC presence, including market dominance, profit repatriation, labor conditions, resource exploitation, tax issues, and cultural influence, necessitate nuanced policymaking in developing countries. Effective regulations are crucial to harnessing the positive contributions of MNCs while mitigating potential adverse effects, to ensure sustainable and inclusive economic development.

2.10. GVC IN PETROLEUM INDUSTRY

Global Value Chains in the petroleum sector represent complex networks of activities that span multiple countries and stages of exploration, production, distribution, and marketing of oil and gas products. These chains are crucial for the global economy, as petroleum remains a cornerstone of energy supply and a driver of industrial activity worldwide. The petroleum industry's GVCs involve diverse actors, including MNCs, national oil companies, service providers, suppliers of technology and equipment, and various support industries.

At its core, the petroleum GVC encompasses upstream activities such as exploration, drilling, and extraction of crude oil, followed by midstream operations involving transportation and storage, and downstream activities including refining, marketing, and distribution of refined petroleum products. These activities often cross international borders multiple times, reflecting the global nature of energy supply chains and the interconnectedness of markets. This integration into GVCs offers several benefits for the petroleum industry. Firstly, it enhances efficiency by streamlining production processes and optimizing resource allocation across the value chain. Secondly, it provides access to global markets, enabling petroleum products to reach consumers worldwide. Additionally, being part of GVCs facilitates technology transfer and knowledge sharing among industry players, fostering innovation and advancements in production techniques. Furthermore, collaboration opportunities within GVCs allow petroleum companies to leverage each other's strengths and resources, leading to improved competitiveness and profitability (Álvarez et al., 2018).

Comprehending how value is created, distributed, and captured across different stages and geographies spore examining the dynamics of technological advancements, regulatory frameworks, market conditions, and geopolitical factors that shape the industry's structure and evolution, thus providing insights into economic development, energy security, environmental impacts, and the strategic positioning of countries within the global energy terrain. For instance, the petroleum industry has maintained its pivotal role in the global energy and hydrocarbon sectors over time. Currently, the United States leads in both crude oil production and consumption, with significant participation from populous countries like China and India. Venezuela holds the largest global oil reserves, while Nigeria ranks prominently at 10th place (OPEC, 2022). Cost considerations primarily drive the industry's inter-connectivity and expansion within GVCs, alongside factors such as demand and supply dynamics, trade restrictions, and market size. Investments directed towards specific assets also play a significant role in shaping the industry's participation in GVCs and global trade. Other important processes in the oil sector to which this segment is devoted are well established and organized in the industry’s value chains explanation in Figure 7.

2.10.1. The Global Petroleum Value Chain

Petroleum was first discovered and rated as an indigenous oil of the Chinese miners around 600 BC and later multiple stages of development sprang (Craig et al., 2018). Oil and gas play critical roles in meeting global energy demand, powering transportation, industry, and households worldwide. The industry is characterized by its vast geographical spread, with major oil-producing regions including the Middle East, North America, Russia, and parts of Africa and South America. The key players in the global oil industry include national oil companies (NOCs) like Saudi Aramco, ExxonMobil, and Shell, alongside numerous independent and smaller firms.

The petroleum industry chain, often referred to as the oil supply chain or value chain, encompasses a series of interconnected processes essential for delivering petroleum products from exploration to end-users. This chain is divided into three main segments: upstream, midstream, and downstream. Álvarez et al. (2018) describes the chain as the series of key activities in oil and gas industry that generate higher profit, beginning from conception level such as the exploration stage to end use or consumption of product/s. The industry operates within complex GVCs, where activities are distributed across multiple countries and firms to optimize efficiency and capitalize on comparative advantages. The production of different outputs of crude oil is dependent upon the API content and tends to require suitability with applicable sulfuric classification. For example, sweet crude oil is generally considered more valuable and efficient due to low sulfur content. This makes it commonly used for processing into other petroleum refining products like gasoline, diesel, jet fuel, kerosene, distillates and other end products for consumption. Figure 6 is an illustration of the activities in the segments of the petroleum framework.

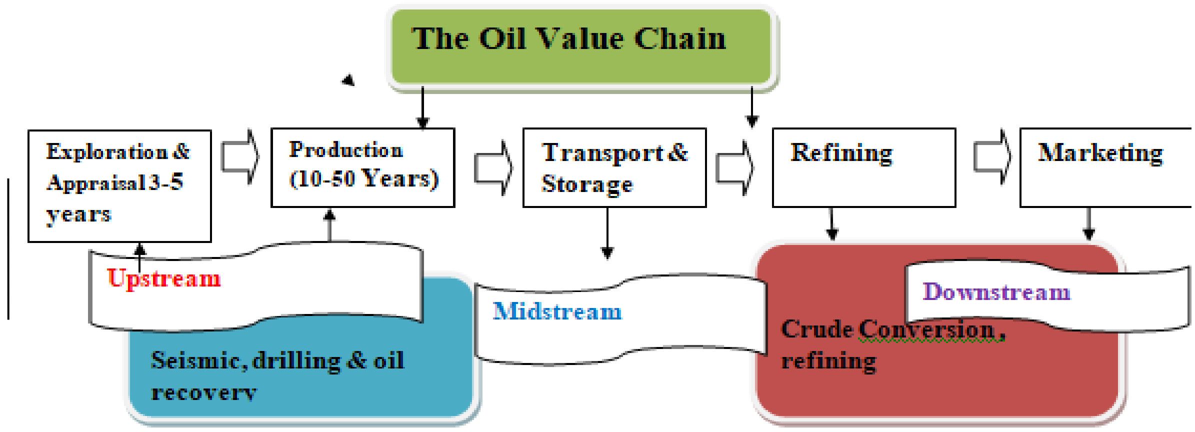

Figure 6: Framework of Petroleum Value Chains

Source: Own elaboration

Figure 6 shows the interconnected network of activities in the oil GVC. These subsectors constantly adapt in various ways to the global economic shifts, technological advancements, and regulatory changes while shaping the global energy landscape.

The process often begins with the discovery of the potential regions for oil and gas exploration. Usually, fields are appraised, developed, and processed after an initial exploration survey. This process unlocks insights and optimizes the entire value chain to enable better and accurate decisions for sustainable and safe petroleum operations. The Chains serve as conduit for expressing the increase in commercial value that is created as crude oil from the primary production before passing through midstream and downstream where the supply chain sits. While some companies operate in one sub-sector, some tend to operate in two to three depending on the strength of their integration in the chain. It also presents a significant challenge for policy makers as it is required that they weigh a wide range of factors in consideration for value maximization and trade factors. The oil value chain has five major inter-linking activities (exploration, production, transportation, refining and distribution). These activities are often sub-divided into three important components of Upstream, Midstream and Downstream operations.

(i) Upstream Segment

This is the initial stage which involves locating oil reserves and extracting crude oil. It includes geological surveys, drilling, and well development. Thereafter, the production and sale. Exploration and Production (E&P) is the broad term for the unit and their responsibilities include surveys, well drilling, equipment delivery, and engineering projects with other auxiliary services provided by oilfield/s. Importantly, drilling is carried out after studies from structural geology and sedimentary analysis are complete. Aside from producing crude oil, the E&P

section also functions as a search unit for both underground and underwater petroleum fields. For conventional processing, the life cycle ranges from 40-50 years in the following order: assessment between 1-9 years, appraisal 1-2 years, drilling 2-7 years and productive years 10-20 years; while the un-conventional takes about 15 years such as: two years of assessment and drilling then 5-10 years to produce in view of modern technology.

This sub-sector of the petroleum industry is technologically advanced and complex, encompassing both upstream and, at times, midstream functions (Álvarez et al., 2018). While it is fraught with high economic risks, it is also highly rewarding, often referred to as the backbone of the entire sector. Critics argue that the sector's substantial profit margins are frequently influenced by external factors such as political dynamics, internal conflicts, and supply control agreements. Conversely, others believe these profits might diminish over time due to fluctuating oil prices and a growing preference among investors for short-term investments over long-term mega projects. The sector is predominantly controlled by lead firms or International Oil Companies (IOCs) and, Cadestin et al. (2018) suggests that the productivity gains achieved by these firms should be equitably distributed to avoid conflicting interests.

Technological advancements in this sector have led to the discovery of unconventional reserves such as tar sand and shale oil. However, this progress comes with significant drawbacks, notably environmental pollution affecting air, sea, land, and contributing to climate change and wildlife disruption (Global Energy Review 2020 – Analysis - IEA, 2021). Major private geophysical and survey companies often partner with leading firms in the upstream oil sector to provide essential services. The cost centers in E&P include Capital Expenditures (CAPEX), Production Costs, and Finding and Exploration Costs. CAPEX covers the development and management of oil fields, while Production Costs encompass both fixed and variable expenses related to operating and capital expenditures. Finding and Exploration Costs involve geological and seismic studies necessary for exploration and appraisal activities. The modern E&P sector increasingly relies on digital technology, including big data analytics, IoT, cybersecurity, robotics, and AI, to enhance production activities and add value to global trade. However, despite the potential cost savings and efficiencies offered by digitalization, the industry has historically been slow to adopt these technologies due to significant capital requirements and market challenges such as low oil prices and the COVID-19 pandemic.

(ii) Midstream

The midstream activities cover the transportation of crude oil, often using pipelines and marine tankers. Pipelines transport large quantities of oil and gas over long distances, typically for transnational and regional distribution. Marine tankers, designed with specialized hulls, carry bulk liquids across oceans. In addition to transporting crude oil, the midstream sector handles natural gas movement, utilizing underground storage and advanced liquefaction technology. This gas-to-liquid process allows for easier and safer storage and transportation of natural gas, facilitating global trade.

Large oil terminals often employ independent storage companies to manage these logistics, acting as terminal operators contracted by leading firms. Prominent examples of midstream companies include Kinder Morgan in North America, CLH Group in Spain, and Forcados Group in Nigeria, all playing key roles in the global oil supply chain.

(iii) Downstream

Refining involves transforming crude oil into usable liquid hydrocarbons for final consumers. The downstream sector focuses on refining crude oil and processing natural gas, converting these hydrocarbons into valuable products through distillation. This sector produces essential items such as gasoline, diesel, kerosene, asphalt, and chemical reagents used in making plastics, pesticides, and pharmaceuticals. These refined products are then distributed to wholesalers, retailers, or directly to industrial clients within the supply chain.

Known for its distillation, conversion, and purification functions, the Refining and Marketing (R&M) sector plays a crucial role in the oil value chain. The key petroleum products, which include those mentioned in figure 7, are highly demanded globally due to their widespread use in transportation, home heating, and industrial processes. Table 5 highlights these top petroleum products, illustrating their significant impact on global trade and various sectors.

Table 5: Refinery Outputs and Uses.

Products	Product types	Uses	EOCD Consumption (2015)
Liquid Petroleum Gases (LPG) & Ethanol	LPG & Ethane	Transportation & Petro-chemical feedstock	5.2
Naphtha	Light distillate	Gasoline & Petrochemical	3.4
Gasoil	Light distillate	Transport fuel	14.00
Jet fuel	Medium distillate	Transport & heating	13.1
Diesel	Medium distillate	Transport, heating & power	2.1
Fuel Oil	Residue	Marine fuel &power	N/A
Lubricants	Specialty	Friction reduction	N/A
Waxes	Specialty	Lubricants, candles	N/A
Asphalts	Specialty	Infrastructure, roads	N/A
Chemicals	Petrochemicals	Several	N/A
Solvents	Aromatic	Paints, coat &cleaners	N/A
Others	---------------	Several	

Source: Alvarez (2018)

2.10.2. Stakeholders in the Oil Industry

The oil sector is a complex and multifaceted industry involving a wide range of stakeholders, each playing a critical role in the exploration, production, refining, distribution, and consumption of oil and its derivatives. Understanding these stakeholders is essential for comprehending the dynamics of the industry and its impact on global economies. This section provides an overview of the key stakeholders in the oil sector, their roles, and their interrelationships starting with the International Oil Companies (IOCs).

The IOCs are major players in the global oil industry and include corporations such as ExxonMobil, BP, Shell, and Chevron. These privately-owned companies operate in multiple countries and are driven by profit motives and shareholder interests. Also, they invest heavily in technology and innovation to explore, produce, and refine oil efficiently. These actors often collaborate with NOCs and other stakeholders to gain access to resources and markets.

The IOCs hold a pivotal position in the oil value chain, akin to leading firms in producer-driven chains. They retain control over capital-intensive extraction and production processes, often locating operations near major consumer markets. However, their model also mirrors buyer-driven chains, as much of their value addition occurs through refining in foreign countries, while decentralized production networks handle crude oil extraction in developing nations. Their primary goal is maximizing shareholder value, leveraging product differentiation and long-term capital investment to distinguish themselves. With significant market concentration and formidable entry barriers, IOCs wield considerable power over suppliers and international connections, influencing organizational control and pricing processes.

Like Ponte's analysis of the coffee chain, IOCs occupy a pivotal position in the oil chain, despite not being the final point of consumption. They maintain their leading firm status through refining activities, where competition among retailers is limited. Seismic surveyors serve as first-tier suppliers, identifying oil reserves worldwide, while IOCs manage extraction and production processes, often collaborating with National Oil Companies (NOCs) and engaging in large-scale crude oil trading. In the oil industry hierarchy, IOCs can be considered both first and second-tier suppliers, acting as financers and operators, particularly in developing nations. Given the diverse nature of the Global Petroleum Value Chain (GPVC) across different countries and markets, the roles of IOCs and NOCs vary, reflecting differences in crude oil types and market dynamics. Illustrating the trading channels within the oil value chain involves understanding the strategic alignment and interplay between IOCs and NOCs.
Based on our schematic design of the Oil Value Chain, the trading channels feature four major actors with distinct but complementary authority roles. To better understand these dynamics, it may be essential to delve into the strategic alignment between IOCs and NOCs, which will be discussed in the next section. Based on our schematic design, the trading channels involve four major actors: seismic engineers, International Oil Companies (IOCs), National Oil Companies (NOCs), and distributors, each with distinct yet complementary roles. To further understand these dynamics, examining the strategic alignment between IOCs and NOCs will be crucial, as discussed in the following section.

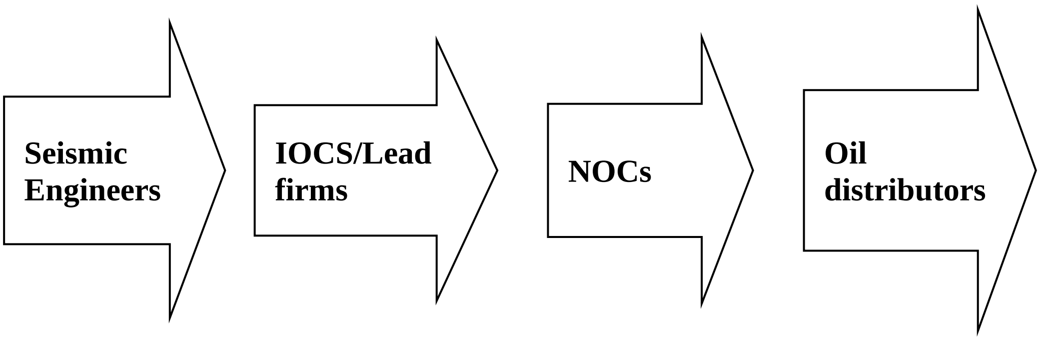

Figure 7: Complementary Roles in Global Petroleum Value Chains (GPVCs)

Source: Own Elaboration

Figure 7 illustrates the distribution of roles within the value chain, highlighting the central role of Multinational Corporations (MNCs) in the petroleum industry of many developing countries. These corporations are not only involved in extraction and production but also play a key role in the sale of crude oil. This centrality challenges the conventional view of MNCs as mere subsidiaries and underscores the influence of MNC strategies on the components of host country NOCs and their National Innovation Systems (NISs). Understanding this relationship involves examining the multidirectional flows of knowledge and how they can enhance domestic production quality and global integration, despite the dominant role of MNCs

National Oil Companies (NOCs) are typically viewed as custodians of their nation's natural resources, wielding significant influence over oil resource management and ownership. They play vital roles in domestic economies and global oil markets, often shaping national oil policies and decisions. Originating in the 1830s in the United States, NOCs initially focused on supplying bulk tank fuel and gasoline, evolving over time into subsidiary National Petroleum companies. Eventually, these entities coalesced into the Seven Sisters International oil company, comprising major players such as Exxon, Mobil, and Shell. The Seven Sisters wielded considerable control over global oil production and reserves by 2005, managing oil and gas transportation, marketing, and sales through integrated network.

These companies exercised significant influence over oil markets, controlling sales and assets while managing the movement of petroleum products within their corporate structure. Their dominance in oil reserves, production, and refining during the mid-20th century underscored their pivotal role in the global oil sector. They also ensured that the flow of petroleum products from producers to consumers occurred through inter-company transfers within their corporate family, while actively monitoring assets like oil and gas reserves. This excerpt demonstrates the significant achievements of the Seven Sisters' companies in oil reserves, production, and refining between 1949 and 1950.

Table 6: NOCs and Operational Status between 1949 and 1050s

Name of Oil Companies 1949-1950	Oil reserves 1940s (million barrels)	Oil production (avg)pd 1950s. (thousand barrels)	Oil refining (avg)pd. 1950s (thousand barrels)	Remarks
Anglo-Iranian oil	13.9	705.7	707.9	Excluding USA, Russia, Hungary & Romania
Gulf Oil	5.8	303.0	40.2	√
Royal Dutch	4.5	646.1	891.9	√
Std Oil (New Jersey)	9.3	925.7	964.5	√
Std Oil (California)	2.8	162.2	150.3	√
Socony	2,.0	147.7	132.1	√
Texas Oil	3.0	183.9	220.3	√
Total	41.3	3074.3	3107.2	
Percentage	82.1	88.1	77.5	

Source: Own Elaboration from NBS Handbook. (2020)

The data presented in table 6 outlines the significant oil reserves, production, and refining activities of the Seven Sisters Company during the period of 1949 to 1950. This conglomerate, comprising entities like Standard Oil (New Jersey), Standard Oil (California), Socony, and Texas Oil, wielded substantial control over global oil reserves, production, and refining, representing 88% of oil production and 77% of refining globally. Additionally, they held about two-thirds of the total privately owned tanker fleets worldwide and controlled approximately 82% of global reserves through concessions from various countries. However, their dominance faced challenges from national oil companies (NOCs), particularly in regions like the Middle East and Nigeria, where NOCs sought to assert control over their oil resource.

Despite the significant presence of NOCs, approximately 45% of the top 20 hydrocarbon-producing NOCs have expanded operations globally, transitioning into international NOCs through processes like internationalization or participation in Global Petroleum Commodity Networks. However, before the rise of international oil companies (majors), NOCs often underestimated the capabilities of IOCs to replace and maneuver oil assets to their advantage through various petroleum agreements. For instance, during the Anglo-Iranian Crises of 1946, Britain's attempts to define oil policies in partnership with the government led to disputes with Iranian NOCs, resulting in low sales and tensions (Marsh, 1998).

In Nigeria, the role of NOCs gained prominence in the 1950s, following initiatives from foreign colonialists and oil merchants to explore and exploit petroleum resources. European oil explorers dominated the industry, including Royal Dutch Shell, British Petroleum (BP), Exxon, and Chevron. However, tensions arose as oil exploration expanded, leading to divisions among ethnic groups preceding Britain's formal decolonization of Nigeria. Nigeria's membership in the Organization of the Petroleum Exporting Countries (OPEC) in 1971 underscored its geopolitical significance in the global oil markets (Rui et al., 2018).

Currently, many top hydrocarbon-producing NOCs, including those in Nigeria, have expanded operations globally to secure oil supply, access attractive hydrocarbon resources, and ensure market access (Craig et al., 2018). Despite opportunities for collaboration between IOCs and NOCs, uncertainties, and risks, including compromised financial stakes and knowledge transfer, remain concerns for lead firms in such partnerships, with implications for GVC participation. Other stakeholders in the oil industry include various entities involved in different facets of the value chain, as well as regulatory bodies, communities, and environmental organizations. These stakeholders play crucial roles in shaping the dynamics of the industry and its impact on society and the environment. We will delve deeper into their roles and interactions in Chapter 5.

2.10.3. Navigating Global Energy Trends: From Consumption Surges to Africa Role in Resource Extraction

Amidst the historical ebbs and flows of the global oil industry, diverse perspectives emerge, shedding light on multifaceted dimensions beyond traditional narratives. Delving into the annals of World War II through the oil embargo era, we uncover not just economic upheavals and geopolitical shifts but also lesser-explored facets that offer unique insights. From the nuanced lenses of historians, economists, and industry analysts, we navigate through pivotal events and transformative periods, unveiling alternative narratives that enrich our understanding of the oil industry's evolution. Beyond conventional interpretations, we explore the social, environmental, and geopolitical ramifications, unveiling the myriad perspectives that shape the complex tapestry of the oil industry's history.

The first half of the 20th century witnessed substantial changes in the global oil landscape, with profound economic implications. Oil consumption in Europe and the United States surged, leading to a greater demand for refined and petrochemical products (Craig et al., 2018). By mid-century, oil had become the predominant source of energy consumption worldwide, reflecting significant advancements in research and development within industrial economies, as highlighted by (Rosenburg, 1993). This transformation facilitated the commercialization of the oil industry during this period. r developing countries, the post-war economic boom fostered the proliferation of export commodities, meeting the heightened demand from affluent and advanced nations. In the 1980s, global oil consumption intensified, accounting for an estimated 84% of global oil demand by 2019. This trend continued to escalate, particularly in developing countries like Nigeria, Libya, and Angola, leading to a significant increase in both oil production and reserves. Table 7 illustrates the trend in global oil consumption from the 19th century onwards, followed by data depicting the trend from 1970 to 2020.

Table 7: Petroleum Consumption in the US from 1850 -1900

Years	Annual consumption (Per capita)
1850-9	0.10
1860-3	0.14
1867-9	0.72
1872	1.26
1880-9	1.74
1890-5	5.74
1900	12.10

Source: Global Energy Review 2020 – Analysis - IEA (2021)

Following the historical narrative, table 7 depicts the annual per capita oil consumption in the USA from 1850 to 1900. The data shows a significant increase in consumption over this period, reflecting the growing reliance on petroleum with a pivotal shift as delineated by (Norman, 2011).

In 1850, the per capita consumption was a modest 0.10 barrels. By 1872, it had risen to 1.26 barrels, indicating the early stages of increased oil use as the industry began to expand. The consumption rate saw a substantial rise by 1890, reaching 5.74 barrels per capita. This marked a period of rapid industrialization and technological advancements, which drove greater demand for petroleum products. By 1900, per capita consumption had surged to 12.10 barrels, reflecting the widespread adoption of oil as a key energy source during the late 19th century. The latter half of the 20th century witnessed the rise of the United States as a dominant player in the oil industry, fueled by advancements such as railroads and mechanization. This era saw a paradigm shift towards producer-driven models, characterized by the pursuit of economies of scale by U.S. oil companies. The consolidation of power within the industry culminated in the formation of the Standard Oil Trust in 1958, an influential conglomerate that wielded considerable influence over global oil markets, particularly in Europe and Asian countries.

The concurrent increase in consumption highlights the pivotal role of petroleum in the industrialization of the United States. The growing reliance on oil during this period underscores its transformative impact on the economy and society. The genealogy of petroleum during this time is characterized by its transition from a niche product to a cornerstone of industrial progress, as advancements in extraction, refining, and technology fueled its widespread use (Norman, 2011). The data from Table 7 encapsulates this transformative era in the history of petroleum, marking the beginning of its central role in modern energy systems.

Next is figure 8, depicting global oil production and consumption from 1970 to 2020. This offers a broader view of the trends and changes in the oil market over the past five decades, complementing the historical context provided by the data in Table 7 thus delineating the traditional trade era and the GVC process.

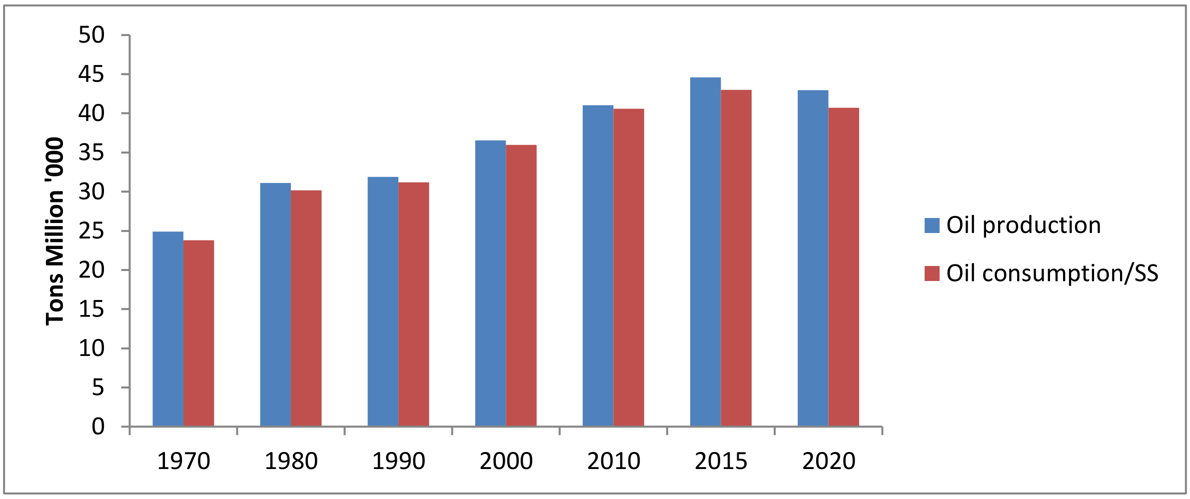

Figure 8: World Crude oil Production and Consumption 1970 – 2020

Source: World Energy Outlook (2022)

Figure 8 data reveals several notable trends spanning over five decades, echoing findings from previous analyses. In 1970, global oil production was 24.91 million tons per day, while consumption was slightly lower at 23.79 million tons per day. This early data indicates a close balance between production and consumption. By the year 2000, production had increased to 36.54 million tons per day, and consumption had risen to 35.97 million tons per day. This period reflects significant growth in both production and consumption, driven by global economic expansion and increasing energy demands.

The highest levels recorded were in 2015, with production reaching 44.58 million tons per day and consumption at 43.52 million tons per day. This peak underscore a period of intense global energy use, likely influenced by rapid industrialization and heightened demand. In 2020, production slightly decreased to 42.97 million tons per day, while consumption also dropped to 40.70 million barrels per day. This decline may reflect global economic shifts, changes in energy policies, or disruptions caused by events such as the COVID-19 pandemic. reveals significant growth in both metrics, with production and consumption peaking in 2015 before a slight decline in 2020. The surge in oil prices during the 1970s incentivized production boosts and accentuated power asymmetries within the value chain, leading to dominance by lead firms and a shift towards more sophisticated production.

Álvarez et al. (2018) attribute this revolution to technological advancements within the GVCs, a perspective supported by theoretical literature in the field. Overall, figure 8 highlights the dynamic nature of the global oil market, characterized by significant growth in production and consumption through the late 20th and early 21st centuries. This trend highlights the evolving dynamics of the global oil market, reflecting increased production and consumption in response to growing energy demands and economic activities.

To further understand these dynamics, figure 9 illustrates country-specific participation and positions in GVCs. This provides insight into how different countries, including major oil producers like the United States, Russia, Saudi Arabia, and Nigeria, have engaged with and influenced global oil markets from 2014 to 2020. It demonstrates the upward trend in global oil demand and aligns it with the corresponding supply and production figures, showcasing the role of key oil-rich nations in shaping global energy trends and their positioning within GVCs.

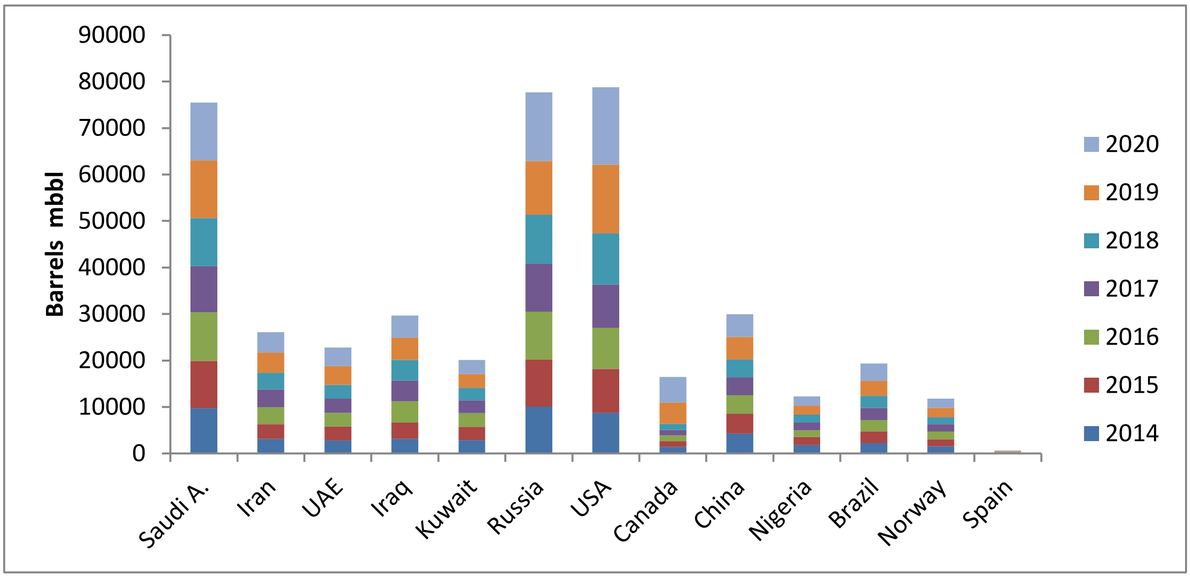

Figure 9: Positions in GPVCs and Crude Oil Production levels 2014 – 2020.

Source: OPEC (2021)

Figure 9 illustrates the participation of different countries in Global Value Chains (GVCs) for oil, highlighting an upward trend in global oil demand alongside corresponding supply and production from 2014 to 2020. The figure identifies the top ten oil-rich countries, including the United States, Russia, Saudi Arabia, and Nigeria, showcasing their roles in the GVCs. While these countries are major producers, their export volumes often lag production levels, as seen with the U.S. and China. This disparity underscores the complex dynamics between production and export strategies.

The surge in demand since 2019 has pressured countries like Kuwait, Iraq, and Nigeria to ramp up production, primarily at the primary level. Although participation in GVCs can lead to increased income through productivity gains, it remains unclear whether these gains are driven by productivity improvements within specific sub-sectors or shifts in sector composition, due to the limited sector-specific data available. The International Energy Agency reports a steady rise in global oil production, with projections extending to 2030. Despite this, the total value of global crude oil consumption saw only a modest increase in 2020, with prices having been notably higher in the last decade. The refinery production showed slight growth, particularly from North America, Iraq, and Norway. As developing countries, led by Nigeria in

Africa, have taken a larger share of crude oil production, the reliance on oil persists amid the ongoing energy transition. This highlights the need for the petroleum industry to adapt to evolving energy landscapes while managing regional supply complexities.

Transitioning from oil production and demand trends, figure 10 presents a detailed view of global oil prices and their fluctuations over time. The analysis tends to provide insights into how these trends in production and consumption have impacted oil prices, revealing the broader economic implications of price changes on the global oil market and its participants. By examining the historical price trends, we can better understand the factors driving market shifts and their influence on both producers and consumers within the global oil terrain.

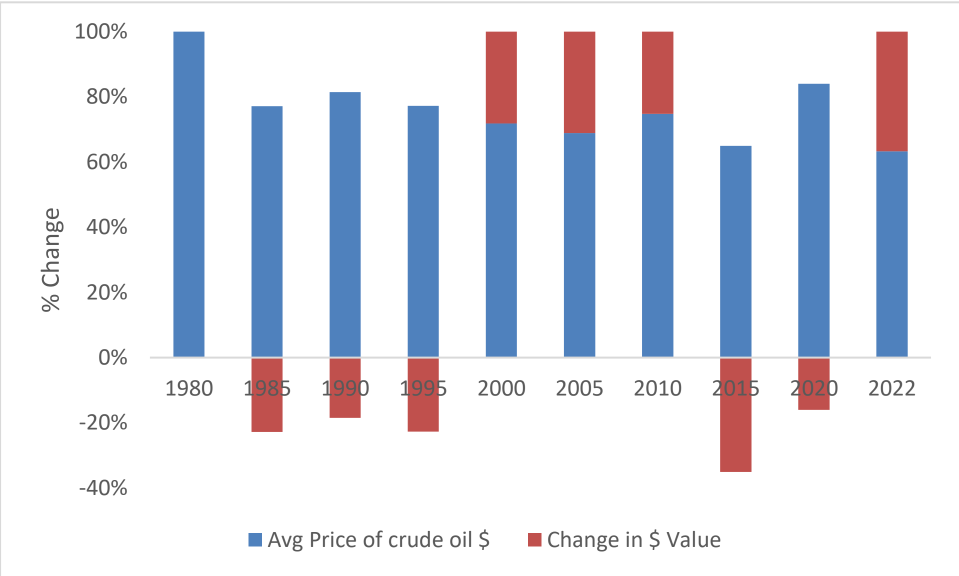

Figure 10: World oil, 1980-2022

Source: World Energy Outlook (2022)

Figure 10 illustrates the average crude oil prices alongside the changes in these prices over the years from 1980 to 2022. The graph shows the price trends, highlighting significant fluctuations in the oil market. The left Y-axis represents the average crude oil prices in U.S. dollars per barrel, while the right Y-axis indicates the dollar value change in prices from one year to the next.

The graph reveals notable trends and fluctuations in crude oil prices. Prices surged to a peak of $100 per barrel in 2022, with a significant increase of $59 from the 2020 price of $41 per barrel. This surge reflects a period of heightened geopolitical tensions and recovery in global demand post-pandemic. In contrast, the lowest price of $17 per barrel in 1995 followed a gradual decline from the $35 per barrel level in 1980. This decline, which occurred over 15 years, was due to a combination of market oversupply and weaker demand. Midpoint prices, such as the $28 per barrel in 2000 and $50 per barrel in 2015, show intermediate periods of price stability between the extremes. The $28 per barrel in 2000 marked a recovery phase following the late 1990s downturn, while the $50 per barrel in 2015 was a period of relative stability before the price fluctuations of the subsequent years.

The figure highlights the volatility of the oil market, driven by geopolitical events, economic conditions, and changes in supply and demand. The clear visual representation of these price changes underscores the impact of external factors on the oil market and provides valuable insights into the historical context of price movements.

Similar uncertainties exist in natural gas production, with technological advancements and economic growth offering opportunities for beneficial changes. However, countries' exposure to supply and demand shocks varies based on their participation levels in GVCs. Continuous monitoring and adaptation are crucial, given oil's non-renewable status and the inherent uncertainties in global energy markets.

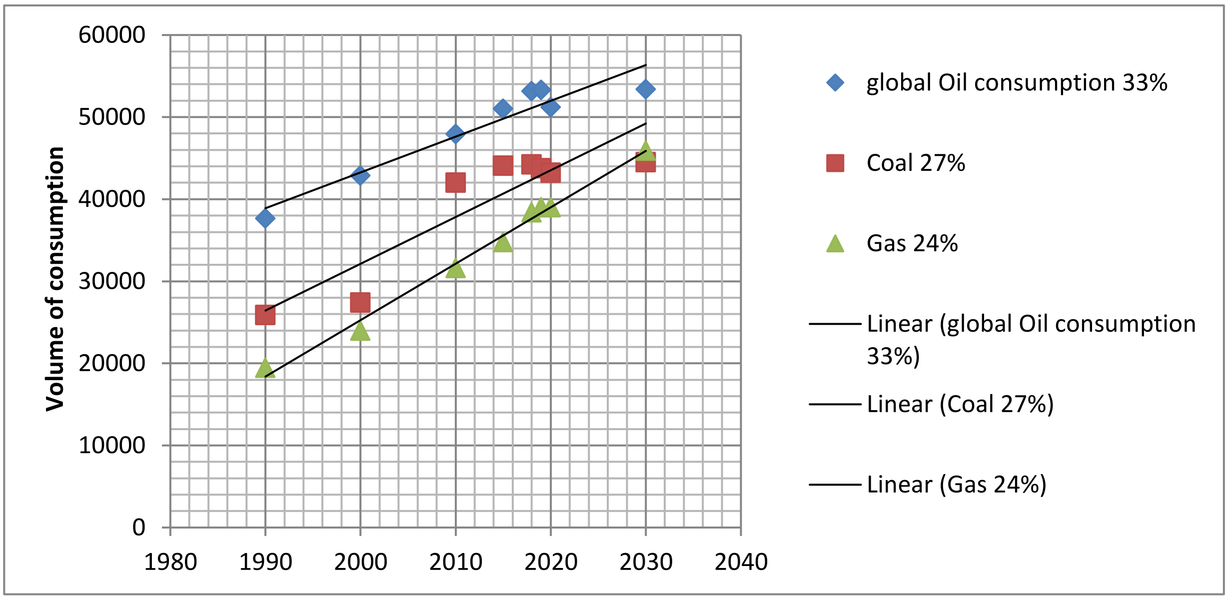

Figure 11: Global fossil fuel consumption & projection 1980-2030

Source: Global Energy Review 2020 – Analysis – IEA (2021)

Figure 11 illustrates the historical and projected trends in global fossil fuel consumption from 1980 to 2030. This graph shows how the consumption of fossil fuels, including oil, natural gas, and coal, has evolved over the past decades and provides future projections up to 2030. Energy is recognized as a vital resource for economic growth and social development, with two-thirds of global energy needs typically met by oil and gas resources. Despite concerns about their negative environmental impacts, fossil fuels remain dominant, constituting nearly 90 percent of global energy consumption. This also highlights oil, coal, and gas consumption trends from 1980 to 2020, with projections extending to 2030. During the 1980s and 1990s, oil

consumption remained relatively stable, but a significant increase occurred in the early 2000s, driven by growing demand from emerging economies like China, India, and Brazil.
One of the key observations include the general increase in fossil fuel consumption from 1980 to the early 2020s, driven by industrial growth, population increases, and rising energy demands worldwide. However, in recent years, there may be signs of stabilization or changes in growth rates due to factors such as advancements in renewable energy, energy efficiency measures, and global efforts to reduce carbon emissions. Looking ahead to 2030, the projections indicate anticipated trends based on current policies and market conditions. These projections help in understanding how consumption patterns may evolve and the potential impacts on global energy markets and climate change mitigation efforts.
Overall, figure 11 provides a comprehensive view of how global fossil fuel consumption has changed over time and offers insights into future consumption patterns, which are crucial for planning and policymaking in the energy sector. Building on the analysis of overall fossil fuel consumption trends. Figure 12 delves deeper into the regional breakdown of global oil consumption, offering a more nuanced understanding of how different parts of the world contribute to and are impacted by the global energy terrain.

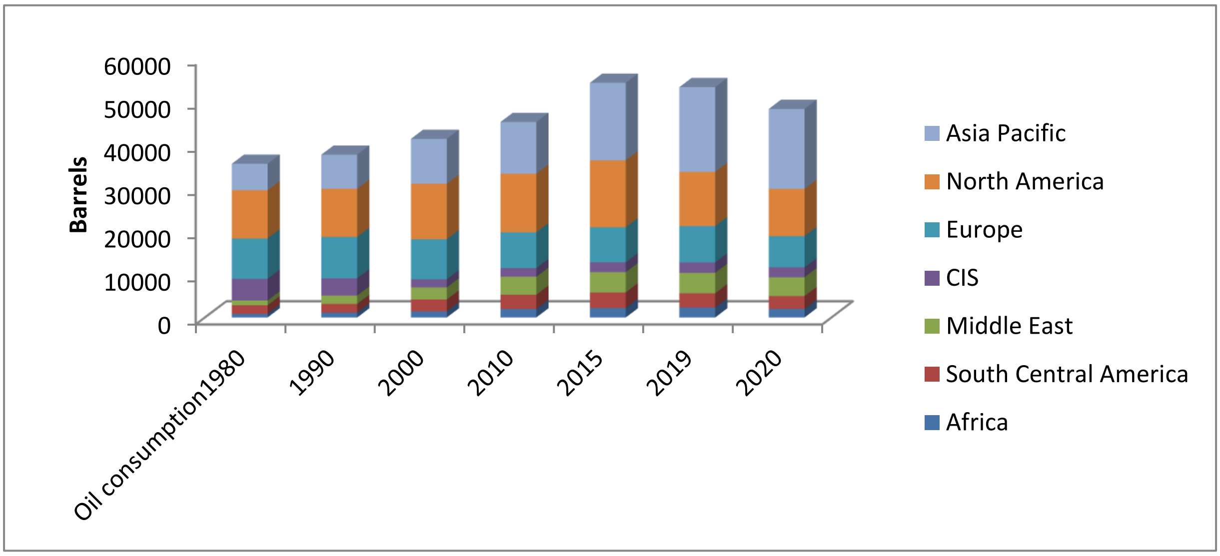

Figure 12: Global Oil Consumption by Region

Source: OPEC (2021)

Figure 12 illustrates the regional disparities in global oil consumption, highlighting that Asia, North America, and Europe are the largest consumers of energy, while Africa shows the lowest consumption levels. Specifically, China, India, and the United States emerge as the top consumers of primary energy, with Africa’s oil derivative consumption contributing only about 3.5% of the global total. The figure also indicates a consistent upward trend in oil consumption since the 1980s, driven primarily by the rapid industrialization and economic growth of emerging economies like China and India.

During the 1980s and 1990s, oil consumption remained relatively stable, but a significant increase occurred in the early 2000s, as demand surged in these regions. Despite global efforts to diversify energy sources, fossil fuels continue to dominate, accounting for nearly 90% of global energy consumption. This reliance on oil, coal, and gas, which are crucial for economic growth and social development, underscores the strategic importance of these resources in global trade and geopolitics. As consumption continues to rise, particularly in Asia and North America, lead firms in the Global Value Chains (GVCs) leverage this growing demand to secure production and reserves, enhance their market positions, and pursue higher profits through new market expansions, mergers, and acquisitions. This dynamic, coupled with the persistent dominance of fossil fuels, presents significant cost advantages for these firms, enabling them to assert producer-driven approaches in global trade.

that the regions with the largest energy consumption are Asia, North America, and Europe, while Africa has the lowest consumption. Notably, China, India, and the United States are the largest consumers of primary energy, whereas Africa's oil derivative consumption is relatively low, accounting for about 3.5% of the total. The figure 12, indicates a consistent upward trend in oil consumption since the 1980s, with China, the U.S., and India emerging as the top consumers of fossil fuels, and collectively accounting for over half of global consumption. This rise in consumption presents cost advantages for lead firms, thus enabling them to assert producer-driven approaches to secure production and reserves, and ultimately aiming for higher profits in global trade by targeting new markets and potential mergers or acquisitions. It also directly influences the patterns of oil production and reserves, as shown in Figure 13**.**

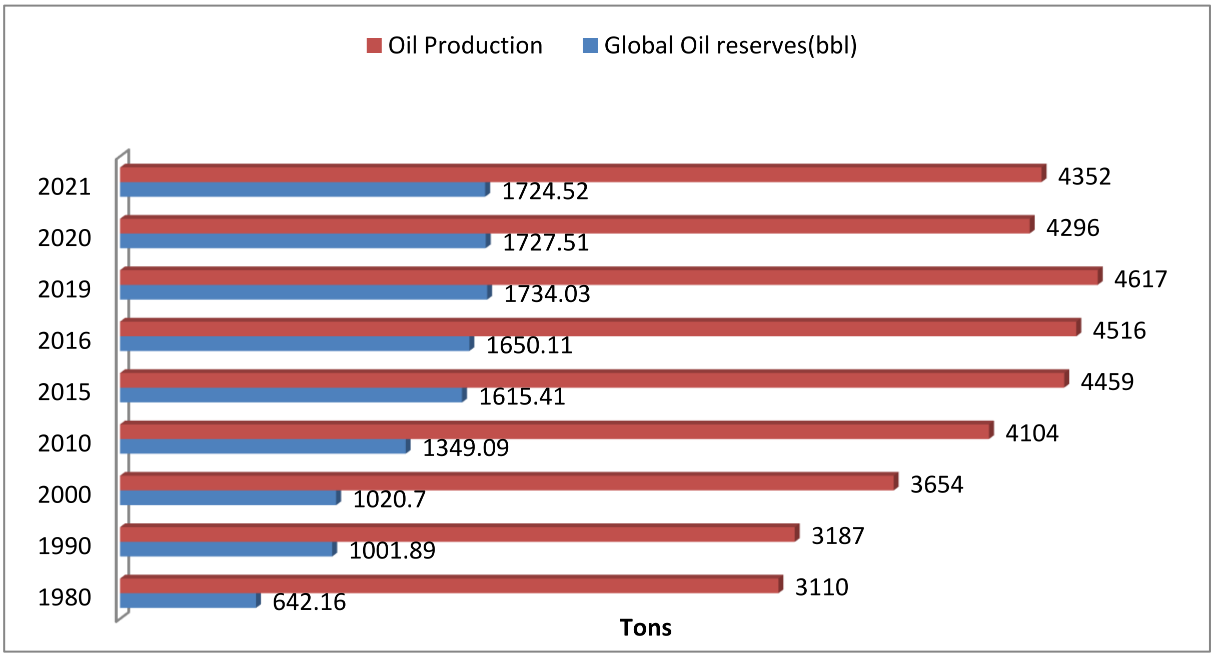

Figure 13: Global Crude oil/Natural gas Production and Reserves

Source: Energy Agency (2021)

Figure 13 shows global trends in oil and natural gas production and reserves from 1980 to 2021, with volumes measured in tones. These metrics provide insights into the industry's capacity to meet global energy demands and the sustainability of future extraction efforts. Oil production trends show significant growth over the decades, driven by technological advancements and the discovery of new fields. Throughout the 1980s and 1990s, production remained relatively stable, with fluctuations influenced by geopolitical events and market dynamics. The 1990s saw a gradual increase which suggests new technologies enabled the exploitation of previously inaccessible fields, while the 2000s marked a period of accelerated growth, particularly with the advent of shale oil extraction in the United States. This trend continued into the 2010s, although production levels fluctuated in response to market conditions and global events such as the occurrence of COVID-19 pandemic in 2020.

Furthermore, the data reveals significant fluctuations in oil production, with the highest levels recorded in 2019 and the lowest in 1980. This period reflects the dynamics of global oil supply and demand, influenced by geopolitical events, technological advancements, and economic factors. It also highlights a consistent increase in global oil reserves over the years, though the distribution of these reserves remains unequal across different periods and regions. This unequal distribution impacts global oil prices, which have also experienced significant volatility, particularly with notable price hikes in the 1980s as earlier discussed.

In summary, figure 13 offers a detailed view of global oil production and reserves, complementing the data on fossil fuel consumption and production levels. Currently, fossil fuels account for 33% of global energy consumption, with coal and gas comprising 27% and 24%, respectively. In terms of production, regions with significant consumption also tend to be major producers, although disparities exist. For instance, while Asia, North America, and Europe lead in consumption, Africa, despite its substantial oil reserves, has lower production levels. This contrast underscores the complex interplay between consumption patterns, production capacities, and reserve management. The figures illustrate how lead firms and nations navigate these dynamics to optimize their positions in the global oil market and GVCs, aiming for strategic advantages in production, trade, and resource management. These trends highlight the need for strategic management of oil resources, especially for regions like Africa, which have substantial oil reserves but lower consumption levels, and emphasize the need for comprehensive policies to ensure sustainable production and consumption of oil, leveraging global trends to enhance energy security and economic growth.

Figures 7 to 13 highlight the evolution and current dynamics of global oil consumption, production, and reserves, showcasing regional disparities, especially Africa's lower production capacity relative to its reserves. These insights underline the broader implications for global energy markets and investment opportunities. Understanding these dynamics is crucial for developing countries to maximize the benefits of GPVC.

2.10.4. Maximizing the Benefits of GPVC From Petroleum Resources (Developing Countries)

Maximizing the benefits of global petroleum value chains (GPVCs) for African countries requires a multifaceted approach that addresses both the opportunities and risks associated with oil sector participation. One of the key issues is the governance of oil and gas resources. Often, petroleum laws and policies in African countries are primarily designed to attract investment rather than to extract maximum economic rents. This results in a scenario where the governments receive substantial revenues from crude oil production but fail to distribute these effectively, hindering broader economic development. To enhance sustainable development, it is crucial to reform these policies to balance attracting investment with ensuring that the generated wealth benefits the entire population. Furthermore, incorporating transparent and robust regulatory frameworks can minimize corruption and ensure that revenues are reinvested into national development projects.

Sharma & Shrestha (2023) emphasize the need for African oil-producing countries to ensure that their oil supplies are reliable, environmentally responsible, and reflect market fundamentals. They highlight the importance of addressing challenges such as high and volatile oil prices, increasing import dependence, and regional interdependencies. To manage these issues, policies should be designed to stabilize the economy, mitigate environmental impacts, and enhance regional cooperation. Strengthening relationships and networks among stakeholders, including both net importing and net exporting countries, can facilitate a more integrated regional value chain. This not only enhances energy security but also supports sustainable management of resources, promoting greater participation in GPVCs. By adopting these strategies, African countries can leverage their oil resources for long-term economic growth and development while avoiding the pitfalls of over-reliance on oil exports.

2.10.5. Oil Importation & Impact on Domestic Institutions

Oil importation plays a crucial role in meeting the energy demands of countries that lack sufficient domestic production capabilities or seek cost-effective alternatives to locally produced oil. There are few literatures in international economics and business that largely explores the determinants of firms in their participation in global oil imports and their impacts. Economically, importing oil can strain national finances and impact trade balances, especially if a large portion of the national budget is allocated to purchasing oil from abroad. Fluctuations in global oil prices directly influence import costs, leading to potential inflationary pressures and impacting consumer prices within the domestic markets.

However, Sharma & Shrestha (2023) noted that declining production of refined oil can lead to increased reliance on imports, exacerbating trade deficits and vulnerability to international market fluctuations. The author also emphasized the remote incidences of hindrances to domestic industrial growth by limiting access to essential energy resources needed for manufacturing and transportation sectors.

In the perspective of energy security, dependence on imported oil exposes countries to risks associated with geopolitical tensions or disruptions in global supply chains. Countries with limited refining capacity may face greater vulnerability to supply shortages, affecting domestic energy availability and stability. This reliance on external sources also underscores the importance of diversifying energy sources and developing robust strategic reserves to mitigate risks associated with oil importation.

Industrially, sectors heavily reliant on oil inputs, such as transportation, manufacturing, and agriculture, are directly impacted by imported oil prices. Higher costs can increase production expenses, reduce profitability, and diminish global competitiveness. This economic ripple effect extends to employment levels and overall economic growth prospects, underscoring the interconnectedness between oil imports and national economic performance.

Environmental and social impacts are critical considerations when assessing the implications of oil imports. Imported oil often carries environmental burdens related to its extraction and transport, potentially leading to pollution, carbon emissions, and environmental degradation. Countries importing oil from regions with lax environmental regulations may face heightened challenges in managing these impacts. Beyond environmental concerns, effective management of oil and gas resources encompasses technical expertise, revenue collection, resource governance, technological advancement, security, transparency, and refining capabilities.

Furthermore, high oil prices associated with imports can exert significant economic pressures, including increased import costs, inflation, and exchange rate volatility. These factors can negatively affect GDP, particularly for net oil-importing countries, thereby limiting opportunities for domestic firms and energy production.

Despite advancements in energy production in some oil-rich countries, the persistence of refined petroleum imports remains a subject of scrutiny. For instance, the USA saw a notable increase in domestic oil production from 4.3 million barrels per day (mbpd) in 2014 to 9.7 mbpd in 2022, yet it continued importing significant volumes (World Energy Outlook 2022). Similarly, Africa witnessed a rise in oil and gas imports from 1.98 mbpd to 4.43 mbpd between 2010 and 2021, underscoring the ongoing reliance on import (IEA, 2021).

Álvarez et al. (2018) suggests the adoption of comprehensive strategies by government, to help countries mitigate the vulnerabilities associated with oil import dependence while striving for sustainable economic development and resilience in the face of the global energy production.

However, while there are some cogent reasons for oil importation, oil-importing developing countries and their domestic firms are presumed to be highly vulnerable, particularly to major supply disruptions and costs (Bawa et al., 2020). Dawar (1999) recommends two cost-effective measures to address these vulnerabilities: enhancing energy efficiency across industrial sectors and implementing strategic petroleum reserves. These measures are aimed at reducing dependency on imports and mitigating the impact of supply disruptions on domestic institutions and economies. Fan et al. (2021) underscore the importance of infrastructural advancement, including the development of robust transportation networks and storage facilities. These investments not only facilitate smoother oil importation processes but also enhance distribution efficiency and reduce operational costs.

Additionally, Ogbuigwe (2018), argues that many developing countries have been under-investing in technology and knowledge, which hinders the efficient reallocation of human and capital resources. For instance, Nigeria recorded its first annual trade deficit in 2016 due to a 9.79% drop in export value. Additionally, trends show that imports of refined oil products meet only about 10% of Nigeria's demand, indicating a persistent imbalance between imports and exports in recent years. The author recommends investment in technology and innovation within the oil sector. This approach aims to enhance domestic production capabilities, reduce costs associated with imports, and improve overall efficiency in the energy sector. By leveraging advancements in technology, such as enhanced oil recovery techniques, 3D drilling techniques and renewable energy integration, oil-importing countries can strengthen their energy security and resilience against external shocks. To complement Ogbuigwe's view, Grace Chukwuma-ekwueme (2023) emphasizes the need for Nigeria and other oil-rich African countries to implement targeted, cost-effective operational strategies and robust refining plans. These measures are essential to reduce dependency on petroleum product imports, strengthen energy security, and foster sustainable economic growth.

2.11. SUMMARY

This chapter begins by covering key concepts such as GVCs, which have emerged due to globalization and are characterized by interconnected production blocks linked by service connections, illustrating the evolving nature of world trade. The chapter outlines the consensus among economic and management scholars on the genealogy of world trade, referencing key authors such as Richard Baldwin, Lee J, Gary Gereffi, Humphrey, and Sturgeon.

Furthermore, the chapter traces the historical evolution of GVCs and their role in driving economic globalization and trade liberalization, emphasizing the benefits of participation, which includes increased efficiency, specialization, and access to new markets. It delves into nuanced concepts of GVC governance and upgrading, exploring factors beyond open trade and investment regimes that influence integration into GVC. It discusses the processes required for developing countries to move up in the global value chain, emphasizing the critical role of upgrading in driving economic development and competitiveness on the global stage. The chapter also elaborates on the governance structure along commodity chains, buyer/supplier relationships, and their crucial roles in the dynamics of GVCs, referencing the five types of GVC governance classifications: hierarchy, captive, relational, modular, and market types, and their levels of coordination and power asymmetry.

The chapter underscores the significance of Trade in Value-Added (TiVA) databases in gaining comprehensive insights into global production networks, going beyond conventional trade statistics. TiVA offers a deeper understanding of GVCs by capturing the integrated economic activities among countries. The discussion emphasizes the need for standardized formats and classifications to ensure the accuracy and reliability of data, which will be crucial for the analysis presented in Chapter 5. In that chapter, we will explore Nigeria's National Petroleum Industry (NPI) and its relationship with the country's participation in GVCs, leveraging insights from TiVA data and statistical computations.

The petroleum industry is highlighted to complement the firm focus of GVC analysis. Moreover, the chapter sheds light on the petroleum industry's historical evolution and its transformative impact on societies, economies, and geopolitics globally. It maps out the complex network of activities involved in the petroleum value chain and highlights key challenges facing oil-rich economies, such as technology stagnation, governance issues, and environmental sustainability concerns.

The chapter concludes by examining the causes and consequences of oil importation among oil-rich economies, identifying key issues such as technology stagnation, governance and transparency problems, environmental sustainability concerns, geopolitical tensions, lack of economic diversification, and insufficient attention to social responsibilities.

Ultimately, the chapter underscores the necessity for comprehensive reviews to address systemic weaknesses and ensure the long-term resilience and sustainability of the oil industry.

Chapter 3.
National Innovation System (NIS)

The term "Innovation System" is interpreted differently by various scholars, often leading to its ambiguous use. In development literature, "innovation" and "innovation systems" are distinct concepts and not interchangeable. Innovation typically refers to the creation, dissemination, and application of new ideas within an industry or economy. Modern commerce views innovation as a set of components or the refined outcome of a process and its causal relationships, while others define it as a new method, idea, or product aimed at achieving organizational success.

Innovation is transformative and can be characterized by its "newness" or the degree of "change" it brings to existing products or practices. This newness can occur on national, regional, global, or industry levels, all driving systemic and economic growth. In this study, we focus on National Innovation Systems (NIS). According to Lundvall (2009), a framework is essential for understanding the processes that drive innovation within a nation. This involves the flow of technology and information among individuals, enterprises, and institutions, primarily through new organizational methods, business practices, or external relations (OECD, 2023). It encompasses the interactions of various actors working together to transform ideas into processes, products, or services. Technological advances like electricity, which have spurred further innovations in fields such as health and medical research (e.g., the Human Genome Project), lasers, and biotechnology, exemplify this. In business, innovation is evident in the computerization and automation of modern systems, such as automobiles, GPS, smartphones, and digital data. While new technologies can be exciting, experts caution that it is crucial to understand their advantages and disadvantages before widespread adoption.

The concept of innovation has evolved over the past three decades, particularly after integrating different theories related to innovation systems (Lundvall, 1992). This evolution has been further examined in recent reports, such as those by the OECD in 2023. Although innovation often depends on inventions, its true potential for fostering growth in organizations or nations is only realized when these innovations are successfully integrated into commercial activities. Consequently, this results in diverse interpretations of innovation systems and National Innovation Systems within academic discussions.

3.1. INNOVATION SYSTEM (IS) CONCEPTS

Several researchers often operate in fluidity in their interpretation of IS and do often create a mix between national knowledge infrastructure, science and technology and their policies. As a result, they end up working with a more demanding description or limited consensus about what Innovation Systems are. This generally affects the broad description of the term “Innovation Systems”, as defined by Freeman in 1987 and Lundvall (1982; 2010). Other frameworks include the Sectoral Innovation Systems (Malerba, 2002), Regional Innovation Systems and lastly, and Corporate Innovation Systems (Fernández-Serrano et al., 2019).

Other examples include the National learning system, Social Innovation Systems, Technological Innovation Systems and even the triple Helix Model, Quadruple & Quintuple Innovation Helix Framework, collaborative Innovation Network, etc. These systems have gained popularity among policy makers and researchers since the 1990s. While Lundvall (2010) posits that the use of technology by institutions and firms promotes the innovation systems approach, Hamidi M. suggests that fundamental factors such as national work patterns, organizational structures of firms, and the educational and labor market institutions associated with them are catalysts that bolster innovation activities, thereby enhancing economic growth (Hamidi & Zandiatashbar, 2020). In essence, the concept of an Innovation System is crucial for understanding how countries foster, spread, and leverage innovations to advance their economic growth and competitive edge.

An NIS or National Innovation System encompasses the dynamic flow of technology and information among people, enterprises, and institutions, which plays a pivotal role in driving the innovative process at a national level. This framework aims to analyze the interconnected relationships among various actors involved in innovation, including governments, universities, industries, and research institutions. It provides a structured approach to understanding how these entities collaborate, exchange knowledge, and collectively contribute to fostering innovation within a country's economy and society.

3.2. NATIONAL INNOVATION SYSTEMS (NIS)

National Innovation Systems (NIS) play a crucial role in shaping a country's economic growth, technological advancements, and overall competitiveness on the global stage. According to Lundvall (1992), the development of NIS typically involves a synergistic relationship between government policies, educational institutions, research, and development (R&D) organizations, and the private sector. Historically, many countries have recognized the need to create robust frameworks to support innovation, leading to the establishment of specialized agencies and initiatives designed to foster a culture of creativity and technological progress. For instance, Edquist & Charles (2005) highlights how countries like South Korea and Finland have utilized government-led initiatives to transform their economies from resource-dependent to technology-driven, showcasing the power of well-structured NIS.

The development of NIS globally has been shaped by various initiatives aimed at enhancing innovative capacity and integrating national economies into the global innovation landscape. Early efforts in many countries focused on establishing institutions and frameworks to support scientific research and technological advancement. One of the key initiatives in the development of NIS is the establishment of funding mechanisms to support research and development activities. Nelson (1993) points out that governments and private sectors invest heavily in R&D to drive innovation and maintain competitive advantages. For example, the United States has numerous funding programs such as the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs, which provide vital support to small businesses engaged in technological innovation. Similarly, Mazzucato (2018.) discusses the European Union's Horizon 2020 program, now followed by Horizon Europe, which allocates substantial funds to foster research, innovation, and collaboration across member states, emphasizing sustainable development and addressing global challenges. These funding initiatives not only encourage domestic innovation but also promote international collaboration, enhancing the global NIS processes.

Also, the development of human capital is another critical aspect of NIS. Countries have been focusing on improving their education systems to better equip future generations with the skills needed for innovative thinking and problem-solving. According to Freeman (1987), this involves integrating STEM (Science, Technology, Engineering, and Mathematics) education at all levels, promoting lifelong learning, and fostering collaboration between academia and industry. Initiatives such as Germany's dual education system, which combines vocational training with academic learning, and Singapore's Skills Future program, which provides opportunities for continuous learning and skill upgrading, are exemplary models. These educational reforms ensure that the workforce is adaptable, skilled, and ready to meet the demands of a rapidly evolving technological landscape, thereby strengthening the NIS and contributing to sustained economic growth and development.

The contemporary discourse on NIS has been profoundly shaped by influential scholars like Freeman (1987), Lundvall (2010), and Nelson (1993). Their contributions underscore the critical role of establishing networks and information systems as essential catalysts for fostering innovation. They emphasized the necessity of collaboration among nationally bounded institutions to enhance technological innovation and economic performance, addressing challenges like cyber-attacks. Over the past three decades, the NIS framework has become a valuable tool for scholars and policymakers in understanding how national institutions can work together to drive innovation.

The effectiveness of NIS in generating and utilizing innovation depends on identifying bottlenecks and recommending policy interventions. High-income countries have shown that robust institutional and infrastructural support, along with a planned ecosystem, are crucial for successful NIS implementation. Granstrand & Holgersson (2019) describe NIS as a vital policy tool for identifying issues within an innovation system, contrasting it with the innovation ecosystem concept, which focuses on the environment and dynamics of innovation. Both frameworks involve a network of actors, institutions, and relationships essential for effective innovative performance.

Despite its success in advanced nations, the application of NIS in developing countries faces significant challenges. These challenges stem from unique economic structures that create specific problems for NIS applications. Godin (2007) points out that early indicators of NIS effectiveness in developing regions rely more on accumulated knowledge and revenue than on substantial R&D expenditure. Critics argue that while a functional view of NIS within enterprises could support growth, inefficiencies among policymakers hinder this process.

Additionally, directly adopting NIS concepts from developed countries without adaptation to local conditions may not be ideal. Mazzucato, et al. (2020) suggest that NIS application in developing countries requires further research, potentially incorporating elements of ecosystem construction and multi-level governance, as seen in regions like Taiwan, East Asia, and India. Addressing these challenges and tailoring NIS to local contexts are crucial for fostering innovation and growth in developing countries.

The effectiveness in gathering and utilizing knowledge in the private, public, and academic sectors significantly determines the success of NIS. However, developing countries often lag and require policy interventions (Egbetokun et al., 2017). A quick glance at NIS policies in developing countries shows that activities by public and private organizations are often insufficient or partially effective, varying by country. This situation calls for adequate innovation policies with necessary pre-conditions, such as those recommended by Lee et al. (2021): (i) a policy problem must exist; and (ii) the state and its public organizations must have the ability and organizational capacity to resolve or mitigate challenges. Understanding the various definitions of NIS from key authors can help in choosing appropriate policies and developing alternatives for fostering more effective NIS in developing economies. For instance:

- Freeman (1987)defined NIS as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technology.
- Hwang & Horowitt (2012) described it as "a human social network that behaves like a socio-biological system, wherein people have developed patterns of behavior that minimize transaction costs caused by social barriers resulting from geography, lack of trust, differences in language and culture, and inefficient social networks.
- Patel & Pavitt (1997) saw NIS as "the national institution, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country.
- Edquist & Charles (2005) described it as "all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovations.
- Lundvall (1992) viewed NIS as "the elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge and are either located within or rooted inside the borders of a nation state.

Over the years, the understanding of NIS has expanded to include a broader range of factors beyond traditional R&D institutions. This includes universities, government agencies, industry associations, venture capital firms, and even cultural norms and social structures that influence innovation processes. The relevance of NIS has grown in the context of changing global economic landscapes characterized by increasing interconnectedness, rapid technological change, and intensified competition. In an era of globalization, nations recognize the need to foster innovation capabilities to remain competitive in the global marketplace.

Globally, NIS has become a central focus for policymakers seeking to promote economic development, attract investment, and create high-value jobs. Countries are developing strategies to strengthen their innovative ecosystems by investing in education, research infrastructure, and industry partnerships to drive innovation-led growth. This concept reflects the growing recognition of the critical role that innovation plays in shaping economic prosperity and societal progress in an interconnected and competitive world.

The next sub-sections examine the types and key components of NIS, including government policies, research institutions, universities, and industry collaboration. It explains how these components interact to support innovation and discusses the merits, opportunities, and challenges associated with NIS implementation, particularly in developing countries where issues like funding constraints, regulatory barriers, and skill shortages impact the innovation ecosystem.

3.3. TYPES OF NIS

NIS can be classified into several types based on various factors such as scope, level of integration, and governance structure. Some common types of NIS include: the global innovation system, national innovation systems, regional innovation systems, local innovation systems and the sectoral innovation systems, all stressing the concept that pertains to the flow of technology, information and people and their interactions in the innovative process. Given the increasing interest in these concepts and definitions, we would first explore the various definitions of innovation system types, followed by a discussion on the distinctions between narrow and broad NIS in their separate expressions by authors.

(i) Global Innovation System (GIS): The GIS refers to the interconnected network of innovation activities, actors, and institutions operating at the international level to facilitate knowledge creation, diffusion, and utilization on a global scale. It emphasizes collaboration and knowledge exchange across national borders to drive technological progress and economic development world-wide.

(ii) National Innovation Systems (NIS) focuses on the innovation activities within a single country, involving the interplay between government policies, research institutions, educational organizations, and the private sector. These systems aim to enhance the national capacity for innovation by fostering a cohesive environment for knowledge creation and application.

(iii) Sectoral Innovation System: A sectoral NIS focuses on specific industries or sectors within the economy, tailoring innovation policies and initiatives to address the unique needs and challenges of those sectors. This approach allows targeted interventions to stimulate innovation and competitiveness in key areas such as healthcare, agriculture, oil or manufacturing activities.

(iv) Regional NIS operates at the sub-national level, typically within a specific geographic region or cluster of industries. It involves collaboration among local governments, businesses, educational institutions, and community organizations aimed at fostering innovation-driven economic development within the region.

(v) Local Innovation System: This system which emphasizes grass-root initiatives functions within smaller geographic areas, such as cities or municipalities. LIS focuses on leveraging local resources, knowledge, and networks to drive innovation and economic growth.

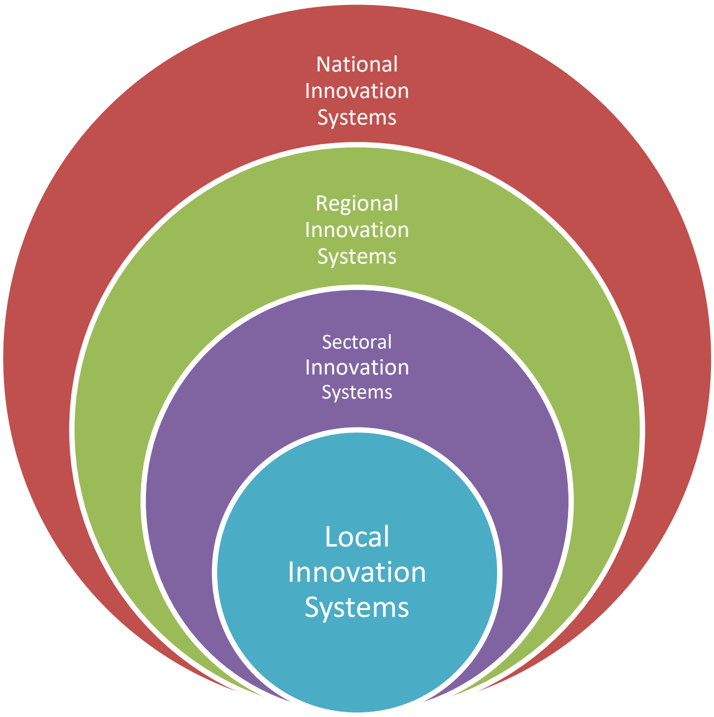

Figure 14: Type of Innovation Systems

Source: Own Elaboration

(vi) Narrow and Broad NIS: Countries differ in the ways in which knowledge flows are structured and in their relative uses of knowledge infrastructures for economic growth and development. In discussing NIS definitions, it is important to note that Lundvall (2010) originally dichotomized the broad and narrow definitions based on aspects of economic structures.

Categorizing innovation by narrow definition attempts to cover only the organizations and institutions that are involved in searching and exploring information (e.g. R&D departments, technology institutions and universities); whereas the broad base definition tends to consider this as a part, hence the addition of aspects of economic structures (socio-political) and the institutional set-up that affects learning, searching, and adapting (Lundvall 2010). Many researchers tend to link the later definition with new concepts such as the smart specializations as well as new digital technologies in the innovation ecosystems (Hund et al., 2021) thus, locating it within the ambience of tacit knowledge, economic and political freedom as well as formal research, while also associating the narrow approach with the triple Helix model where(Richard Nelson, 1993) involves the research institutions, firms and government as distinct in this field. Whereas other literatures tend to support the broad-based approach with emphasis on the range of balance between the demand and supply side in innovation activities, critiques argue that the innovation policy is still fuzzy hence require more government clarifications and purpose Edquist & Charles (2008), hence, this according to Harmaakorpi et al. (2017) makes it more challenging among researchers.

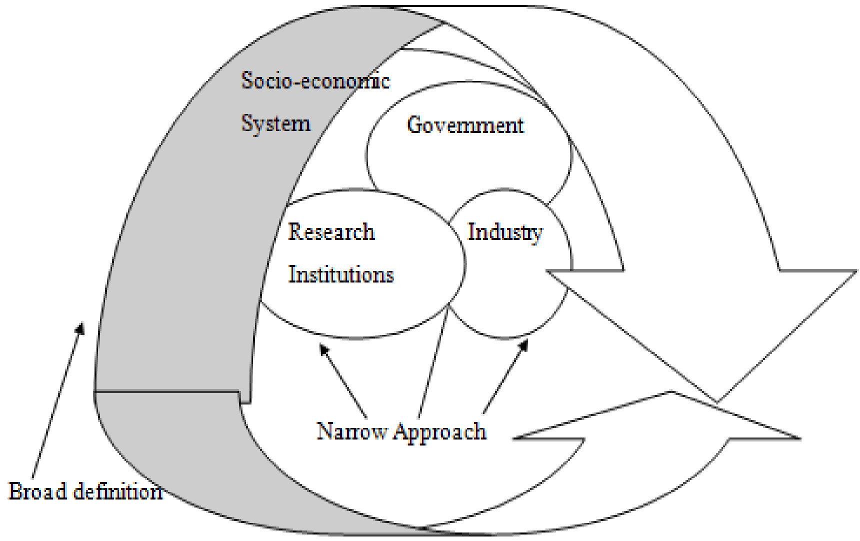

Figure 15: Broad & Narrow NIS

Source: Own Elaboration

Table 8: Broad & Narrow definitions of NIS

Series	Core targets	Narrow	Broad
1.	Main Pillars	National Science System	Knowledge in technology and learning
2.	Authors	Edquist & Charles (2005) and Nelson (1993)	Fredrich List (1841 and 1959) Freeman (1987) Lundvall (1988 and 1997)
3.	Focus	Science-based learning, radical innovation and firm-level STI	STI & DUI learning & user-producer interaction and incremental innovation
4.	Policy implementation	Promotes Science-based learning, Research & Development (patents), High-tech	Framework for improved learning across organizations. ii Experience-based, tacit knowledge & technology diffusion iii. Development of high-tech spin-off companies
5	Economic Performance	Growth of production & productivity employment, Balance of payment, exports market shares etc.	Growth in industrial performance index, investments, stock value etc.
6	Dynamic Performance capability	Education & competence building, experience building, R&D investment and collaborations	Labor mobility, knowledge sharing

Source: Own Elaboration

Table 8 depicts the difference between the narrow and the wider views in NIS descriptions. The findings were further enhanced by different results from authors like R Nelson, Lundvall, and Edquist. The empirical work of Lundvall distinctly shows the different institutional arrangements, especially in universities and firms such that the specific socio-economic, cultural, and political frameworks are delineated.

Nonetheless, experts posit that a few of these diverse types of NIS have their own strengths, weaknesses, and implications for innovation and economic growth. However, the choice of NIS model tends to depend on factors such as national priorities, institutional capacity, and the broader socio-economic context. Overall, the distinction between narrow and broad types of National Innovation Systems (NIS) reveals important insights into how countries can approach innovation and economic development.

3.4. COMPONENTS OF A FUNCTIONAL NIS

This section sets the stage for a deeper exploration of effective NIS by outlining the key components that contribute to its success. These components include government policies, research institutions, universities, and industry collaboration, which are essential for creating an environment conducive to innovation. To introduce and establish the importance of understanding how these components interact to support innovation within a country.

The interaction within the NIS occurs through the process of exchange of knowledge, resources, and expertise among its key components. Government policies provide the framework and incentives for innovation, while research institutions and universities generate new knowledge and technologies. Industry collaboration bridges the gap between research and commercialization, facilitating the transfer of innovations into the marketplace. This collaborative ecosystem fosters continuous feedback loops, driving iterative improvements and accelerating the pace of innovation within the

Li et al. (2023) asserts that effective NIS features strong collaboration and networking among its various actors, thus, facilitating the exchange of knowledge and resources. It is often supported by robust infrastructure, including physical, digital, and financial elements that enable innovative activities. Additionally, a culture that values and encourages innovation and risk-taking is essential for fostering thriving.

Harmaakorpi et al. (2017) believes that its features work with a high frequency of consultation, deliberation and effective linkages and networks among the actors facilitate the exchange of knowledge and resources. Effective collaboration ensures that different sectors can leverage each other's strengths and innovations. Networking among institutions promotes synergy and amplifies innovation outcomes. This interconnectedness is crucial for the dynamic functioning of networks.

Lundvall (2009) describes it as supportive infrastructures of physical, digital, and financial infrastructure to support research labs, high-speed internet, and financial systems particularly in developing countries. These elements provide the necessary tools and resources for innovators to develop and commercialize new technologies. A robust infrastructure also attracts effective output.

The basic components of NIS are uniquely three, comprising the University, industry, and Government. They form a complex set of relationships where the innovation systems' performance can be assessed. The economy of nations is directly based on knowledge and information which is widely recognized as an important source of growth for economic development(Lundvall et al., 2002). The major merit is that it connects the essential elements of space, economy, politics, and knowledge to the interactions of synergy in a systemic way that generates transformation/s. According to the later author, the best-known taxonomy in NIS is that it provides the avenues where firms are categorized in clusters to promote efficiency. To strengthen the potential of NIS, Lundvall et al. (2002), draw attention to the roles of local actors in respect of three important elements of learning, linkage and investment in the overall component that seeks to promote the taxonomy. Reflecting on the major policy implications is the coordination of activities for a successful NIS. Carrillo et al. (2023) explain the relationship between technology development and economic progress as an important variable in NIS component. The authors noted that the desire to produce and sustain economic gains supports the drive among actors.

A well-functioning NIS is often described as those with the mechanisms for the transfer and diffusion of knowledge across sectors and institutions. Knowledge flow is facilitated through collaborations, publications, and technology transfer offices. This exchange of information ensures that innovations are not isolated but integrated into broader applications. It also helps in quickly addressing and solving emerging and long-standing issues, especially those with the capability of producing several important outputs, including:

(1) Opportunities particularly in the creation and diffusion of new knowledge, products, processes, and technological opportunities.

(2) innovation resources, including fiscal capital, financing options, a competent labor force, and supportive educational structures.

(3) guidance for technology, market, and partner research.

(4) networking and linkages for knowledge exchange.

(5) provision of facilities, equipment, and administrative support.

(6) encouraging research and development.

(7) promotes rules and regulations that enhance market access and protect innovators' rights.

(8) the creation and change of institutions

(9) incubation and acceleration of entrepreneurs and small firms

(10) consultancy service/s

It is important to note that these activities which form the basis for good NIS components are not ranked according to importance, but all together refer to the different dimensions of inputs that can help in determining a good NIS process. However, attempting to link these components to a potential national performance would require that a high level of technical collaboration, increased knowledgebase, personnel mobility and technology diffusion be employed for improved innovation systems capabilities. According to Edquist & Charles (2005), key input provisions necessary to revitalize NIS, especially in developing countries, include knowledge inputs (such as research, training, and development), demand-side activities (including public procurement of innovation and support for relevant actors in the innovation system like networking and organizational process changes), and enhancements in support services for innovative firms (such as financing and incubation of key innovative ventures).

The recent studies aimed at illustrating the essential elements in NIS strategies to effectively map interactions include those by Harmaakorpi et al. (2017) and Li et al. (2023). Germany is a good example of robust industrial base, strong research institutions, and the Fraunhofer Society's role in applied research. Germany's NIS is unique due to its focus on engineering and manufacturing excellence. The country's system promotes close collaboration between industry and research institutions. This synergy has enabled Germany to maintain its position as a leader in high-quality manufacturing and engineering innovation. From the latter's explanation, the rationale of the economic importance of NIS is in the increase in research and technology; to identify the leverage points in policy making and the promotion of sources for joint industry activities from the nexus of the components.

3.5. NIS IN DEVELOPING COUNTRIES

The NIS in developing countries refers to the network of institutions, policies, and actors that interact within a country to foster innovation and technological development. These systems are critical for economic growth, competitiveness, and in addressing developmental challenges. The key components of NIS typically include government policies and regulations, research institutions and universities, the private sector, financial institutions, civil society, and NGOs, as well as international organizations and foreign aid. Each of these components plays a crucial role in supporting and enhancing the innovative ecosystem within a developing country. A developing country is often defined by seven key traits: a) political turmoil and frequent crises; b) high levels of unemployment, poverty, and notable social disparities; c) underdeveloped markets and reliance on informal practices; d) emerging financial institutions with limited regulation; e) poor and inefficient infrastructure; f) an economy heavily impacted by global economic shifts; and g) vulnerability to unpredictable capital flows. These conditions are especially prevalent in the "least developed countries" (LDCs).

As reported by the United Nation's Economic and Social Council, OECD(2022) these countries have an exceptionally low-income level, with per capita income falling below 1,000 dollars. Their indicators for health, nutrition, and education (human development index) are also weak, and their economic vulnerability is high. This is largely a result of their dependence on a narrow range of sectors, the disorganization within their economies, and the inefficiency of their productive systems.

Ibeme (2020) notes that developing countries face unique challenges in establishing effective NIS. Limited financial resources are a significant barrier, as insufficient funding for research and development (R&D) and innovation-related activities can stifle progress. Weak institutional frameworks and inadequate infrastructure further hinder innovation efforts. Additionally, the phenomenon of brain drains, where skilled professionals migrate to developed countries for better opportunities, poses a substantial challenge. Low levels of collaboration between universities, research institutions, and the private sector also impede the development of a robust NIS.

To strengthen NIS, developing countries can adopt several key strategies. Capacity building through investment in education and training is essential to develop a skilled workforce capable of driving innovation. Improving physical and digital infrastructure is crucial to support innovation activities. Policy reforms that encourage R&D investment and protect intellectual property rights can create a conducive environment for innovation. Promoting public-private partnerships can enhance collaboration and resource sharing. Leveraging international cooperation for technical assistance and funding can provide the necessary support for innovation initiatives (Lee et al., 2021).

Few developing countries have made significant strides in fostering innovation through their NIS. For example, India has implemented initiatives such as innovation hubs and the “Startup India” campaign to support new enterprises. China’s NIS is characterized by substantial government investment in R&D and strong collaboration between universities and the private sector. Brazil has focused on advancing agricultural technologies through institutions like EMBRAPA. Kenya’s “Silicon Savannah” demonstrates the potential of leveraging technology and innovation to drive economic growth, particularly in the ICT sector. Robust NIS can significantly contribute to economic development in developing countries. Innovation enhances productivity by making production processes more efficient and creates jobs through the emergence of new industries and companies. Improved competitiveness allows firms to compete better in global markets. Innovations can also address social challenges by providing solutions in areas such as healthcare, education, and environmental sustainability (Egbetokun et al., 2017).

Looking forward, the future direction of NIS in developing countries includes embracing digital transformation to leapfrog traditional development stages, ensuring that innovation benefits all segments of society through inclusive innovation, and focusing on sustainable development to promote economic growth and environmental conservation. By overcoming barriers and leveraging strategic initiatives, developing countries can build robust NIS that supports sustainable and inclusive development (Casadella & Tahi, 2023).

Future research on National Innovation Systems (NISs) in the Global South emphasizes the importance of understanding the unique characteristics of developing countries and building capabilities through innovation learning policies. As suggested by Lundvall (2009) and reinforced by Cicera (2018), the four basic elements include: (i) the interactions among enterprises (, (ii) interrelationship between enterprise and industries (iii) diffusion of knowledge & technology and (iv) movement of personnel.

In consideration of the “Interaction in Enterprises”, the element explains how businesses within developing countries collaborate, compete, and share resources. Understanding these interactions, as highlighted by Gay et al. (2021) is crucial for fostering a supportive innovation ecosystem.

Regarding the "Inter-relationship between Enterprises and Industries", the focus is more on the connections between individual businesses and the broader industry sectors they belong to. It examines how these relationships influence innovation and industry growth. On knowledge diffusion, the element investigates how knowledge and technological advancements spread within and between industries. Effective diffusion, emphasized by Freeman (1987), is key to ensuring that innovation benefits a wide range of stakeholders. Finally, the movement of personnel examines how the mobility of skilled workers affects innovation. The movement of personnel between enterprises, industries, and regions can facilitate the transfer of knowledge and skills, enhancing overall innovation capacity in policies, as noted by Mazzucato et al. (2020). Focusing on these elements, research can provide valuable insights into how developing countries can design and implement effective innovation learning policies that are tailored to their specific needs and context. Some of these key components are included in the framework presented in figure 16.

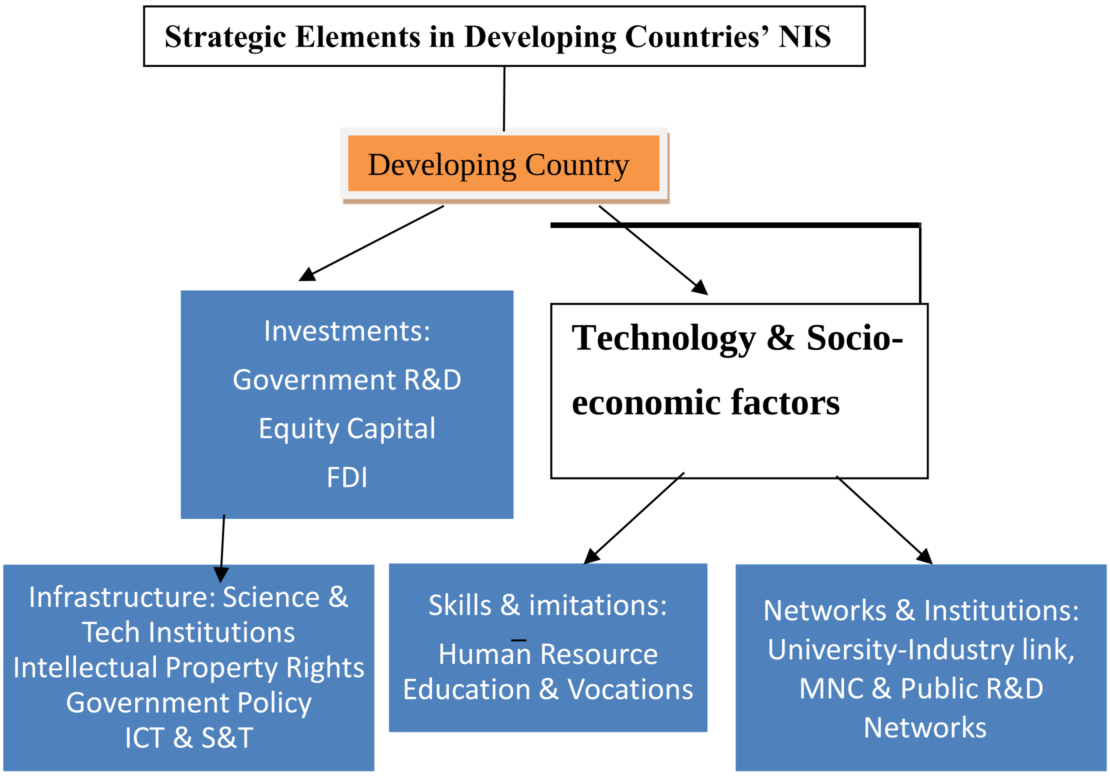

Figure 16: Key Factors in Developing Countries' NIS.

Source: Own elaboration

Figure 16 illustrates the National Innovation System (NIS), which consists of several key components that collaboratively promote innovation within a developing country. Government policies establish the regulatory framework and incentives that encourage innovation. Research institutions and universities act as centers for generating and sharing knowledge. Industry collaboration unites businesses, entrepreneurs, and other stakeholders, facilitating the exchange of ideas, resources, and expertise across various sectors. These components interact through partnerships, funding mechanisms, and joint projects, creating a vibrant ecosystem where ideas are developed, tested, and brought to market, ultimately driving economic growth and enhancing competitiveness.

In many developing nations, the government often plays a central role in establishing the regulatory framework and providing incentives to stimulate innovation. This may include funding for R&D, tax incentives for innovative companies, and policies that encourage foreign investment in technology sectors. By creating a supportive policy environment, governments can help to lower barriers to innovation and attract investment in high-tech industry.

Research institutions and universities in developing countries are critical for generating new knowledge and technologies. These institutions often collaborate with industry to conduct applied research that addresses local challenges and opportunities. By focusing on areas that are particularly relevant to the national context, such as agriculture, health, or energy, research institutions can help to drive innovation that has a direct impact on economic development.

Industry collaboration is also an essential component of NIS in developing nations. This involves partnerships between businesses, entrepreneurs, and other stakeholders to share resources, expertise, and ideas. Such collaborations can lead to the development of new products, processes, and services that enhance competitiveness and drive economic growth. Industry clusters and innovation hubs are examples of how these collaborations can be structured to foster a dynamic ecosystem of innovation. Thus, the interaction between these components (government policies, research institutions, and industry collaborations), where efficient, tends to create a vibrant and dynamic innovation ecosystem. This ecosystem enables the development, testing, and commercialization of new ideas, ultimately driving economic growth. For instance, countries that successfully implement NIS can see improvements in productivity, job creation, and overall economic resilience.

Lundvall (2010) emphasizes the importance of capabilities in the innovation process, drawing from Amartya Sen's framework, which links innovation to the expansion of human capacity and quality of life. Lundvall argues that innovation should consider social and environmental aspects, advocating for "bottom-up" innovation policies that build capacities from the grassroots level. This approach, exemplified by concepts like "jugaad innovation"; an innovative, resource-efficient solution common in emerging economies highlights the potential for local ingenuity to drive development.

Building competences through learning opportunities is also crucial, especially in the poorest countries were improving quality of life and reducing disparities are paramount (Casadella & Tahi, 2023). It has been suggested that this can be achieved by orienting demand towards developing innovation capacities in industry and services, and promoting learning based on experience (Lee et al., (2021).

The concept of NIS must also consider the internationalization and globalization of innovation systems. Metcalfe (1995) explores how the NIS framework, originally developed for advanced economies, can be adapted for developing countries by fostering global linkages and facilitating inward knowledge flows to strengthen local innovation capacities. Harmaakorpi et al. (2017) notes that these linkages are essential for building effective NIS in developing contexts, despite the challenges posed by local political and economic conditions. Hund et al., (2021)highlight the importance of more competences and intermediaries, such as industry associations, in negotiating stable business environments and fostering innovation.

In assessing the NIS of Thailand,Lee et al. (2021) developed a framework based on policy adoption, implementation, and evaluation. The study's recommendations for Thailand included minimizing resource allocation conflicts, incentivizing private sector innovation, encouraging university participation in NIS, and rationalizing public sector components. This country-specific approach underscores the need for each developing nation to tailor its NIS to its unique context, ensuring policies are relevant and effective.

Overall, the literature suggests that while developing countries face significant challenges in establishing effective NIS, there are opportunities to build on the experiences of advanced economies and adapt innovative policies to local conditions. By focusing on building capacities, fostering global linkages, and addressing socio-economic factors, developing nations can create robust NIS that support sustainable economic growth and development.

3.6. FROM NIS TO INNOVATION CAPABILITIES IN THE DEVELOPING COUNTRIES

In many countries' National Innovation Systems (NIS) provide a foundational framework for understanding how various components such as government policies, research institutions, universities, and industries interact to foster innovation within a country. In developing countries, the focus on NIS highlights the importance of creating an environment conducive to innovation through coordinated efforts and strategic policies. However, translating the concept of NIS into tangible innovation capabilities requires addressing specific challenges and leveraging unique opportunities present in these nations (Cicera, 2018).

The building blocks includes "Human Capital" development as articulated by Lee et al. (2021). The authors emphasized that developing countries must invest in education and skills training to create a knowledgeable and adaptable workforce. Enhancing technical and vocational education can empower individuals to contribute effectively to innovation processes. Contemporary scholars like Cirera & Maloney (2018) emphasize that developing countries should prioritize building their innovation capabilities by enhancing and adapting existing technologies. This strategy enables these nations to achieve incremental improvements that significantly enhance productivity and competitiveness in global markets. Instead of striving solely for radical innovations, they should focus on creating a robust environment that supports continuous learning and adaptation.

Lee et al. (2021) argue that integrating and upgrading imported technologies is crucial for many developing economies. This involves enhancing local skills, improving organizational practices, and fostering stronger linkages between different actors within the innovation system. By focusing on these areas, developing countries can develop more resilient and effective NIS that support sustainable economic growth.

Furthermore, innovation systems in less developed countries are often interpreted through their structures rather than their technological outcomes. According to Hyeri (2019) the innovation strategies in the Global South tend to exhibit retrospective (ex-ante) characteristics. This means that learning processes are designed to move upstream, focusing on conditions of emergence and development. Essentially, these strategies aim to build foundational capabilities before attempting to achieve advanced technological outcomes, thus ensuring a solid base for sustainable innovation. However, one can refer to the workings of the innovation system of the South Schmitt & Muyoya (2020) to steer the performance of developing countries through innovation capabilities. This approach is essential because the knowledge capital and the activities of human resources indicating capabilities are often not captured.

Wang & Le (2018) identify three types of performance measures that can support the capabilities to ensure growth in developing countries' NIS.

(I) Knowledge Generation: Measured by scientific publications, patents, the number of engineers and scientists, R&D activities, and technological diversity.

(II) Technology diffusion: Indicated by the number of technology users, spin-offs, training programs, mobility of professionals, licenses, and joint ventures.

(III) Utilization of New Knowledge: Reflected by the number of new firms, investments, employment rates, sales figures, market shares, growth rates, profitability, and share values.

Ndicu et al. (2023) by using the UNCTAD capability index further supports the need for continuous assessment and improvement of performance through technology catchup and continuous traditional innovation technology. This index combines skills availability with technology activities, providing a comprehensive measure of a nation's capability to innovate and develop.

However, a dynamic performance measure is needed to indicate the extent to which a developing country's national innovation system can enhance its learning and innovation capability, thus moving towards a more productive sector in the economy. Inspired by some aspects of the learning and upgrading culture. Gregersen& Johnson (2021) suggest defining the upgrading of sectors by the NIS approach as a process where creativity and investment in education are valued for optimal productive outcomes. This includes:

(i) Learning and Innovation Capabilities: Represented by the availability of supportive resources for learning and competence building.

(ii) Capability-based Performance: Such as available venture capital, increasing educational levels and skills upgrades, new knowledge acquisition, and the innovation and upgrading status.

Birgitte Gregersen & Johnson (2021) emphasize the importance of learning and innovation capabilities, supported by resources for competence-building, available venture capital, increasing educational levels, and skills upgrades. They suggest that interactions, cooperation, and knowledge synergy among people, organizations, and firms are crucial for supporting economic development.

The key indicators of these capabilities are essential for understanding how NIS can drive economic growth and development in developing countries. These indicators emphasize the importance of interactions, cooperation, and knowledge synergy between people, organizations, and firms, with monitoring enforced to support economic development. This includes navigating complex challenges to establish effective NIS that drive innovation and economic growth. In turn, by learning from advanced countries and focusing on grassroots innovation and capabilities building, developing nations can enhance their innovation systems. This comprehensive approach ensures that developing countries can effectively utilize their innovation systems to foster sustainable growth and competitiveness, as detailed in Table 9 from Gregersen & Johnson (2021).

Table 9: NIS Embedded Capability-based performance.

Learning & Innovation Capabilities	Capability-based performance	Examples
Education & Competence	Increasing educational level Relevant vocational training High and broad participation in Lifelong Learning	Expenditure on education (Primary, secondary & tertiary) Expenditure on Lifelong learning Hours and money spend on vocational training
Supportive Resource Availability	Adequate Knowledge Infrastructure Pervasive use of ICT Available Venture Capital and availability of other educational resources to foster learning and competence building	Number of Internet users Venture capital & Investment Funds Incubator facilities, R&D and Investment in capital equipment
Collaboration, innovation, co-operation & knowledge synergies between people, organizations, and disciplines	Implementation of Problem Based Learning curriculum University-society relations Public-private Partnership	Collaboration patterns, Sources of information for innovation (CIS surveys) R&D contracts, joint ventures FDI Labor mobility schemes
New Knowledge Acquisition	Efforts to acquire and integrate new knowledge into the economy through research, collaborations, and technology transition	Continuous training to match evolving industry needs

Source: Adapted from Birgitte Gregersen & Johnson (2021)

Table 9 pertains to the assessment of how NIS enhances or influences the performance of organizations or firms based on their embedded capabilities. In this context, "embedded capabilities" could refer to the specific competencies, resources, or capacities that organizations develop or acquire within the framework of the NIS. Gregersen's work explores how these embedded capabilities contribute to the overall performance, innovation outcomes, competitiveness, and sustainability of firms operating within a national innovation ecosystem. It aims to identify best practices, challenges, and opportunities for enhancing NIS effectiveness and fostering economic development through NIS.

3.7. NIS AND THE INNOVATION SYSTEMS IN PETROLEUM INDUSTRY

This National Innovation System (NIS) is pivotal in shaping the innovation landscape within any industry, including the petroleum sector. The petroleum industry, characterized by its capital-intensive and technologically driven nature, relies heavily on innovations to enhance efficiency, improve safety, and meet environmental standards. The integration of NIS into this sector supports the development and deployment of new technologies, ensuring the industry's growth and sustainability in ways such as:

- **Technology development:** The petroleum industry depends on continuous technological advancements to optimize extraction, refining, and distribution processes. NIS fosters innovation by linking research institutions, universities, and industry players, enabling the development of technologies such as enhanced oil recovery (EOR) techniques, digital oilfields, and advanced drilling methods. These innovations are essential for increasing production efficiency, reducing costs, and minimizing environmental impact.
- **Knowledge transfer and collaboration:** Effective NIS promotes collaboration among various stakeholders in the petroleum industry, including government agencies, private sector companies, and research institutions. This collaboration facilitates knowledge transfer and the sharing of best practices, which are crucial for innovation. For example, partnerships between oil companies and universities can lead to breakthroughs in energy technologies and environmental protection methods.
- **Policy and regulatory Support:** A well-functioning NIS provides the necessary policy and regulatory framework that encourages innovation in the petroleum sector. Governments can support innovation through incentives for R&D, funding for technological projects, and regulations that promote sustainable practices. Such policies ensure that the industry remains competitive while addressing global challenges like climate change and resource depletion.
- **Challenges and Opportunities:** The petroleum industry's innovation system, underpinned by NIS, faces challenges such as fluctuating oil prices, environmental concerns, and geopolitical risks. However, these challenges also present opportunities for innovation, particularly in developing cleaner technologies and alternative energy sources. NIS can play a critical role in guiding the industry through these transitions, ensuring that innovation aligns with both economic and environmental goals.

Empirical literature and Insights

Recent studies emphasize the importance of NIS in driving innovation within the petroleum industry. -Craig et al. (2018) and Sharma & Shrestha (2023) portray innovation within the oil systems as a multifaceted process influenced by economic and social context, characterized by organizational changes driven by evolving capacities. The petroleum industry's pivotal role in societal development and its imperative to maintain competitiveness and innovative capacities are underscored by PwC (2017) reflecting a continuum from its historical origins. Isabella City, as cited by Sharma & Shrestha (2023) emerges as a pioneering locale for developing theories on innovation systems within the petroleum sector, with its early phases marked by minimal incentives, labeled as a "technology tranquility" phase, transitioning to heightened innovation amidst increased global market demands during the 1970s and 1980s.

Cirera & Maloney (2018) emphasize the significance of NIS in developing countries where it serves as catalyst for economic growth, fostering entrepreneurship, job creation, and industry diversification, alongside addressing societal challenges through innovations in various sectors. Jurowetzki et al. (2018) also, emphasizes the pivotal role of a robust NIS in enhancing global competitiveness, promoting sustainable development through the adoption of green technologies, and integrating effectively into global petroleum value chains.

However, contrasting perspectives remain. Huang et al. (2017) introduce a supply-side technology theory, suggesting that earlier innovations in the oil and gas sector were driven more by external technological advancements and anticipated demand than by internal industry demand. Na et al. (2024), posits equipment manufacturing reforms and competitiveness as major drivers of current technology innovation, identifying low investment in R&D as a hindrance to sector's ability to catch-up with global advancements.

Reviewing expert opinions, Ogbuigwe (2018) highlights escalating growth prospects for the oil and gas industry, fueled by high demand and supply factors, with notable increases in deep-water drilling and oil refining. Innovation in the industry is shaped not only by these demand and supply factors but also by the interaction of different segments and the critical role of intellectual property rights.

Van der Loos et al. (2021) analyze the co-evolution of industry, innovation systems, and context over time, observing radical technological shifts driven by R&D efforts of major oil companies in off-shore wind development. Their study of the Netherlands and Norway petroleum process underscores the impact of oil and gas legacies on offshore wind markets, highlighting contrasting approaches to innovation systems and industrial participation. Theoretical contributions include the significance of context conditions, the interplay between political and sectoral frameworks, and the non-static nature of innovation system.

Overall, the integration of National Innovation Systems (NIS) within the petroleum industry is pivotal for fostering innovation, driving economic growth, and maintaining global competitiveness. Empirical studies reveal how NIS influences various aspects of the petroleum sector, from technological advancements to policy frameworks. The findings underscore the importance of a robust NIS for addressing contemporary challenges and ensuring the sustainable development of the petroleum industry.

3.8. PETROLEUM CLUSTERS AND NIS

The petroleum clusters represent dynamic ecosystems where innovation, collaboration, and technological advancement converge to drive progress within the petroleum industry. These clusters are characterized by geographical proximity and concentration of industry players, and serve as hubs for research, development, and commercialization activities. Understanding the dynamics of petroleum clusters is essential for comprehending how innovation thrives within the oil industry and how National Innovation Systems (NIS) play a crucial role in shaping their evolution. This section explains the intricacies of petroleum clusters, exploring their key attributes, benefits, and contributions to innovation within the petroleum sector. Through an examination of data, we unravel the significance of petroleum clusters and their interconnectedness with NIS, thus, offering insights into fostering a conducive environment for innovation and sustainable development within these vibrant ecosystems.

Ndicu et al. (2023) in their study on technological catch and the backward linkages to the manufacturing sector in developing countries sees clustering as a potential driver of industrial development. They employed a sub-sectoral approach rather than an aggregate approach to better capture opportunities and challenges at the micro or firm level within the oil sector clusters. This approach included primary empirical research using semi-structured interviews and scale questionnaires, complemented by secondary research from oil and gas industry databases. Teka found limited local content in pipeline fabricating and manufacturing functions, with no significant material inputs from the local economy due to weak local capabilities and a scarcity of skilled labor. The study also highlighted an incoherent local content policy that favored forward linkages and misalignment with national industries.

Lastly, the present study also utilizes semi-structured interviews and scale questionnaires, supplemented by secondary research, to evaluate the oil and gas sector's innovation systems. However, while Teka's study was conducted in Angola, this study focuses on Nigeria and aims to address decision-making processes to improve the overall business environment of the oil sector. NIS are frameworks that encompass the networks and interactions among various entities within a nation, including government bodies, universities, industries, and research institutions. These systems play a crucial role in fostering innovation by facilitating the flow of technology, knowledge, and information across these entities. Scholars like Christopher Freeman and Bengt-Åke Lundvall have contributed significantly to defining NIS, emphasizing its role in initiating, importing, modifying, and diffusing new technologies within a country. Effective NIS strategies involve provisions such as providing knowledge inputs through research and training, stimulating demand-side activities like public procurement of innovation, supporting networking among key players, and improving support services for innovative firms such as access to finance and business incubation. Recent studies, including those by Harmaakorpi et al. (2017) and (H. Li et al., 2021), Leffler (2019) and Zhang (2022) underscore the importance of innovation in production chains for decision-makers in the petroleum industry.

Within the Petroleum Industry Innovation System (PIS), the proliferation of clusters is notably influenced by efforts to align oil demand with research and development (R&D)

activities, as well as the diffusion of external technologies from emerging industries. Scholars such as Truskewycz et al. (2019) highlight how these clusters are dynamic ecosystems where industry innovators leverage oil demand fluctuations, price hikes, and supply dynamics to drive higher investments in R&D. This strategic focus is on services, equipment design, and innovative production techniques underscores the pivotal role of upstream oil production processes.

Moreover, as companies in Exploration & Production (E&P) face challenges with depleting traditional reserves, they are increasingly exploring more complex and less accessible oil fields (Watkins et al. 2015). This shift necessitates substantial investments in new technologies and methods, such as deepwater drilling and advanced refining processes. According to experts, these investments drive innovation within the industry but also introduce strategic complexities and dynamic challenges.

Table 10: Petroleum Industry Clusters & transition scenarios

Former approach	Petroleum clusters in Transition
• Large Monopoly in energy & power	Fewer small start-ups due to capital intensive nature (Modular refineries)
• Oligopoly in switching equipment/s	Dangote Group in distribution and markets
• Clusters along value chain cartel (industry alliance)	Research Orgs, Universities & technology centers, Ecosystem actors and Civil society alliance (cross-sectoral alliance)
• Refining &supplier scale domination	Orientation towards new technology diffusion & adaptations (high quality oil output).
• International cooperation	Transnational (de-carbonization pathway) Achieving high industry rank with modern tech

Source: Own Elaboration

The Oil industry clusters represent geographically concentrated networks of interconnected firms, suppliers, and supporting institutions within the petroleum sector. These clusters facilitate collaboration, knowledge sharing, and specialization among companies engaged in various stages of the oil value chain, from exploration and production to refining and distribution. The clustering phenomenon in the oil industry enhances efficiency by promoting economies of scale, reducing costs through shared infrastructure and services, and in fostering innovation through collaborative R&D efforts. Moreover, these clusters often integrate with Global Value Chains (GVCs), where they play crucial roles as nodes specializing in specific tasks or technologies. For instance, clusters in regions like Houston in the United States or Aberdeen in Scotland are hubs where companies collaborate on advanced technologies, equipment design, and specialized services. This integration into GVCs allows these clusters to contribute to global oil markets by supplying critical components, expertise, and technologies essential for the smooth functioning of the petroleum value chain worldwide

However, clustering in the oil industry can lead to concerns such as monopolistic practices, where dominant firms within a cluster may wield significant influence over market dynamics and pricing, potentially limiting competition and innovation. Table 10 provides a visual representation of the evolving dynamics within the petroleum industry, showcasing shifts in monopolistic structures, technological advancements, and the transition towards refined fuel imports. These changes underscore the industry's move towards network digitalization, aligning with contemporary NIS expectations as outlined in preliminary reports by Gregory King, professor of petroleum engineering at Authur Lake Library Innovation, (2020). This highlights the industry's pivotal role as a key actor-producer in shaping the evolution and dynamics of innovation processes over time.

Table 11: Activities in oil refining 1862 -2000s

Year	Process	Policies & Purpose	By-products
1862	Atmospheric distillation	Production of kerosene	Naphtha, tar etc.
1870	Vacuum distillation	Production of original lubricant and cracking feedstock	Asphalt, residua Coker feedstock
1913	Thermal cracking	Increase in gasoline production	Residue, bunker fuel
1916	Sweetening	Reduction of Sulfur & odor	None
1930	Thermal reforming	Improvement of Octane number	Residue
1932	Hydrogenation	Removal of sulfur	Sulfur
1932	Coking	Base-stock production of gasoline	Coke
1933	Solvent extraction	Improvement of lubricants viscosity index	Aromatics
1935	Solvent de-waxing	Pour point improvement	Waxes
1935	Catalytic Poly	Gasoline yield & octane number	Petrochemical feedstock
1937	Catalytic cracking	Higher Octane gasoline	Petrochemical feedstock
1939	Vis-breaking	Viscosity reduction	Increase in distillate, tar
1940	Alkylation	Increment of gasoline yield & Octane	High-octane aviation gasoline
1940	Isomerization	Production of Alkylation feedstock	Naphtha
1942	Fluid catalytic cracking	Gasoline yield & Octane increment	Petrochemical feedstock
1950	De-asphalting	Conversion of low-quality naphtha	Asphalt
1952	Catalytic reforming	Removal of sulfur	Aromatics
1954	Hydrodesulphurization	Removal of mercaptans	Sulfur

Year	Process	Policies & Purpose	By-products
1956	Inhibitor Sweetening	Conversion to molecules with high octane number	Disulfides
1957	Catalytic Iso-merization	Improvement of gasoline quality & reduction of Sulfur	Alkylation feedstock
1960	Hydro cracking	Pour point improvement	Wax
1974	Catalytic Dew axing	increment of gasoline yield from residue	Heavy residue
1975	Residual Hydro cracking		Heavy residue treatment
2000s	Modern distillation tracking equipment & big data technology.	Improved & integrated data, transparent reporting, performance monitoring, & automated alerts.	Artificial Intelligence (AI) compliance in progress.

Source: Craig et al. (2018)

Table 11 tracks the evolution of oil refining over centuries, highlighting phases of technological advancements and industry restructuring, which underscore the critical role of robust National Innovation Systems (NIS) in driving transformative changes towards a high-tech petroleum sector. Many literatures notion that the first and second primary transformation phases were between the years of 1862-1870 and between 1913-1935 (the conventional life cycle stage) while the third phase (between 1937 – 1960 marked the period for increased challenges to improve quality of oil production in view of high demand. The effect was evidenced in the use of Thermal cracking equipment that allowed appreciable increase in the yields of refined oil products. The fourth phase (1962 – 1975), the period of oil price fluctuation/s, higher demand, with peak oil situations which further exposed the industry to the needs for securing projects in harsh and less accessible environment thus, giving rise to even more innovation opportunities. Finally, the 21st century phase according to experts has put learning and innovation at the center with more infrastructural highlights into petroleum industry transformation particularly as the industry is undergoing major restructuring and technology changes given the cost and other high demands to match the digital divide in the knowledge economy. This transformation underscores the pivotal role of NIS in facilitating transformative changes towards a high-tech petroleum sector.

Table 12: Various empirical studies on National Innovation Systems

Author	Year	Journal	Research	Key findings	Opportunities & questions for further study
Kiseleva et al	2019	Technology and Management	Innovation Development in Oil & Gas	Historical phases in petroleum	
Intarakumnerd *et al.*	2012	Research Policy	Studying national innovation systems	The main issue in the NIS in Thailand is its lack of synergy between its	

Author	**Year**	**Journal**	**Research**	**Key findings**	**Opportunities & questions for further study**
Kiseleva et al	2019	Technology and Management	Innovation Development in Oil & Gas	Historical phases in petroleum	
			in less successful countries	development and economic structure	
Hassani et al.	2017	Technology Research petroleum Institute	The Role of Innovation & Tec Technology Innovation: Case study of Research Institute of Petroleum Industry	Technology Organizations in NIS Oil & Gas Industry becoming more integrated	
Lee and Tunzelmann	2015	Research Policy	Analyzing the ICT industry within the national innovation system in Taiwan	The flow of capital, human resources, knowledge, and product are important to the performance of an innovation cluster	
Gunasekara	2019	The Journal of Technology Transfer	Evaluating the role of the university in a national innovation system	The role of the university is beyond education and research, but includes generative and developmental roles	
	2010-2021	Oil and gas journal	Growing impact of energy sources	The Growth in Renewable energy sources, impacting oil share in global electricity production	
Lee and Park	2021	Technology	Examining the factors that influence the success or failures of national innovation systems in Korea	The role of government in the developmental process in the NIS, and research collaboration are important factors	What role/s does government play in the innovation strategies of firms?
Lundvall	1994: 2009	Industry and Innovation	Analytic concept innovation8systems and their development tools	Factors that enhance innovation within an innovation system include R&D, competence building, creation of a new market, forecasting user needs, organizational change, networking, financial innovation, and incubation of ideas	What are capability performances and when is it used?
Filippetti and Archibugi	2011	Research Policy	Analysis of the factors that can lead to innovativeness during national crisis, Innovation performance measurements etc	The quality of the human resources, the specialization in the high-technology sector, and a developed financial system are the key to	What are the suggestions or approaches to capability-based performances among actors?

Author	Year	Journal	Research	Key findings	Opportunities & questions for further study
Kiseleva et al	2019	Technology and Management	Innovation Development in Oil & Gas	Historical phases in petroleum	
				innovativeness in times of crisis	
Shapiro et al.	2016	The Journal of World Biz. Technology Transfer	A study on the relationship between national innovative systems and the development within the nanotechnology sector	The performance of the NIS has a direct relationship with the advancement in the nanotechnology sector	
Freeman Bartels et al.	1987 2012	Innovation Systems	Policy implications for developing national innovation systems in developing countries	It is necessary that the government in developing countries focus on establishing an environment that supports education & competence, markets & knowledge infrastructures	What is the share of innovative private & public activities in developing countries?
Chaminade Nelson Winter	2012 1982	Research Policy	Understanding the systems problems in national innovation systems	System problems can be classified as networking, S&T infrastructure institutions, and support services	What are the factors that enhance the performance of innovation clusters? What is the level of support required from the Government?

Source: Own Elaboration

Table 12 serves as an important highlight on key authors and relevant journals that have significantly contributed to the field of National Innovation Systems (NIS). Authors such as Christopher Freeman, Bengt-Åke Lundvall, Richard Nelson, and others have laid foundational theories and frameworks that shape our understanding of how nations innovate and develop. Their works, often published in prestigious journals like Research Policy, Technological Forecasting and Social Change, have provided insights into the institutional, organizational, and systemic factors that influence innovation processes at national level. It is a guidepost for future research directions and policy interventions aimed at nurturing robust National Innovation Systems worldwide.

3.9. SUMMARY

The chapter provides a comprehensive exploration of NIS, beginning with a clear distinction between various innovation system concepts. It offers a thorough definition of NIS and traces its conceptual and historical evolution. The discussion delves into the foundational framework of innovation systems, examining the legitimacy and governance of innovation policies. It highlights the development of the innovation concept over time, identifying key actors and their interactions within the innovation process. The chapter also emphasizes the economic structure's role in innovation, particularly focusing on the creation, diffusion, and utilization of ideas.

Further, the chapter explores the dynamic context of various types of innovation systems, such as regional, national, sectoral, and global. It differentiates between Broad and Narrow NIS approaches. The Broad approach considers the social, cultural, and political environment's influence on innovation, while the Narrow approach focuses on institutions and policies directly related to scientific and technological innovation. References to key authors like Lundvall, Nelson, and Edquist underscore the importance of these approaches for economic growth.

The chapter also draws on comparative studies, analyzing development countries' NIS, the NIS and economic implications as well as its knowledge infrastructure in developing countries compared to advanced economies like the innovation system in the Netherlands and Norway. This chapter further illustrates how different countries manage their NIS, highlighting the importance of clustering in driving innovation. The chapter reviews the interactions between various energy sources from 1980 to 2021, emphasizing the critical role of NIS in economic growth and diversification, particularly in developing countries.

Moreover, the chapter emphasizes that strong NIS are essential for economic growth and diversification. By integrating advanced technologies and fostering innovation, nations can enhance global competitiveness, create new industries, and address social challenges, ensuring sustainable and resilient economic development.

In summary, the chapter elucidates how innovation systems fuel systemic and economic growth across different geographical scales, with "newness" and "change" serving as defining characteristics of innovation. By dissecting the types of NIS and their contextual respective context, the chapter underscores the intertwined influence of scientific and socio-political factors in fostering innovation. This comprehensive overview sets the stage for the integration of GVC and NIS, laying the groundwork for deeper insights into their combined impact in the subsequent chapter.

Chapter 4.
Combining Global Value Chains (GVCS) and National Innovation Systems (NIS)

This chapter explores the synergies between GVCs and NIS, examining how countries leverage their innovation systems to enhance their position in global value chains. It analyzes case studies and empirical research to illustrate the interplay between GVC participation and innovation capabilities, thus shedding light on the strategies that countries employ to navigate the complexities of global economic integration. Through this analysis, we aim to provide a comprehensive understanding of how GVCs and NIS intersect and shape countries' economic trajectories in an increasingly interconnected way.

4.1. OVERVIEW OF GVC & NIS

In recent years, the intersection of Global Value Chains (GVCs) and National Innovation Systems (NIS) has become increasingly significant in shaping countries' economic development trajectories. GVCs represent the intricate networks of production and distribution that span across countries, while NIS embodies the institutional framework and policies that facilitate innovation and technological advancement within a nation. This chapter aims to explore the synergies between GVCs and NIS, shedding light on how countries strategically leverage their innovation ecosystems to enhance their position in global value chains.

At the heart of this exploration lies the recognition that participation in GVCs can serve as both a driver and an outcome of innovation within a nation. By integrating into global value chains, countries gain access to new markets, technologies, and knowledge spillovers, thereby stimulating innovation and economic growth. Conversely, a robust national innovation system can bolster a country's competitiveness in global value chains by fostering the development of cutting-edge technologies, skilled labor force, and supportive institutional framework.

Throughout this chapter, we will delve into empirical evidence, case studies, and theoretical frameworks to elucidate the dynamic relationship between GVC participation and innovation capabilities within NIS. We will examine the strategies, policies, and best practices employed by countries to harness the synergies between GVCs and NIS effectively. Additionally, we will discuss the challenges and opportunities presented by this intersection, offering insights into how countries can navigate the complexities of global economic integration to achieve sustainable development and competitiveness on the world stage.

By exploring the combination of GVCs and NIS, this chapter seeks to provide policymakers, researchers, and practitioners with a nuanced understanding of how countries can leverage their innovation systems to thrive in an increasingly interconnected and competitive global economy.

One strong empirical study by Rigo (2021) investigated the relationship between GVC participation and Innovation Capabilities in developing countries. The study analyzed data from a sample of countries and found that increased integration into GVCs was positively associated with higher levels of innovation, as measured by patent filings, research and development (R&D) expenditure, and technology adoption rates. The findings suggest that GVC participation can serve as a catalyst for innovation, enabling countries to tap into global knowledge.

Another empirical study by Ambos et al. (2021) examined the role of NIS in shaping countries' positioning within GVCs. The study conducted case studies in several countries and found that countries with strong national innovation systems tended to perform better in global value chains, particularly in industries characterized by high levels of technological complexity. The research highlighted the importance of supportive institutional frameworks, investment in human capital, and collaboration between the public and private sectors in driving innovation and enhancing competitiveness within GVC.

Also, the empirical study by Lee et al. (2023) investigated the impact of GVC participation on firm-level innovation in value creation. Using firm-level data, the study found that firms engaged in global value chains tended to invest more in innovation activities such as R&D expenditure, technology acquisition, and product development. Furthermore, firms that were more integrated into GVCs demonstrated higher levels of productivity and competitiveness compared to those with limited participation. This study provides further evidence of the positive relationship between GVC participation and innovation outcomes at the firm level.

The empirical findings highlight the importance of strategic policies and best practices for leveraging the combination of GVCs and NIS to enhance innovation outcomes. Countries seeking to maximize the benefits of GVC participation can implement targeted policies to strengthen their innovation systems, such as investing in education and research infrastructure to develop a skilled workforce and promote technology transfer. Additionally, fostering collaboration between government, industry, and academia can facilitate knowledge sharing and the development of innovative solutions tailored to the demands of global value chains. By aligning their innovation strategies with the requirements of GVCs, countries can position themselves competitively in the global economy and drive sustainable economic growth.

4.2. LEVERAGING GVC AND NIS

(i) Enhancing Innovation Ecosystem

The key strategy is in the development of supportive regulatory frameworks that incentivize innovation and facilitate the integration of domestic firms into global value chains. This may involve implementing measures to protect intellectual property rights, streamlining bureaucratic processes for business registration and licensing, and promoting a conducive business environment for foreign investment. Moreover, fostering international cooperation and partnerships can enable countries to access new markets, technologies, and sources of knowledge, thereby enhancing their innovation capabilities and competitiveness within GVCs.

Overall, a holistic approach that combines targeted policies, regulatory reforms, and international collaboration is essential for countries to harness the synergies between GVCs and NIS effectively.

(ii) Investing in Education

Another important strategy is investing in education and skill development initiatives that equip the workforce with the necessary capabilities to participate effectively in global value chains. This includes promoting STEM (Science, Technology, Engineering, and Mathematics) education, vocational training programs, and lifelong learning opportunities to enhance the human capital base. By investing in education and skill development, countries can ensure that their workforce remains adaptable, innovative, and competitive in an increasingly interconnected global economy.

(iii) Promoting Sustainable Practice

Encouraging the adoption of sustainable technologies and practices throughout value chains, including renewable energy sources, waste reduction, and environmentally friendly production methods. This not only enhances competitiveness but also addresses pressing environmental concerns and meets consumer demand for ethically produced goods.

4.3. Policies and Best Practices

Based on the intersection of GVCs and NIS, several policies and best practices can be identified to enhance countries' competitiveness and economic development.

(i) Policies

(a)Innovation Policy Alignment: Government or management can formulate policies that align with the dynamics of GVCs, focusing on fostering innovation in sectors where the country has comparative advantages. This involves investing in R&D, supporting technology transfer, and creating incentives for firms to innovate and upgrade their capabilities within GVCs.

(b)Skill development: Innovation and skills development programs are crucial for countries to effectively participate in GVCs. Policies aimed at improving the quality and relevance of education, promoting lifelong learning, and supporting vocational training can help countries meet the demand for skilled workers in GVC-linked industries.

(c)Trade Facilitation: Streamlining trade procedures, reducing bureaucratic barriers, and harmonizing regulations can lower transaction costs and facilitate cross-border trade within GVCs. Policies that promote transparency, predictability, and efficiency in customs clearance, licensing, and certification processes can enhance the attractiveness of a country as a GVC destination.

(d)Investing in Infrastructure:

Investing in infrastructure, such as roads and transportation networks, is crucial for facilitating the smooth flow of goods and services within GVCs. Upgrading infrastructure not only reduces trade costs but also improves connectivity, making it easier for businesses to transport inputs and finished products across borders (Xu & Luo, 2018). Additionally, investments in logistics hubs and digital infrastructure further enhance efficiency in supply chains, allowing for better coordination and tracking of shipments. Overall, infrastructure development plays a fundamental role in enabling countries to fully integrate into GVCs and capitalize on the opportunities for economic growth and development. This means that Governments can implement policies to prioritize infrastructure projects that support GVC activities and enhance the overall business environment.

Lately, it has been a series of multi-disciplinary strategies aimed at rekindling the interest for economic development. Many authors tend to allocate this effort to other benefits, and the opportunities in the synergies that GVCs and NIS offer. The impacts and extracts driven by the established paradigms and narratives in their single forms include:

(i) Knowledge Transfer: GVCs facilitate the exchange of knowledge, technology, and best practices across borders, which can enrich the innovation capabilities within NIS. This knowledge transfer enhances domestic innovation and fosters the development of new products and processes.

(ii)Specialization and comparative advantage: The integration of the duo allows countries to specialize in areas of comparative advantage, leveraging their strengths to contribute specific components or services to global value chains. For instance, Jurowetzki et al. (2018), view the advantage of economic activities in the aspect of technology adoption and upgrading. The author emphasizes that GVC participation exposes firms within NIS to advanced technologies and production methods employed by lead firms in global supply chains. This exposure tends to serve as catalyst for technology adoption and upgrading, thus leading to improvements in productivity, quality, and innovation capacity.

(iii)Increasing economic activities as experimental particularly in production, others tend to regard it as an emerging field on innovation and development with a learning perspective. For this reason, exposure to the externally focused GVCs and the internally focused NIS approach are created. This specialization enhances efficiency and competitiveness within NIS axis.

(iv)Foreign Direct Investment (FDI) and R&D Investment: GVC integration with NIS attracts foreign direct investment to countries with robust innovation ecosystems, as multinational corporations seek to leverage local expertise and resources. This investment contributes to research and development (R&D) efforts within NIS, stimulating science and technology building particularly for developing economies (Shenkoya, 2019).

(v)Alignment of policies and Institutional Support: The combined framework allows policymakers to align trade policies, industrial strategies, and innovation policies to create an enabling environment for economic growth. Jurowetzki et al. (2018) explains that the coordinated effort at the national level has the tendency to support the development of innovation-driven economies and enhance competitiveness in global markets and emphasizing that the global nations designated as "Modern or Advanced" seems to somewhat become irrelevant in development studies. But Cirera & Maloney (2018) argue that there is still a dichotomy since the low- and middle-income nations tend to share lower income with less advanced technology thus, developing a tendency for more productivity lags but with potentials for catch-up in subsequent periods in the future. This tends to reveal that there are different

geographical histories and policies for various development paths hence the emphasis on the move away from previous single-grand narratives that are without the combination.
Jurowetzki et al. (2018) reveals that this new combination helps in understanding the socio-economic processes and builds a more actionable knowledge base; thus, the synthesis stimulating new research direction is generated. Therefore, the two perspectives of GVCs and NIS is seen as a combination that facilitates learning and identifies weaknesses in both innovation systems and development studies.

Indeed, at first glance, the innovation system and global value chain approaches appear to be relational in nature and complement each other by focusing on a variety of possible relationships between heterogeneous actors but there are contradictions according to literature. Hernandez (2021) posits that they do not provide much understanding of the innovation systems process, which is necessary to focus on the interactions of local and global linkages, thus, suggests the system perspective through process learning for transformation towards sustainability.

Other significant contradictions present themselves in the following: Firstly, the interpretation of NIS describes it as interactive learning with partners engaging in equal footings while government carries out power in neutrality and efficiency. On the other hand, GVC approach considers power dynamics in corporate interaction with the recognition for the limitations of the state capacities particularly in developing economies (Gereffi, 2019). In addition, the conventional understanding of NIS has often been notion along the nation state levels according to Freeman (1987); while the GVCs are often seen in the perspective of helping to address the shortcomings of the nation-states using technology innovation spaces (Schmitt & Muyoya, 2020). Thirdly, the contradictions in terms of the GVCs have often been in how the concept neglects the consideration of upgrading of single business activities in the national, regional, and local institutions (Ryan et al., 2022).

4.4. Other Perspectives in the Integration of GVC and NIS

This section discusses other aspects of the interplay between GVCs and NIS with emphasis on the opportunities and challenges for economic growth. This is important for understanding how countries can leverage global economic integration to foster domestic innovation and industrial upgrading. This section explores the dynamic interactions between GVC participation and NIS development, illustrating how these systems mutually reinforce each other to drive economic growth and technological advancement with examples.

Combining the Global Value Chain (GVC) framework with National Innovation Systems (NIS) provides a comprehensive approach to enhancing innovation capabilities and economic development in developing countries. GVCs offer a structure that emphasizes the global interconnectedness of production processes and the flow of goods, services, and knowledge across borders (Cattaneo et al., 2013). By integrating GVCs with NIS, countries can leverage international linkages to boost their innovative ecosystems. This integration facilitates the alignment of local innovation initiatives with global market needs, enhancing the efficiency and effectiveness of investments in research and development (R&D) and promoting the spread of new technologies (Pietrobelli and Robellitti, 2011).

Furthermore, the interaction tends to facilitate knowledge transfer and capacity building in developing countries (Egbetokun et al., 2017). Through participation in global value chains, local firms gain access to advanced technologies and best practices, which can be adapted and improved within their national contexts (Rodrik & Kennedy, 2018). This synergy supports the development of dynamic innovation systems that can respond to both local and global challenges. For example, Lee et al. (2021) argues that integrating GVCs into NIS strategies can help developing countries move up the value chain, enhancing their competitiveness and fostering sustainable economic growth. By harnessing the strengths of both frameworks, policymakers can create more resilient and adaptive innovation systems that contribute significantly to national and global economic development.

Frederick (2014) observed a mix of opportunities and challenges in the interaction process of international trade and economic globalization. While certain production levels can boost global trade, the different institutional frameworks within which NIS and GVCs operate can lead to conflicts in policies and priorities. Roper et al. (2017) argue that the ability to exploit externally acquired knowledge and enhance local innovation capabilities at both the firm and local production levels support the integration of GVCs and NIS. This combination fosters an environment where local firms can benefit from global knowledge flows and adapt them to their specific context.

The capacity-building process between GVCs and NIS tends to be interactive, involving multiple actors even if they are not directly engaged. Chandra Shekar & Joseph (2022) noted that learning is more effective when GVC-related knowledge complements other forms of knowledge channels, such as cluster training in innovation systems within universities or businesses. The success of integrating GVCs and NIS is attributed to efforts in building internal capabilities, generating internal knowledge, sustaining services, ensuring smoother transitions, and providing ongoing support. However, limited access to advanced technologies and knowledge transfer remains a significant challenge. This integrated approach emphasizes the importance of internal capacity building while leveraging global interactions to drive local innovation and economic development.

However, in the case of upgrading in the integration, Schmitt and Muyoya (2020) observes that functional upgrading has the tendency for certain levels of constraints especially in developing countries as it may not only involve capability building but also the level of specialization in industries particularly where the entry barrier is higher and prospects for learning and growth, higher. But Lin & Schulz (2023) argues the reverse in view of the high percentage of children with E-learning access that tends to compensate for reduced access to information. Nonetheless, the author believes that it may be important for developing countries to move beyond the narrow interpretation of NIS as the outcome of science-based research to closely integrated and collaborative learning towards the strengthening of both GVC and NIS. By relying on both the domestic and international knowledge source, some literatures explain that knowledge and quality production can complement each other (e.g. the horizontal linkage between Denmark and China). Similarly, Pietrobelli and Robellitti (2011) discuss the important role that NIS play in supporting the development of local firms' capabilities particularly in helping to enhance competitiveness. They find that firms with stronger internal resources often become directly integrated into GVCs. For instance, a good short-term strategy for government policy redirection towards promoting Foreign Direct Investment (FDI) may enhance capital and fertilize employment opportunities(G. Lin et al., 2018).

While the policies that promote new avenues for GVCs may be widely confirmed in literature, there are still ambiguities as to what constitutes a reliable framework that enhances the combination of GVCs and NIS. Further proofs are recorded in the works of Sampath & Ayitey (2016) where their study of 74 developing countries shows the presence of strong innovation system (especially where firms explore and utilize leveraged knowledge to technologically diversify), as being a distinguishing feature of success. Nonetheless, they explain that R &D expenditure, scientific and other journal publications are weak with firm-level indicators of innovation capabilities across some developing countries thus, contributing to low GVC participation.

Other empirical evidence tends to underscore the significant impact of integrating GVCs with robust NIS on a country's economic and technological advancement. For instance, in South Korea, the coordinated development of GVC participation and NIS has been pivotal. The country's electronics industry, particularly in semiconductors, exemplifies how active engagement in GVCs, supported by a strong NIS, has facilitated substantial technological upgrades and enhanced global competitiveness (J. Y. Lee et al., 2023). This synergy has been fostered through substantial investments in R&D, facilitated by government policies aimed at supporting innovation and industrial development.

Another notable example is China, which has leveraged its participation in GVCs to transform its manufacturing sector. The country's engagement in global production networks, coupled with targeted NIS policies, has enabled rapid industrial upgrading and technological catch-up. China's automotive industry, for example, has benefited from foreign direct investment and technology transfers, which, in turn, Ahave been bolstered by state-led initiatives to develop domestic innovation capacities (Gereffi, 2019). These efforts have resulted in significant improvements in production processes, product quality, and the development of homegrown technology.

Additionally, the capacity-building process between GVCs and NIS tends to be interactive, involving multiple actors even if they are not directly involved. Chandra Shekar & Joseph, (2022), find that learning is easier when GVC-related knowledge is complemented by other knowledge channels, such as clusters and training within innovation systems at universities or businesses. Success in integrating GVCs and NIS is often attributed to efforts in building internal capabilities that generate internal knowledge, sustain services, facilitate smoother transitions, and provide simpler ongoing support. However, there are warnings about limited access to advanced technologies and knowledge transfer, which can hinder the full potential of this integration.

Overall, while the combination of GVC and NIS participation in Global Value Chains offers significant opportunities for economic development and integration into the global economy, it also presents challenges that require careful consideration and proactive policy responses. Countries need to adopt strategies that leverage their innovation systems, enhance infrastructure, and address regulatory and institutional constraints to fully harness the benefits of GVC participation while mitigating associated risks. By embracing a holistic approach that combines technological upgrading, skills development, and sustainable practices, countries can position themselves competitively in the evolving landscape of global trade and investment. Moreover, fostering collaboration and knowledge sharing among stakeholders, both domestically and internationally, is essential for maximizing the synergies between Global Value Chains and National Innovation Systems and driving inclusive and sustainable economic growth.

The next section proposes a novel highlight on the co-evolution between global value chains and innovation systems. This will specifically advance the explanation on the dynamics of building innovation capabilities at the firm level along the combination of GVCs and NIS approach in what is termed the Co-evolution of the duo (GVC & NIS).

4.5. CO- EVOLUTIONAL STAGES OF GVC & NIS

The co-evolution of global value chains (GVCs) and national innovation systems (NIS) involves a complex interplay influenced by a myriad of macro and micro-level factors.

4.5.1. Foundation for Interaction and Integration

These factors include a country's developmental stage, governance capabilities, economic policies, market dynamics, technological landscapes, and the characteristics of local Jurowetzki et al. (2018), delve into this intersection through an integrated analysis employing bibliometrics, natural language processing, and qualitative methods. Their study reveals parallel but minimally interactive paths in economic development approaches, as evidenced by distinct references and strategies among firms integrating into global chains. The research advocates for synthesizing the GVC and NIS framework yet acknowledges methodological challenges in achieving empirical integration across diverse research paradigms.

This structure ensures a clear progression from a brief introduction to a more detailed exploration of the foundational aspects supported by academic insights.

4.5.2. Linking the stages of Co-evolution

The specific nature of co-evolution of global value chains and innovation systems sometimes vary greatly, depending on the assortment of macro- and micro-factors. These include the level of development and governance capacity of the country, the macro-economic context, the trade policy framework, the main market segments, the existence, and development of other external channels (e.g. FDI, human capital mobility, direct exports), the technological characteristics and knowledge bases of the predominant sectors and the characteristics of local firms (e.g. size, openness, presence of knowledge gatekeepers, level of formality). Having identified the subsets in the factors that make up the effectiveness of the combination, Jurowetzki et al. (2018), in studying the Combination of the Global Value Chain and the Innovation System perspectives examines the combined techniques from bibliometrics and natural language processing with a hermeneutic qualitative analysis. The results of the study showed that the different approaches to economic development have evolved in parallel but with very limited interaction as reflected in shared references. The results also show that there is very little overlap in terms of the core literature and that firm strategies for integration in chains are conditioned by local and national institutional contexts, and not only by the role of the state and state intervention. Based on these observations, they see good reasons for why an attempt to work toward a synthesis of innovation system and global value chain approach should function. However, there are also some challenges in bringing the approaches together, particularly regarding the methodological basis of empirical investigation drawing on integrated research which resolve can be feasible within the stages of development. Building on these foundational insights, the co-evolution of GVCs and NIS progresses through several distinct stages. These stages delineate the evolutionary trajectory from initial development to advanced integration, each characterized by unique challenges and opportunities for economic actors and policymakers.

(i) Preliminary development stage:

During the initial development phase, a complete production and innovation system is not yet established. Instead, fragmented structures exist, providing only the basic competencies required for initial participation in Global Value Chains. At this stage, countries and firms focus on building basic infrastructure, developing initial capabilities, and attracting foreign direct investment (FDI). This stage often involves establishing basic institutional frameworks and policies to support industrial activities. According toHumphrey, (2002). It is crucial for laying the groundwork for future integration into GVCs by building essential capabilities and infrastructure. Despite the system's weak and fragmented nature, its early formation is essential for long-term GVC integration. The presence of emerging production and innovation pockets allows for the gradual development of core skills and basic infrastructure, such as transportation, communication, and human capital, which lays the groundwork for future industrial upgrading. Although innovation capacity remains limited, participation in global production networks fosters knowledge spillovers, labor mobility, demonstration effects, and increased private sector investment. These dynamics facilitate the transition toward a more structured and integrated innovation system.

(ii) Entry and Initial Integration Stage: At the Entry and Initial Integration Stage, firms and countries take their first meaningful steps into Global Value Chains (GVCs) by engaging in specific segments of production. Typically, their participation is limited to supplying raw materials, basic components, or performing low-value-added tasks such as assembly. Entry into GVCs at this stage is often driven by factors such as low labor costs, access to natural resources, and favorable trade policies. Local suppliers generally have basic skill levels, and governance structures tend to be captive or hierarchical, where lead firms exert significant control over production processes.

A crucial focus at this stage is establishing initial linkages with multinational corporations (MNCs) or lead firms**.** According to Gereffi (1996), successful integration requires firms to meet international quality and production standards set by lead firms, which helps them establish credibility in global markets. Lead firms or dominant industry players also play a vital role in guiding the learning process of local suppliers and subsidiaries, helping them strengthen their production and organizational capabilities. This mentorship can improve efficiency and productivity, allowing firms to enhance their competitiveness. However, participation at this stage often remains limited to specific, low-value-added tasks such as assembly or basic manufacturing. This can lead to a risk of lock-in, where local firms become dependent on their roles within the value chain without developing the strategic capabilities necessary for higher-value activities like product innovation or technological development. This challenge has been observed in sectors such as IT services in South Africa**,** where firms entered GVCs but faced barriers to upgrading due to a lack of advanced skills and innovation capabilities.

Despite these challenges, this stage provides a critical learning platform for firms to build foundational production capabilities that can later be leveraged for deeper GVC integration. As firms gain experience, acquire technical know-how, and improve their ability to meet industry standards, they lay the groundwork for transitioning to more complex stages of development, where they can move beyond basic manufacturing into higher-value activities within the global market.

(iii)Expansion and strengthening stage: In this phase, firms and countries deepen their integration into Global Value Chains (GVCs), building on the capabilities developed in earlier stages. During this phase, local production capacities improve, absorptive capacities strengthen, and governance structures become more diverse. Unlike the initial stages where firms were mainly engaged in low-value tasks, they now take on more complex roles within the value chain. Governance structures evolve to include both modular and relational types of coordination, each influencing firms' learning processes and technological development differently.

In modular value chains, suppliers specialize in producing components and parts that adhere to strict technical specifications. While lead firms set high standards and expect suppliers to keep pace with technological advancements, they typically do not provide direct learning support. However, this process facilitates positive knowledge spillovers**,** as firms are exposed to new technologies, best practices, and efficiency improvements that benefit the broader economy (Oritiz-Ospina, 2018). Conversely, in relational value chains, interactions between firms are more complex and less standardized. Here, production processes rely on stronger collaboration, trust, and complementary competencies between local firms and global lead firms. Learning in this context is driven by direct, face-to-face interactions, enabling deeper knowledge exchange and skill development. This engagement fosters stronger innovation systems, as firms gain access to advanced expertise, technology transfers, and upgrade production capabilities.

A key factor in strengthening GVC participation at this stage is the development of a more integrated and knowledge-intensive innovation ecosystem. Vocational training institutions and industry-relevant education programs play a crucial role in enhancing firms' technical and managerial capabilities, particularly in engineering and product design. By investing in human capital and R&D, firms improve their competitiveness and increase their ability to move into higher-value activities. Additionally, GVC participation encourages infrastructure development and service expansion, as firms require improved logistics, transportation networks, and digital connectivity to remain competitive. The involvement of lead firms, particularly in relational GVCs, further supports the deepening of National Innovation Systems (NIS), as firms leverage external knowledge and technological resources to enhance their long-term growth and competitiveness (Borin et al., 2021).

(iv) The Advanced and Autonomous Innovation stage: At this stage, firms and countries move beyond dependence on external knowledge and foreign lead firms, shifting towards independent technological development and innovation-driven competitiveness. Local firms no longer rely solely on foreign investment or technology transfers but instead develop their own cutting-edge solutions, enabling them to compete at the highest levels of global markets. This transformation is characterized by strong domestic innovation capabilities, well-developed research and development (R&D) ecosystems, and globally competitive industries. A defining feature of this phase is the transition from being mere participants in GVCs to becoming lead firms and innovators. Companies engage in original design manufacturing (ODM) and original brand manufacturing (OBM), allowing them to create proprietary technologies, establish strong brands, and dictate market trends. The governance structures shift towards market-based and network-based relationships, where firms interact as equals rather than operating under hierarchical or dependent structures.

A critical driver of success in this stage is the presence of a robust and dynamic NIS, which enhances firms' skills, learning experiences, and feedback mechanisms (Jurowetzki et al., 2018). These interactions between GVC participation and innovation systems create mutual reinforcement, where firms leverage their global linkages to upgrade capabilities while simultaneously strengthening the national ecosystem for innovation. As illustrated in Figure 17, this process enables firms to move beyond production-based roles and engage in higher-value activities such as design, branding, and advanced research. The presence of strong university-industry linkages plays a crucial role in sustaining continuous innovation and knowledge spillovers. Government policies that support innovation, such as intellectual property protection, R&D incentives, and funding for high-tech industries, further contribute to the success of firms in this phase. Additionally, a highly skilled workforce capable of engaging in advanced research, design, and high-value manufacturing is essential for maintaining competitiveness.

Moreover, firms at this stage play a major role in shaping global production networks. They actively invest in foreign markets, acquire strategic assets such as patents and key technologies, and participate in international standard-setting processes. Countries that reach this level benefit from higher economic resilience, diversified industries, and long-term competitive advantages. Examples of economies that have successfully reached this stage include South Korea, Taiwan, and China, where firms have progressed from assembly-based roles to becoming global technology leaders (Gereffi, 1996). Their success is largely due to consistent industrial policies, investments in science and technology, and strategic upgrading within GVCs. Ultimately, reaching the advanced innovation stage requires a sustained commitment to research, technological advancement, and institutional development. It represents the final step in the co-evolution of GVCs and NIS, where countries no longer just follow global trends but actively shape and redefine the structure of global industries.

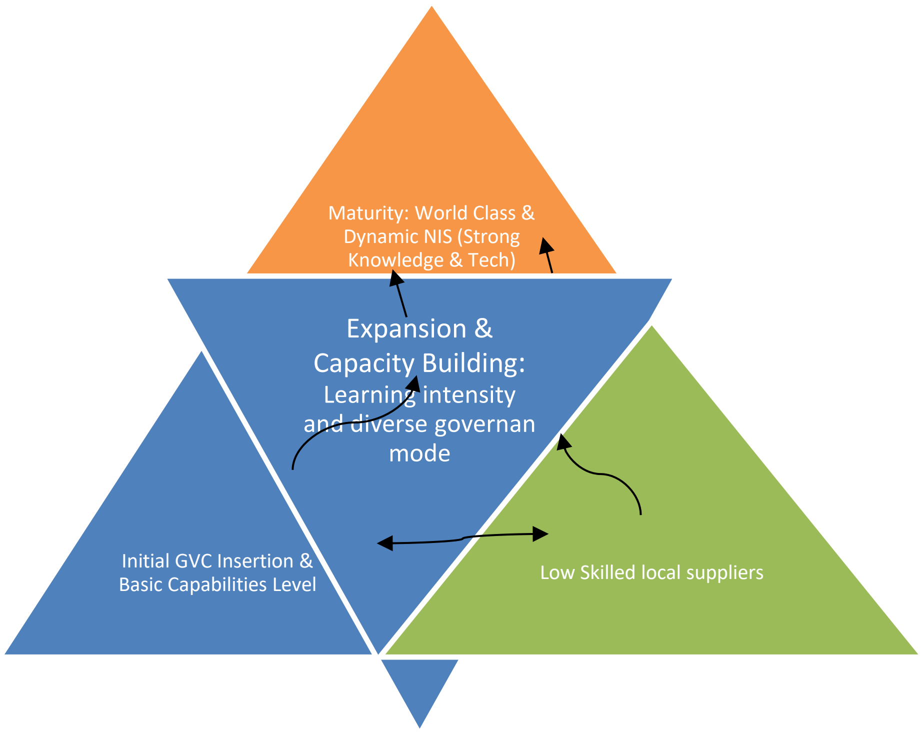

Figure 17: GVC- co-evolution comparing the characteristics of each Stage.

Source: Own Elaboration derived from Lema et al. (2018)

Figure 17 illustrates how global value chains (GVCs) interact with local firms, focusing on various aspects such as product requirements, technology, organizational models, and support from leading GVC companies (e.g. the orange group color often represents a specific type of interaction or capability development). It illustrates aspects related **to** initial integration and capability-building indicating the foundational stage where local firms start interacting with GVCs, learning basic requirements, and receiving initial support. Subject to the strength of the system, the flows between the innovation systems and the local firms could provide specialized skills and knowledge, extension services such as metrology, standard certifications or incubation services, financial resources, and local research inputs mainly based on adaptations of existing knowledge.

The blue arrow (left side) indicates the changing local firm capabilities influence where and how they can engage in different types of GVCs (e.g. in different markets), considering their competitive dynamics. Changes in local firm capabilities, arising from local and global learning processes, may influence the governance structures of GVCs (Gereffi et al., 2005) including the sourcing strategies of the lead firms (Jurowetzki et al., 2018).

The central blue triangle represents the relative capabilities of local firms engaged in GVCs, which significantly shape the development of the innovation system. This occurs due to the demand for various forms of knowledge and resources from educational and scientific institutions, as well as specialized services provided by quality assurance agencies, business associations, and similar entities. A clear illustration of the interplay between GVCs and NIS can be seen in Nigeria's oil industry, particularly in the upstream subsector focused on crude oil production in shallow and deep-water regions. This analysis bridges two streams of literature, connecting them to related frameworks.

Knowledge spillovers within this system can arise through mechanisms like demonstration effects, workforce mobility, and the establishment of forward and backward links within the innovation system. As depicted in Figure 19, local oil service firms play a pivotal role in this innovation process. Their contribution depends on their internal expertise and the external knowledge gained through interactions with key players like Shell BP, Total Oil Incorporated, Pipeline Infrastructure Company, and Gas & Petroleum Processing Company. The focus here is primarily on interactions between GVCs and NIS. While other forms of direct interactions between these systems, such as when multinational corporations integrate into local systems, also influence the sector, this discussion emphasizes the co-evolution of system and chain dynamics in the Nigerian oil industry as a specific case study.

Overall, the specific nature of co-evolution of global value chains and innovation systems tends to also vary greatly, depending on an assortment of macro- and micro-factors. These include the level of development and governance capacity of the country, the macro-economic context, the trade policy framework, the main market segments, the existence, and development of other external channels (e.g. FDI, human capital mobility, direct exports), the technological characteristics and knowledge bases of the predominant sectors and the characteristics of local firms (e.g. size, openness, presence of knowledge gatekeepers, level of formality). Basically, depending on such factors or co-evolution strategies, global value chains and innovation systems prospects to unfold in a large array of context specific trajectories.

4.5.3. Illustrative Trajectories of GVCs Co-evolution

There are four hypothetical trajectories of GVC- co-evolution, namely, the gradual, the in-out-in, the aborted and the retrograding trajectories. These four trajectories include:

(i) The gradual trajectory: this is the result of a positive co-evolution between GVCs and ISs and it occurs when the local innovation system has the prerequisite strength, and the value chain characteristics allow for knowledge flows and interactive learning. Lema et al. (2018) supported the emergence of a gradual trajectory. They show the rapidity and complexity of technological change either due to the technology characteristics of some sectors (technology push factor) or the nature of demand (demand pull factor) – and how it can create opportunities for more intense interactions between global value chains and innovation systems. They analyze the drivers of product differentiation and innovation in two very different sectors in China (mobile phones and electric two-wheelers), highlighting the role of policy in supporting the GVC-IS co-evolutionary trajectory. They revealed that although changing customer demand created the pressure to improve functionality and quality of products in the Chinese market, in both sectors, public policy supported the development of capabilities. The electric two-wheeler sector expanded rapidly due to governmental restrictions on gasoline-led motorcycles. So, although the technological change was much slower, the domestic policy helped Chinese firms to secure greater shares of an expanding market by investing greater R&D capabilities while, at the same time, benefiting from extensive support from the national innovation system. In the mobile phone sector where technological change was rapid and of a disruptive nature, firms similarly benefited from public policies that supported capabilities development. Their findings reinforce how firm-level and publicly led investments in innovation capabilities work together to promote innovation (Humphrey et al., 2020).

(ii) The in-out-in trajectory: Lee, Szapiro and Mao, supported this trajectory, using cases of Korean and Brazilian firms (K. Lee et al., 2018). They suggest that (a) participation in the GVCs is necessary to acquire foreign knowledge and production skills in the preliminary development stage (b) separation and independence from existing foreign-dominated GVCs is required for functional upgrading at mid-level stages and that (c) latecomer firms and economies need to reintegrate into the global chain after establishing their own local value chains, ultimately reaching the maturity stage. According to them, new technologies, and more precisely short-cycle technologies that rely less on existing knowledge stocks, offer better opportunities for latecomer countries to achieve world-class competence.

(iii) The aborted trajectory: this may occur if the innovation system is relatively weak and fragmented, and the value chains do not provide access to critical knowledge, resources, and pressure for learning. In this case, local firms remain stacked and learning rates are slow because knowledge does not transmit or spill over from GVC enterprises to the wider innovation system, due to limited local absorptive capacity. An example is offered by Ponte & Gibbon, (2005), who investigate the aquaculture chains in four Asian countries, finding that, in contrast to producers in China, Vietnam, and Thailand, where functional upgrading occurred, Bangladesh lacked sufficient quality and capacity in respect of the domestic regulatory framework and public sector support, which meant that upgrading attempts were unsuccessful (Gibbon et al., 2008). Government subsidies for processing plants in the shrimp and prawn chains created limited incentives for investment, allowing plants to operate at lower efficiency levels than their counterparts in competing regions. Additionally, global value chains provided insufficient knowledge and resources to meet international food safety standards, largely due to the lack of enforcement of traceability norms. A similar scenario can be observed in Nigeria's refining subsector, where Tony Ogbuigwe in 2018 noted that state-run refineries suffer from poor maintenance and operate far below their capacity. This combination of local inefficiencies and minimal GVC involvement has significantly hindered the local industry's ability to improve and remain competitive.

In the case of apparel sector in Kenya, Lesotho, and Swaziland, GVC linkage and spillover effects were constrained by limited absorptive capacity. While these countries succeeded in attracting Asian FDI, a scarcity of local manufacturing firms translated into an inability to absorb spillovers through demonstration and collaboration effects. The low capability levels did little to elicit the interest of foreign-owned firms in establishing interactions and linkages and the main reason for their involvement in these countries was the possibility to export to the U.S. market under the AGOA preferential treatments. Furthermore, few opportunities for learning and innovation arose due to external control of supply chains. Reliance on foreigners for management and technical tasks in these chains constrained knowledge spillovers and inhibited local entrepreneurial responses and learning processes.

(iv) The retrograding trajectory: This can happen when the innovation system is too frail to maintain competitiveness in GVCs, particularly in the face of changes in global value chains and shifts in global demand. A relevant example is the cassava industry, as illustrated by Kaplinsky (2019) in Thailand, where the shift from the EU market to the GVC targeting the Chinese market has caused a change in product forms from pellets to chips. This transition has led to a reduction in the degree of processing, given that chip production is a labor-intensive operation with very low added value; pellet production builds on chip production, adding value by grounding, stemming and molding chips into pellets. They also described the same case in the Gabon timber industry where due to the entry into the international market of China and the shift from exporting processed logs to the EU to unprocessed logs (under strict environmental standards), the focus changed to quantity rather than quality, thus reducing processing and even leading to some compelling evidence of illegal exports. These examples show how the local production and innovation system may be unable to prevent footloose sectors from relocating or responding to external competitive threats arising from the entry of competitors into the world market. In such cases, the local businesses may be squeezed out from GVCs and lose some of their capacities, moving down the technological chain.

Clearly, trajectories in the real world may not always fit within those illustrated in our framework in a stylized manner. Nevertheless, the suggested framework is intended to highlight the multiplicity, diversity, and nonlinearity of possible pathways. It offers important inputs to stimulate a debate on how policy should be structured to combine domestic and foreign sources of knowledge to promote innovation capacity and economic development. Principally, it lends strength to argue that we not only need to move away from policies that automatically assume a positive effect of GVC involvement for learning and capabilities building, but we also urgently need to proactively engage in combining global value chains and innovation systems as two complementary instruments if we aim to foster sustainable economic development.

The findings indicate that the capacity to diversify technologically across export categories is closely tied to robust innovation systems. This is reflected in national capability indicators such as public R&D investments, scientific publications, intellectual property payments, and patents filed by residents. The study also highlights the emergence of several high-performing countries, particularly in emerging economies. It concludes that firms in these successful countries utilize various aspects of their innovation systems to harness knowledge flows within and beyond GVCs, enabling them to expand export capacity and branch into new GVCs. This aligns with the present study, as both share similarities in data collection methods and objectives, focusing on how global value chains and innovation systems can contribute to economic growth.

4.6. THE LINK BETWEEN GVC & NIS

The link between National Innovation Systems (NIS) and Global Value Chains (GVCs) is essential for understanding the interplay between national policies and global economic integration. Rather than merely accounting for similarities and disparities, the link between these two concepts emphasizes their complementary nature. Seven key dimensions highlight the connection between NIS and GVCs: unit of analysis, dimensions of variability, level of technological sophistication, capability acquisition, policy focus, methodological approach, and disciplinary foundation.

(i) Unit of Analysis

The research typically focuses on open systems that assess the performance of national economies, emphasizing the role of institutions within a country's borders. In contrast, GVC research examines vertical production processes that transcend national boundaries, focusing on how global economic activities are structured and governed (Gereffi, 1996a). Despite these differences, both approaches are inherently relational, focusing on the interactions and linkages between various actors. Synthesis research faces the challenge of disentangling these relationships, focusing not only on intrinsic features but also on exogenous factors such as national and international institutions that influence these relationships and their outcomes.

(ii) Dimensions of Variability

Both NIS and GVC approaches are relational, but they differ in their focus. GVC research often concentrates on dyadic corporate relationships and their sectoral aggregations, while NIS research encompasses a wider array of relationships within a national system. GVC research has developed typologies for different governance types, emphasizing unequal power relationships and upgrading within value chains. In contrast, NIS research focuses on the coherence of national systems but lacks established typologies for different forms of systemic relationships in developing countries, often assuming equal exchanges. The process of upgrading in GVC literature is weakly theorized, especially regarding functional upgrading, which is more thoroughly explored in NIS research.

(iii) Level of Technological Sophistication

NIS tends to focus on general technology metrics, such as aggregate R&D investment and university–industry interactions, often targeting high-tech industries. This contrasts with GVC research, which frequently addresses low-tech sectors prevalent in developing countries, such as textiles or furniture. These sectors may rely more on "doing, using, and interacting" forms of learning rather than formal science systems. Synthesis research must find a middle ground, exploring technological contexts where GVC interactions occur and competence building is possible, supported by national policies.

(iv) Acquisition of Capacity

GVC literature emphasizes learning from lead firms and buyers, which is often too narrow for broader industrial development questions. This literature can offer insights into the specific form of learning driven by user interactions in low-income economies. Synthesis research can use the concept of interactive learning as a foundation to examine learning within both local and transnational linkages, considering constraints from power relationships, institutions, and socio-economic structure.

The policy prescriptions of the two approaches differ significantly. GVC research often suggests joining global value chains through narrow export promotion schemes. In contrast, NIS research advocates building development through strengthening domestic system interactions and industrial policy (Mazzucato et al., 2020). The different emphases reflect the distinct objectives and scopes of the two frameworks.

GVC research, initiated by sociologists and political economists, often uses cross-national sectoral case studies, though quantitative studies have been increasing. This research aims to overcome methodological nationalism by focusing on global production structures. Conversely, NIS research has stronger quantitative foundations, though it also employs country-level case studies, particularly in developing countries where standard innovation metrics like patent data and R&D expenditure may be less relevant.

Both GVC and NIS approaches are socio-economic and multi-disciplinary. NIS started with economists integrating institutions and organizations into economic analysis. GVC began with sociologists incorporating elements from industrial organization, development economics, and transaction cost theory. This multi-disciplinary foundation allows both frameworks to adapt and integrate insights from various fields, enriching the analysis of global and national innovation dynamics.

Table 13: The link between GVC & NIS

	Global value chains	National innovation systems
Unit of analysis	Relationships and exchange of goods and services between buyers and suppliers in the global economy	Relationships within and between firms, institutions and socio-economic structures at national level
Dimensions of Variability	• Value chain governance • Corporate power • Upgrading	• Coherence/fragmentation of the system • Science- and experienced-based learning • Rate and direction of innovation
Level of technological/ activity sophistication (in empirical cases)	• Mainly simple manufacturing (e.g. textiles) • Use of (technological) capital goods	• Middle and high-tech • Focus on creation and diffusion of technology
Acquisition of Capabilities	Learning from lead firms and buyers	Local interactive learning
Policy focuses	Joining and upgrading in global value Chains	Building and strengthening innovation systems
Methodological Approach	International trade and case data	Community innovation survey Analysis using indicators e.g. patents, research & developments. Case studies
Discipline foundation	Economic sociology	Evolutionary economics

Source: Jurowetzki et al. (2018)

4.7. OPPORTUNITIES AND CHALLENGES OF GVC & NIS COMBINATIONS FOR DEVELOPING COUNTRIES

Engaging in Global Value Chains (GVCs) allows countries to access global markets and advanced technologies, driving economic growth and technological advancement. A robust National Innovation System (NIS) supports this by fostering research, development, and collaboration between academia and industry. The synergy between GVC participation and a strong NIS enables nations to specialize in high-value-added activities and enhance their competitiveness. Together, GVCs and NIS create a pathway for sustainable economic development and innovation.

4.7.1. Complementary Features and Opportunities

Combining Global Value Chains (GVCs) and National Innovation Systems (NIS) offers unique opportunities and benefits that can significantly enhance economic development and technological advancement. This section explores the complementary features and potential opportunities that arise from the integration of GVCs and NIS, highlighting how countries can leverage these synergies for growth and innovation.

(i) Enhanced Knowledge Transfer

The integration of GVCs and NIS facilitates the flow of knowledge and technology across borders. By participating in GVCs, local firms gain access to advanced technologies, best practices, and new skills from leading global firms. This interaction promotes learning and capacity building, enabling firms to improve their production processes and innovate more effectively. For example, South Korea's electronics industry has benefited significantly from knowledge transfers through its involvement in global production networks(Lee et al., 2023).

(ii) Increased Research and Development

Participation in GVCs can stimulate investments in research and development (R&D) within national innovation systems. As local firms engage with global markets, there is a greater incentive to invest in R&D to stay competitive. This leads to the development of more robust innovation systems that support continuous technological advancement. China's automotive industry, for instance, has leveraged foreign direct investment and technology transfers to boost its R&D capabilities and foster innovation (Gereffi, 2019).

(iii)Diversification and Economic Upgrading

Integrating GVCs with NIS helps countries diversify their economies by moving up the value chain. Through GVC participation, local firms can shift from low-value activities to more complex and higher-value tasks, such as design, marketing, and brand development. This process of economic upgrading enhances competitiveness and promotes sustainable growth. Countries like India have successfully diversified their ICT sector by integrating GVC participation with strong national innovation policies (Pietrobelli & Puppato, 2016).

(iv) Development of Supporting Infrastructure

GVC participation often necessitates the development of supporting infrastructure and services, such as transportation, logistics, and communication networks. These improvements not only facilitate smoother integration into global markets but also benefit the broader economy. Investments in infrastructure catalyze further economic activities and enhance the overall efficiency of the innovation system. For instance, investments in telecommunications infrastructure have been crucial for the growth of India's IT sector.

(v) Strengthening Institutional Framework

Combining GVCs and NIS requires the alignment of institutional frameworks to support innovation and global trade. Governments play a crucial role in creating policies that foster collaboration between local firms and global value chains. These policies include incentives for R&D, support for vocational training, and measures to protect intellectual property. By strengthening institutional frameworks, countries can create an enabling environment for innovation and economic growth (Borin et al., 2021).

(vi) Addressing Environmental and Social Concerns

Integrating GVCs with NIS also provides opportunities to address environmental and social challenges through sustainable practices and technologies. By adopting green technologies and sustainable production methods, countries can reduce their environmental impact and promote social well-being. This approach is particularly important for achieving long-term sustainable development goals. For example, efforts to incorporate green technologies in global value chains have helped countries like Denmark and China reduce carbon emissions and improve environmental sustainability (Pietrobelli and Robellitti, 2011).

Overall, the complementary features and opportunities in combining GVCs and NIS highlight the significant potential for countries to enhance their innovation capabilities and achieve economic growth. By leveraging the synergies between GVCs and NIS, countries can facilitate knowledge transfer, increase R&D investments, diversify their economies, develop supporting infrastructure, strengthen institutional frameworks, and address environmental and social challenges. These integrated approaches are essential for fostering sustainable development and improving global competitiveness.

4.7.2. Challenges in the Combination of GVC and NIS

While the integration of Global Value Chains (GVCs) and National Innovation Systems (NIS) offers significant opportunities, it also presents various challenges that need to be addressed to maximize the potential benefits. This section discusses the key challenges associated with the co-evolution of GVCs and NIS.

(i) Institutional Misalignment

The of the major challenges is the potential for institutional misalignment. GVCs and NIS often operate within different institutional frameworks, leading to conflicts in policies and priorities. For instance, GVCs may prioritize efficiency and cost reduction, while NIS may focus on long-term innovation and capability development. Aligning these frameworks requires careful policy coordination to ensure that the objectives of both systems are met (Frederick, 2014).

(ii) Limited Access to Advanced Technology

Developing countries often face challenges in accessing advanced technologies and knowledge from global firms. This limited access can hinder the full potential of GVC participation and the development of robust innovation systems. Local firms may struggle to move beyond low-value activities and achieve significant technological upgrades. Ensuring broader access to technology and knowledge transfer is crucial for overcoming this barrier (Chandra Shekar & Joseph, 2022).

(iii) Capacity Building and Development

Building the necessary capabilities and skills to participate effectively in GVCs and leverage NIS is a significant challenge. This includes developing technical skills, managerial capabilities, and innovation competencies. Many developing countries lack sufficient vocational training institutes and educational programs that align with the needs of GVCs. Investments in education and training are essential to build a skilled workforce that can drive innovation and economic growth (Borin et al., 2021).

(iv) Power Imbalance and Dependency

GVCs often involve unequal power relationships between lead firms and local suppliers. This can result in local firms becoming dependent on lead firms for knowledge and market access, limiting their ability to innovate independently. Addressing these power imbalances requires policies that support local firms in developing their capabilities and reducing dependency on lead firms (Schmitt & Muyoya, 2020).

(v) Policy and Regulatory Challenges

Developing effective policies and regulations to support the integration of GVCs and NIS is complex. Policymakers must balance the needs of global integration with domestic innovation goals. This includes creating incentives for R&D, protecting intellectual property, and ensuring that regulatory frameworks facilitate rather than hinder innovation. Moreover, policies need to be adaptive to the rapidly changing global economic landscape.

(vi) Sustainable Development and Social inclusion

Ensuring that the integration of GVCs and NIS contributes to sustainable development and social inclusion is another critical challenge. This involves adopting sustainable production practices, reducing environmental impacts, and ensuring that the benefits of economic growth are broadly shared. Policies must address environmental and social concerns to promote inclusive and sustainable development (Pietrobelli and Robellitti, 2011).

Overall, combining Global Value Chains (GVCs) and National Innovation Systems (NIS) presents both opportunities and challenges for economic development and innovation. Integration facilitates knowledge transfer, increases R&D investments, diversifies economies, develops supporting infrastructure, strengthens institutional frameworks, and addresses environmental and social challenges. However, it also faces challenges such as institutional misalignment, limited access to advanced technologies, capacity building, power imbalances, policy and regulatory hurdles, and the need for sustainable development.

To effectively leverage the synergies between GVCs and NIS, policymakers and stakeholders must address these challenges through coordinated efforts, investments in education and infrastructure, and the development of supportive policies and regulations. By doing so, countries can enhance their innovation capabilities, achieve sustainable economic growth, and improve their global competitiveness.

4.8. SUMMARY

This chapter examines the connection between Global Value Chains (GVCs) and National Innovation Systems (NIS), focusing on how these two relational approaches work together by emphasizing the interactions between different actors within each system. It adopts a strategic approach aimed at bolstering the economic competitiveness and innovation prowess of countries. The integration leverages the interlinked global production networks of GVCs to spur innovation, facilitate technology transfer, and promote industrial advancement within the domestic economy, with the NIS framework serving as a facilitator for these objectives.

However, the chapter also notes that current approaches do not provide a comprehensive understanding of the dynamics necessary to elucidate the interactions between local and global linkages. This study reveals the specific nature of the co-evolution of GVCs and innovation systems, indicating both variability and alignment in the approaches of various authors. The chapter presents an overview of GVC and NIS, their co-evolution and development stages, the link between the two perspectives, the effect of policies on their combination, opportunities and challenges, governance, and the illustrative characteristics of local firms.

The co-evolution of GVCs and NIS follows distinct, context-specific trajectories influenced by various factors. This process unfolds in two major stages: the preliminary development stage and the expansion and strengthening stage. The four hypothetical trajectories, gradual, in-out-in, aborted, and retrograding, help identify both opportunities and risks associated with GVC evolution. Additionally, this chapter examines the linkage between NIS and GVCs, focusing on their fundamental essence rather than merely comparing similarities and differences. Seven key distinctions are identified as strengths of their integration: unit of analysis, dimensions of variability, technological/methodological approach, firm capabilities, policy focus, and disciplinary foundation.

The chapter also delves into the risks associated with combining GVC and NIS, such as technology dependence on lead firms, which could constrain domestic innovation autonomy, and the risk of widening inequalities as smaller firms may struggle to keep up with the technological advancements driven by GVC participation within the NIS framework.

To strengthen the combination of GVCs and NIS, the chapter highlights several measures, including fostering collaboration between firms and research institutions, investing in education and skill development programs to enhance local firms' capabilities, and creating a conducive regulatory environment to encourage investment in research and development. Forming partnerships with lead firms in GVCs can leverage the benefits of global production networks for domestic economic development and innovation enhancement.

Overall, the chapter concludes by highlighting the complexity of achieving a balance between the extent and nature of GVC integration and domestic innovation system capabilities in developing countries. It observes that some nations struggle to effectively implement GVCs due to limitations in absorbing new knowledge, while others benefit from increased openness to global interactions, facilitating catch-up growth. The study emphasizes the importance of contributing to ongoing research on GVC and NIS, particularly in the context of Nigeria's oil sector and its NIS.

Meanwhile, the subsequent chapter focuses on the Oil Industry in Nigeria, providing a detailed case study that illustrates the practical application of the concepts discussed in this chapter. This aims to provide insights into how Nigeria can enhance its economic resilience and competitive edge through strategic NIS and GVC integration.

PART 3.
EMPIRICAL ANALYSIS

Chapter 5.
The Oil Industry in Nigeria and its Position in the GVCs

The Nigerian oil industry holds a paramount position in the nation's economy, serving as a linchpin with strategic importance to the country's economic development. It stands as a cornerstone of the nation's economy, embodying both the promise of prosperity and the challenges of sustainable development. Although with complexities, the industry is renowned as the largest oil producer in Africa and a significant player on the global stage. The oil sector occupies a pivotal position within the intricate web of global oil trade.

Driven by the desire to explore and understand the complexities behind the oil industry in Nigeria, this chapter attempts to examine the dynamics of the industry and to gain useful insights on the factors that leads the world of oil in the country. One of the main aspects in this examination considers providing a comprehensive overview of the Nigerian oil industry, its strategic importance, challenges, and its crucial role within GVCs, thus, setting the stage for a deeper exploration of its participation in Trade in Value-Added (TiVA) analysis.

Through an examination of its positioning within GVCs and its participation in TiVA, we aim to unravel the complexities of the industry and shed light into the underlying factors of the paradox of Nigeria's status as a net exporter of crude oil while simultaneously importing fuel-oil instead of producing it domestically. This paradox underscores the need for a holistic understanding of the industry's structure, trade dynamics, and value chain participation. By unpacking these complexities and proposing strategies for addressing systemic challenges, we aim to chart a course towards a more upgrading and resilient oil industry with inclusive and sustainable energy future for Nigeria.

Also, many literatures have hinted that the industry's journey is marked by significant milestones and complex dynamics, therefore, the need to understand the activities of various actors within the industry, including MNCs, the indigenous firms, international oil companies, and government agencies, will be explored to unravel its complexities.

Moreover, the role of the state in shaping the oil industry cannot be overstated. Government policies, regulations, and institutional frameworks have profound impacts on the industry's operations, investment climate, and socio-economic outcomes. By examining the interplay between state actors, industry stakeholders, and external forces, we gain valuable insights into these interactions of governance, resource management, and sustainable development in Nigeria's oil sector.

The thoughts in the chapter are concluded with a summary that seeks to illuminate the multifaceted nature of the Nigerian oil industry and its position in GVC. Summarizing, it strategically aligns the TiVA analysis as central to addressing the first research question, thereby positioning it as a pivotal component of the thesis, while also touching on the discovery of oil from its historical roots to the contemporary challenges and opportunities. Through a comprehensive analysis of oil sector's structure, interactions, and role within global value chains, the chapter seeks to provide valuable insights and actionable recommendations for the oil industry's upgrade with a glean on stakeholders across the energy landscape of oil production in the country.

5.1. BACKGROUND OF THE NIGERIAN OIL INDUSTRY AND ITS SIGNIFICANCE

Nigerian oil industry traces its origins back to 1956 when oil was discovered in the Oloibiri area of the Niger Delta region, specifically at the "Agbada Formation" near Rivers State in the onshore basin. This pivotal discovery was made by Shell D'arcy, which later became Shell Petroleum Development Company (SPDC), then the sole concessionaire in Nigeria. Two years later, in 1958, Nigeria entered the ranks of oil exporters when the first commercial quantity of crude oil came on stream.

The subsequent decades saw remarkable economic growth, with annual increases exceeding 7% during the 1970s, solidifying Nigeria's status as the largest oil producer in Africa by the 1980s. During this period, Nigeria emerged as one of the leading crude oil producers and exporters globally. The steady increase in crude oil production, particularly with major discoveries in deeper offshore waters, has positioned Nigeria as a significant player in the global oil and gas market. Oil and gas have come to dominate Nigeria's industrial sector, generating substantial export revenue and making a substantial contribution to the country's economy (Rui et al., 2018). The map provides a research-based view and access to further information on Nigeria and the formation of its oil industry at Oloibiri in the Niger-Delta oil region.This has made O/Agbada formation a historic location in the history of oil discovery in Nigeria.

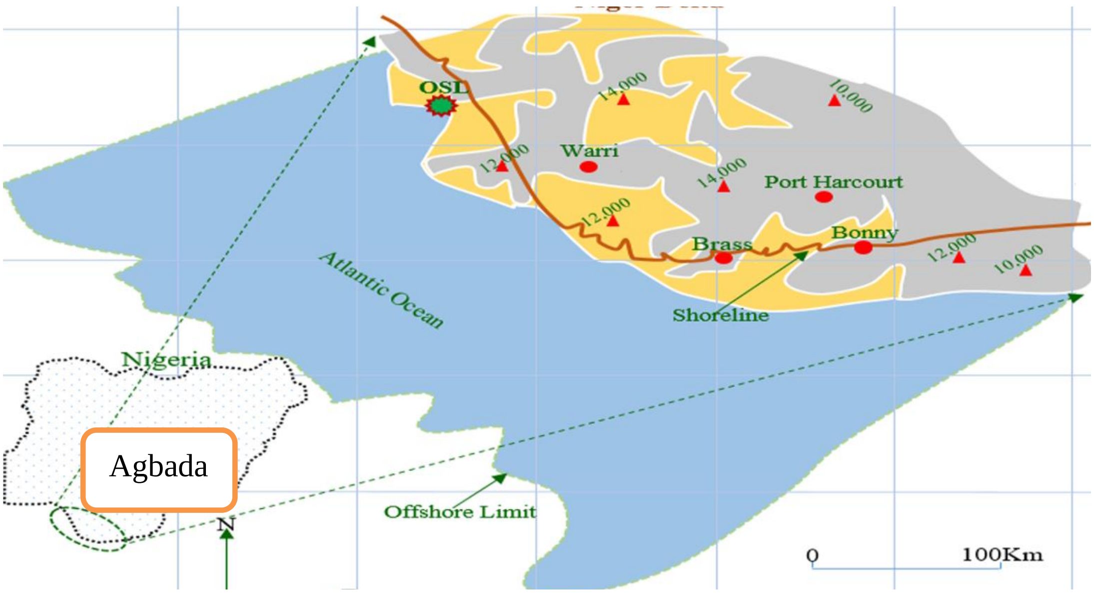

Figure18: First commercial oil drilling location in Nigeria at "Agbada and Akata"

Source: Grace Chukwuma-ekwueme (2023b)

The visual aid in figure 18, is to help readers visualize the geographical location where oil was first discovered and its significance in shaping the trajectory of the Nigerian oil industry. The Nigerian oil industry, particularly the oil and gas sector, has remained a cornerstone of the country's economy, playing a pivotal role in various economic indicators. Accounting for over 90% of export earnings, 80% of government revenue, and 10% of the country's GDP (Olayungbo, 2019), the sector has a profound impact on Nigeria's fiscal stability and overall economic performance. Nigeria is renowned for producing light sweet crude oil with low sulfur content, a highly sought-after quality in the production of various oil derivatives such as gasoline, diesel oil, and kerosene.

In terms of market trends, the hydrocarbon trade significantly contributes to Nigeria's economy, accounting for over 90% of total exports and foreign exchange. Despite fluctuations in global oil prices and production levels, Nigeria has consistently been one of the world's top oil producers, with revenue from oil exports totaling over $340 billion since the 1990s (Okon et al., 2020). However, the country still faces the paradox of being a net exporter of crude oil while importing most of its refined oil products.

The country plays a vital role in international energy markets through its "Sweet API" quality of crude oil, petroleum product exports, and its relationship with OPEC. Becoming the eleventh member of OPEC on July 12, 1971, Nigeria has maintained a successful link and symbiosis with the organization, even amid macro-economic uncertainties, natural catastrophes, geopolitics, and recent global health crises. This support is evident in Nigeria's continued cooperation and invaluable contribution to the successful implementation of the Declaration of Cooperation (DoC) between OPEC and non-OPEC countries. One prominent figure in Nigeria's relationship with OPEC is the late Dr. Rilwanu Lukeman, whose contributions were central to the evolution of OPEC and non-OPEC relations, oil producer/consumer dialogue, and management of OPEC member country participations in early United Nations COP meetings and conferences on the environment. Serving as the president of OPEC conferences between 1986-1989 and 2002, as well as Secretary General of the organization between 1986-1988 and 1995-2000, Dr. Lukeman's leadership exemplifies Nigeria's commitment to inclusiveness and cooperation within OPEC. This collaborative approach has earned the country great respect, as noted by former OPEC Secretary General Late Mohammad Sanusi Barkindo.

Over the years, Nigeria has delineated areas for oil exploration into blocks, with concessions granted to various oil companies based on merit. Since the 1980s, the country has had 388 oil blocks, although only 173 are currently active (Iwuoha, 2021). The oil and gas sector has attracted significant foreign direct investment, contributing to the country's economic growth during the 1970s and 1990s. This is characterized by its three primary segments: the upstream segment, responsible for exploration and production of crude oil; the midstream sector, tasked with storage and conveyance of crude oil; and the downstream sector, primarily engaged in refining, marketing, and distribution of refined petroleum products to end-users.

Indeed, the oil sector in Nigeria is multifaceted as it also plays a crucial role in supporting employment, improving living standards, providing energy and securing substantial earnings (Olayungbo, 2019). Furthermore, the sector has garnered global recognition with daily crude oil production and exports reaching approximately 2 million barrels. Despite these achievements, there is a growing impetus toward natural gas as part of Nigeria's energy landscape, thus, indicating an institutional diversification strategy within the energy sector.

Also, the significance of the oil sector within Nigeria's broader energy landscape cannot be overstated. As one of the strongest influencers of the country's economy, the oil industry holds a central position in meeting energy demands and shaping energy policies. Despite Nigeria's abundant conventional and renewable energy resources, the oil sector remains paramount, particularly in terms of electricity generation and supply. Notably, the sector experienced substantial improvements in electricity power supply in 2004, marked by enhanced energy-saving measures, increased generation efficiency, and the significant utilization of natural gas resources. However, the sector has faced challenges stemming from population growth, which has led to increased energy demand, highlighting the need for sustainable energy solutions and diversification efforts.

Nigeria has four refineries with combined installed refining capacity of 455000 barrels per day. It holds significant implications for the country's energy security, economic development, and overall resilience in the oil industry. These refineries represent a critical component of the nation's energy infrastructure and were built to contribute to its self-sufficiency in meeting domestic demand for refined petroleum products.

The petroleum sector in Nigeria operates within a heavily regulated framework, with most segments under government control. Exploration, field development, and crude oil production are typically conducted through Production-Sharing Agreements (PSAs) between foreign companies and the state-owned National Oil Corporation (NNPC). Over time, the Federal Government of Nigeria (FGN) progressively increased its equity participation with international oil companies operating in the country, from 20% to 60% in 2004 (Olayungbo, 2019). This escalation also led to the formal establishment of NNPC as a state-owned company by Decree 33 in 1977, solidifying the government's supervisory role in the oil sector.
Subsequent amendments to oil policy legislation and adherence to OPEC summit declarations further underscored Nigeria's commitment to assert greater ownership over oil concessions held by foreign entities. This strategic approach not only bolstered the nation's economic resilience during periods of oil market volatility but also contributed to enhanced crude oil exports, economic growth, employment opportunities, and trade in petroleum production.

The Nigerian National Petroleum Corporation (NNPC), established in 1977, has played a central role in the country's oil and gas sector, overseeing exploration, production, refining, and distribution activities. Over the years, NNPC has been instrumental in Nigeria's efforts to expand its refining capacity and enhance energy security.

In the 1980s, NNPC embarked on initiatives to increase the country's refining capacity. One significant milestone was the rehabilitation and upgrading of existing refineries, which resulted in a notable increase in capacity. For instance, the combined installed capacity of Nigeria's four refineries rose from 320,000 barrels per day to 455,000 barrels per day. This expansion was aimed at bolstering the nation's ability to meet domestic demand for refined petroleum products and reduce reliance on oil imports. Despite these efforts, challenges such as operational inefficiencies, inadequate maintenance, and supply chain disruptions have persisted, limiting the refineries' ability to operate at full capacity (Ogbuigwe, 2018a). As a result, Nigeria continues to face significant gaps between domestic refining capacity and demand for petroleum products, necessitating continued reforms and investments to address these challenges and optimize the performance of the refining sector.

Despite the establishment of NNPC in 1977 and the subsequent nationalistic effort to gain more control over the country's oil resources, Nigeria's monopoly over oil prospecting, refining capacity, domestic oil transport has been limited to 20% since 2015 (Ogbuigwe, 2018; Odularu, 2008). The country's heavy dependence on oil makes its economy particularly vulnerable to fluctuations in crude oil prices. Industry data shows that Nigeria's oil and natural gas exports earned $52 billion in 2015, a significant decrease from $35 billion in 2014, with further reductions to $34.21 billion in 2019, largely attributed to falling oil prices according to the country’s Debt Management & Operations, report as highlighted by Peter Eze & Richard Apiri (2020). The country's fiscal buffers, including the Sovereign Wealth Fund and the Excess Crude Account, have also declined, from $11 billion in 2012 to $60 million in 2021. According to reports from the World Energy Outlook (2022). Nigeria experienced of a sharp decline in crude oil exports started in January 2012, with imports totaling 449,000 barrels per day, a 54% decrease from the previous month. Factors contributing to this decline include initial moves by the USA, a major buyer, as well as reductions in import quantity due to the potential of Shale oil production and increased production of West Texas Intermediate (WTI), Bakken, and Eagle Ford production. Nigeria's share of crude oil imported into the United States dropped from over 10% to 5% within the reviewed period (Okorobia, 2018).

Further reductions occurred in 2014 when Nigeria's crude oil production dropped by 7.44 million barrels, and in 2016, production disruptions reached 750,000 barrels per day (Enwereuzoh, 2021). Subsequent years saw declines from about 2.0 million b/d in 2018 to 1.8 mbpd in 2019, further decreasing to 1.6 million barrels per day in 2020, lower than the pre-COVID estimate of 2.3 mbpd. Similar deductions in production were observed in earlier years such as 1998 and 2001, with cuts of approximately 540 thousand barrels per day (Okon et al., 2020). These trends have significant implications for Nigeria's gross earnings and the volume of accumulated oil reserves by the end of 2021. The short-term cuts from 2012 onwards, combined with sharp reductions in capital, led to a real GDP growth reduction of -19.22% in Nigeria's oil sector GDP in 2022, (Olujobi et al., 2022).

Between 2015 and 2019, Nigeria surpassed its petroleum imports budget by $58.5 billion, as revealed by estimates from the OPEC Annual Statistical Bulletin of 2020. During this period, the oil cartel reported imports valued at $264.57 billion, while exports amounted to $206.07 billion. Despite interventions such as natural gas liquids conversions and the establishment of significant crude oil and natural gas reserves, Nigeria still imports large volumes of refined petroleum products. This persistent reliance on imports has resulted in consistent resource gaps, with import deficits equivalent to an average of 20% of Gross National Income (GNI), particularly after the year 2010. Furthermore, the trend of reductions in the contribution of oil to GDP reflects decreases from 19.65% in 1995 to 16% in the year 2000, and from 14.8% to 13.8% between 2011 and 2012 respectively, with a further decline to 10%

since 2015. This decline has not kept pace with population growth and consumption, especially as petroleum products are increasingly being imported.

Therefore, one stands to wonder or ask: Why is Nigeria, a net exporter of crude oil, also a net importer of refined oil?

While many studies attribute the growing imbalance to the industry's position in the Global Petroleum Value Chains (GPVCs), particularly with low refining capacity, others suggest that it relates to a poorly organized National Innovation Systems (NIS). Some observers note labor market deficiencies characterized by the growing inability to support the employment of over 55 million potential labor force, heightened by continuous inequality and social exclusion. Additionally, there are views that it is due to government fiscal indiscipline (the Dutch disease) and increased over-dependence on oil, leading to foreign borrowing, which amounted to $32 billion in external financial debt in year 2021, requiring urgent debt servicing in foreign currency.

Consequently, Nigeria's oil wealth has brought untold physical, attitudinal, and economic hardships to the citizenry, especially due to its inability to produce and supply refined fuel sufficiently to the populace (Iheukwumere et al., 2020). Besides the economic challenges, there are physical diversities associated with oil production, including gas flaring, seepages in the ecosystem, poverty, and poor economic development amidst low-complexity oil refineries (Olujobi et al., 2022). The attitudinal effects, related to the physical problems, have led to the emergence of illegal oil refining, increased carbon emissions, militias, and pressure groups perceived to be individuals and groups protesting the imbalances, resulting in incidents such as the kidnapping of oil workers and ransom payments from oil multinationals.

To address these challenges, the industry and government have embarked on several initiatives such as refinery rehabilitation and expansion, investment in the petrochemical sector, and collaboration with international partners. Measures to curb consumption have included increasing fuel oil prices, imposing taxes on oil production, and temporarily closing some fuel stations, alongside stricter enforcement of speed limits. Regulatory reforms, including the enactment of the Petroleum Industry Act (PIA) in 2021, aim to enhance transparency and governance in the sector. Additionally, environmental management measures are being implemented to mitigate the impact of oil production activities.

Additionally, the country envisions a surge in oil production in the coming years. Industry sources indicate that Nigeria plans to revitalize its oil industry with a $19.0 billion investment, starting with $4.1 billion to develop its petrochemical sector over the next three years and the construction of two additional refineries (Ogbuigwe, 2018b). The petrochemical chain creates significant revenue that supports GDP growth in the country and represents about 18% of industrial production annually. To enhance the safety, availability, and affordability of products, part of the sustainability approach of the sub-sector includes utilizing researchers to identify technological needs. Roadmaps according to industry sources include collaboration with industries, universities, technology suppliers, and government laboratories to develop the necessary pre-competitive technologies for transformation.

Furthermore, NNPC has invested $2.76 billion in the Dangote refinery, one of the five planned upcoming refineries in the country. In June 2018, the government granted foreign oil companies five additional oil licenses in the Niger-Delta Basin for deep-sea and shallow-water explorations and in the northern Chad basin, as there are high expectations of more light oil and gas deposits. Industry efforts also target improving non-destructive evaluations of external pipeline corrosion under insulation Osagie (2023), as well as other research-based developments aimed at establishing the 21st-century Nigeria's petroleum industry of our dreams.

Despite various interventions by the Nigerian government to address challenges in the oil sector, such as inadequacy in refining capacity, policy reforms, and environmental degradation, the effectiveness of these efforts remains in question. Persistent reliance on imported refined petroleum products, environmental damage, and inefficiencies in the refining process highlight the need for more comprehensive and sustainable solutions. This research aims to offer a searchlight and provide recommendations to address these pressing challenges in the Nigerian oil industry.

5.2. ASSESSING THE POSITION OF NIGERIA'S OIL INDUSTRY

Nigeria's oil industry plays a crucial role in its economy, accounting for a significant portion of 90 percent export earnings, 80 percent government revenue, and approximately 10 percent in terms of GDP. Despite its importance, the industry faces various challenges and opportunities that influence its position both domestically and globally.

5.2.1. Detailed Examination of the Nigerian Petroleum Industry

Assessing the position of Nigeria's Petroleum Industry (NPI) involves examining several key factors. The oil industry in Nigeria is a multifaceted sector, impacting various aspects from the economy to environmental and social factors.

Economically, it stands out as a dynamic contributor to the country's GDP, solidifying Nigeria's role as a major player in the global hydrocarbon market. Accounting for approximately 10 percent of the nation's GDP, crude oil production and exports reinforce Nigeria's status as a net exporter of crude oil.

Nigeria's efforts of transitioning to a middle-income status are supported by increasing investment in the oil sector, with a projected Compound Annual Growth Rate (CAGR) of 4.5% by 2025 (Olanipekun & Alola, 2020). In addition to crude oil, the country's top exports include petroleum gas, scrap vessels, special purpose ships, and refined petroleum products. However, historical records suggest a lack of investment in local refineries by multinational corporations operating in Nigeria, leading to a reliance on imported refined fuel products (Wang et al., 2022). In terms of oil production, Nigeria is one of the largest oil producers in Africa and a key player in the global oil market. As of 2020, the country has proven crude oil reserves of over 37 billion barrels and proven natural gas reserves of approximately 209.5 trillion cubic feet, reflecting a 1.5% increase from the previous year. The daily crude oil production in Nigeria stands at around 2.2 million barrels, making it one of the top oil-producing countries in the world. Nigeria also ranks as the sixth-largest producer of liquefied natural gas (LNG) globally. This substantial production capacity has positioned Nigeria as a significant exporter of crude oil and natural gas.

The oil industry has historically been characterized by its role as a supplier of raw materials to the global market. The country's crude oil, known for its low sulfur content, is highly sought after due to its efficiency in refining processes. Despite this, Nigeria faces challenges in refining its own crude oil thus continues to import significant quantities of refined petroleum products. This reliance on imported refined products highlights the need for strategic investments and reforms to enhance local refining capabilities and reduce dependence on foreign refineries. The oil and gas sectors are moderately consolidated, with major multinational corporations playing a dominant role. Key players include Shell Petroleum Company, Exxon-Mobil Corporation, Total Energy, Chevron, and the Nigerian National Petroleum Corporation (NNPC). These companies are integral to the industry's operations, providing expertise, technology, and capital. addition to the significant production of crude oil, Nigeria's petroleum industry provides fuel for transportation, heating, and industrial uses, as well as raw materials for the chemical industry. The country adopts advanced technologies such as catalytic processes and advanced materials for better-quality exploration and production of crude oil with reduced emissions.

In addition to the significant production of crude oil, Nigeria's petroleum industry provides fuel for transportation, heating, and industrial uses, as well as raw materials for the chemical industry. The industry offers thousands of well-paid jobs, with approximately 65,000 direct jobs and over 250,000 indirect employment opportunities, contributing substantially to Nigeria's gross domestic products.

Natural gas plays a crucial role in Nigeria's energy consumption, providing about 80% of the energy consumed and more than 98% of the transportation fuels. The annual oil and gas production is about 40 million barrels, with drilling activities concentrated in the Niger-Delta region. The oil-rich Niger-Delta states include Akwa-Ibom, Abia, Anambra, Bayelsa, Cross-River, Delta, Edo, Imo, and Ondo States. Additionally, Lagos and Kogi States, which are outside the Niger-Delta region, also produce oil, bringing the total number of oil-producing states in the country to eleven. Figure 19 shows the geography of the oil states and a regional map illustrating the distribution of oil fields in Nigeria.

Figure 19: Nigeria's Oil Producing Fields and Constituent States.

Source: NNPC report, NBS (2019)

Despite the industry's substantial contribution to Nigeria's economy, particularly in export earnings, government revenue, and GDP, the sector faces several challenges. These include underinvestment in local refineries, environmental concerns, and fluctuating global oil prices. Addressing these challenges through strategic reforms and investments is crucial for Nigeria to fully realize its potential in the global oil market and achieve sustainable economic growth.

The country has four refineries with a combined installed capacity of 445,000 barrels per day. However, in recent years, the number of functional refineries has decreased, with fuel production declining to less than 20% of capacity over the past two decades. Currently, only the NNPC refinery in Port-Harcourt remains operational, contributing to a significant decrease in feedstock availability. The Petroleum Industry Act (PIA) of 2021 has introduced mandates for changes in the composition and monitoring of imported products to ensure fuel quality.

In the aspect of Marketing, the petrol stations in Nigeria are highly fragmented. As of 2018, there were about 2,700 service stations across the country, with the NNPC operating approximately 700 of these stations in all 36 states and Abuja (Ogunlowo et al., 2018). The number of service stations has since increased, along with throughput. However, nationwide gasoline consumption has remained relatively steady. Recent price increases have led to a 10% reduction in per capita gasoline usage, as subsidies have not sufficiently offset the cost increase.

Nigeria is a member of the Organization of the Petroleum Exporting Countries (OPEC), which helps to coordinate and unify petroleum policies among member countries to ensure the stabilization of oil markets. This membership provides Nigeria with a platform to collaborate with other major oil-producing nations and influence global oil prices and supplies (OPEC, 2022).The country exports crude oil to several countries worldwide, with major buyers including India, the United States, Spain, the Netherlands, and France. These exports play a crucial role in the global oil supply chain, helping to meet the energy demands of these nations. While Europe remains a key market for the Nigerian oil exports, the dynamics of crude sourcing decisions, as highlighted by An et al. (2018) underscore the role of refinery-level optimization in shaping trade relationship. Other historical developments in Nigeria's oil sector are listed in table 14.

Table 14: Development Outlook in Nigeria's Oil Sector.

Year	Events & Developments in Nigeria's Oil Sector
1956	Oil discovery at Oloibri by Shell D'arcy
1958	Pioneer commercial daily sales/export of 5110 barrels to UK
1960	➢ Increase of 847,000 barrels of crude oil exports ➢ Gulf Oil Company licensed to explore & produce crude oil
1961- 1965	➢ First Oil Refinery built at Eleme- Port-Harcourt with a capacity of 38,000 barrels per day (enough to meet domestic needs then). ➢ Various Oil companies were granted the oil exploration rights - Chevron, Mobil Oil, Elf etc.
1966 -1969	Coup d' Etat & Civil war periods and the stalling of oil operation
1970	➢ End of Civil war coinciding with rising global oil prices ➢ Large Oil discoveries in the Shallow Waters by Shell Petroleum Company, ExxonMobil and Chevron. ➢ GDP growth rate of 25% from 14%
1971	Nigeria became a member of OPEC
1977	Establishment of State-owned Oil Corporation (NNPC)
1980s	Declines in oil production and introduction of the Structural Adjustment program (SAP)
2000-2010	Rise in oil production from 1.8 mbd to 2.5 mbd resulting in higher GDP of above 7%.
2015-2016	➢ Slower growth and drop in oil production (effect of global economic shocks, high volatility in market price/s & poor management of oil revenue) ➢ Economic Recession
2017-2019	Exiting recession and looking beyond petroleum
2020-2022	➢ Contractions in oil production due to Covid-19 Pandemic. ➢ Average daily oil production dropped from 2.0mbd to 1.14 mbd, the lowest since 1999

Source: Own Elaboration

5.2.2. Key Drivers in Nigeria's Petroleum Industry

The petroleum industry in Nigeria is influenced by various key drivers that shape its operations, impact on the economy, and interaction with global markets. These drivers include environmental considerations, market dynamics and demand patterns, competitiveness within the industry's environment, market and demand patterns, competitiveness, energy efficiency initiatives, and continuous process improvement efforts. Each of these factors plays a critical role in defining the trajectory and sustainability of Nigeria's petroleum sector.

(i) Environmental considerations

(ii) Market and demand pattern

(iii) Competitiveness

(iv) Energy Efficiency

(v) Process improvement.

i) Environment

Concerns of environment are central to the operations of the petroleum industry in Nigeria. Oil exploration, a fundamental aspect of this industry, has significant environmental implications. Continuous drilling activities can disrupt underground reservoirs, potentially leading to reduced hydrocarbon seepage and methane emissions into the atmosphere.

Additionally, the transportation and storage of crude oil and natural gas pose risks of environmental contamination, including air, water, and soil pollution. According to a report from the Nigerian Department of Petroleum Resources (DPR) and the National Oil Spill Detection and Response Agency (NOSDRA), there have been over 4,200 reported oil spill incidents in the past 50 years, highlighting the severe environmental degradation challenges faced by Nigeria (Ukhurebor et al., 2021). Despite existing environmental laws and regulations, challenges persist, emphasizing the need for improved environmental impact assessments and compliance strategies. Effective monitoring and implementation of emission reduction measures, waste minimization, and robust environmental management practices are crucial for mitigating environmental risks associated with oil production in Nigeria. Figure 20 illustrates instances such as the Eleme well leakage, highlighting the critical need for maintenance and environmental stewardship in the oil industry in sustaining the economy.

Figure 20: Oil Leakage at Eleme Refining Well – Rivers State.

Source: Handbook NBS (2019)

(ii)Marketing and Demand for petroleum

The market and demand factors are crucial in shaping the trajectory of the petroleum industry in Nigeria, given the indispensable role of oil in the global economy. Firstly, oil remains an essential commodity for various sectors, including transportation, manufacturing, and energy production. Its versatility and energy density make it irreplaceable in many applications, ensuring consistent demand worldwide. Secondly, the world's dependence on oil underscores the necessity for Nigeria to produce more crude oil and refined products. As a significant oil producer, Nigeria relies on petroleum exports for a substantial portion of its revenue and foreign exchange earnings. The country's economy is intricately linked to global oil markets, necessitating increased production to meet domestic needs and capitalize on other export opportunities (Ogunlowo et al., 2018).

Moreover, with rising population growth and economic development, the demand for petroleum products within Nigeria is expected to continue growing, further underscoring the importance of expanding crude oil production and refining capacity to meet domestic consumption needs and enhance economic stability.

Consequently, there are heightened expectations for increased revenue, particularly during periods of high demand and global market upswings, due to the country's significant role in the energy sector.

In Nigeria, the procurement and distribution of petrol, fuel oil, and lubricants are managed through long-term contracts to ensure consistent supply. These contracts are often established with specific operational and support elements in place to maintain efficiency and reliability. Additionally, the Department of Petroleum Resources (DPR) and the Petroleum Products Pricing Regulatory Agency (PPPRA) oversee the fuel quality control framework, ensuring that products meet specified standards before reaching the market. Also, the Nigerian

National Petroleum Corporation (NNPC), as the state-owned company, plays a central role in the distribution of fossil fuels and revenue maximization. It coordinates with various stakeholders to ensure the effective distribution of petroleum products across the country.

Furthermore, marketing plays a crucial role in shaping consumer behavior and influencing demand for petroleum products in Nigeria. Effective marketing strategies can enhance product visibility, stimulate demand, and contribute to revenue growth for oil companies. Furthermore, marketing initiatives can influence consumer perceptions of fuel quality, environmental sustainability, and pricing, thereby impacting market competitiveness and brand loyalty within the industry. By strategically managing marketing efforts, stakeholders can optimize the distribution and consumption of petroleum products in Nigeria.

(iii) Competitiveness

One of the key factors influencing the performance of Nigeria's petroleum industry, both domestically and internationally is in the aspect of competitiveness. Domestically, the industry faces competition from other sectors for investment, talent, and resources, necessitating policies and strategies to enhance its attractiveness and viability (Petroleum Industry Act {PIA}, 2021). Internationally, Nigeria competes with other oil-producing nations for market share and investment opportunities, requiring measures to improve efficiency, reduce costs, and enhance productivity. Additionally, global trends such as technological advancements, regulatory changes, and geopolitical dynamics shape the competitive landscape of the petroleum industry, influencing Nigeria's position and strategies. Moreso, efficiency initiatives could play a critical role in driving the competitiveness and sustainability of Nigeria's petroleum industry. This involves optimizing operations to reduce costs, and maximizing output, thereby enhancing the industry's ability to compete effectively in global markets.

Historically, the transition from Shell's sole concessionaire status over Nigeria's oil business to a more diversified landscape involving other oil companies, individuals, and politicians highlights the competitive evolution of the sector. Shell's pioneering drilling activities, starting in 1938 and culminating in discoveries like the “Oloibiri, Agbada and Akata-1" well in 1956, set the stage for intensified competition. Following the transition to democratic governance from 1999 to 2012, power dynamics shifted, facilitating the inclusion of other oil companies in allocation and export processes. Notably, industry giants like Shell, ExxonMobil, and Total Oil compete vigorously, each targeting different segments of the market through exploration, production, and various strategic ventures.

Industry data has shown that MNCs such as, Shell, ExxonMobil, Total Oil etc., compete vigorously in Nigeria's oil industry, each striving to dominate various sectors of the market. They engage in exploration and production activities, with Shell focusing on both onshore and offshore fields, ExxonMobil on deepwater projects, and Total Oil participating in joint ventures and production-sharing contracts. These companies invest heavily in technology and innovation to enhance operational efficiency and maximize production rates. Additionally, they maintain downstream operations, including refining, distribution, and marketing of petroleum products, often competing for market share in retail fuel sales.

While these oil merchants are known for their agility and innovation in Nigeria's oil industry, the state-owned NNPC has historically been perceived as slower to adopt innovative practices. Unlike its private counterparts, NNPC's decision-making processes are hindered by Poor infrastructural maintenance, bureaucratic hurdles and political considerations, leading to delays in implementing new technologies and processes (Ogbuigwe, 2018b). However, NNPC plays a crucial role in Nigeria's oil sector by managing the country's oil and gas reserves, overseeing exploration and production activities, and ensuring domestic supply stability. Despite its perceived lag in innovation, NNPC remains a key player in driving the industry forward, albeit with potential for improvement in adapting to changing market dynamics and technological advancement. Therefore, maintaining competitiveness is crucial for Nigeria to maximize the benefits of its petroleum resources, attract investment, and sustainably develop its oil and gas sector in the face of evolving challenges and opportunities. Table 15 illustrates the various oil discoveries made by oil companies such as Shell, Mobil, Total, among others, and serves as a benchmark for assessing competition within the industry from 1970 to 2015.

Table 15: Share of Nigeria's oil discoveries by multinational companies 1970 – 2015.

Year	Shell	Gulf	Mobil	Elf	Texaco	Ashland	AGIP	Others
1970	74.47	20.05	4.68	0	0.35	0	0	0.45
1975	63.50	12.38	10.64	3.91	0.42	0.36	0	4.79
1980	56.69	16.47	10.59	4.17	2.10	0.41	0.59	8.93
1985	49.89	16.57	11.98	6.23	3.10	1.56	0.73	9.99
1990	51.18	15.29	13.16	5.30	3.24	2.11	1.22	9.50
1995	46.11	19.87	14.81	6.56	2.80	0.96	1.18	7.70
2000	40.1	6.0	27.80	6.60	3.11	2.11	2.6	9.80
2005	48.4	0	31.80	6.40	5.8	0.96	3.8	8.40
2010	56.7	0	28.0	10.2	6.4	0.03	3.3	10.20
2015	47.8	0	24.5	7.0	6.8	0	2.3	7.0

Source: NBS (2022)

(iv) Energy Efficiency

Nigeria's energy landscape is primarily shaped by the production and utilization of liquefied natural gas (LNG) and the dominance of thermal power generation, primarily fueled by natural gas. LNG production serves as a cornerstone of Nigeria's energy exports and domestic supply diversification, driven by the country's abundant natural gas reserves. Meanwhile, thermal power generation, accounting to over 80% of Nigeria's electricity supply, is propelled by the country's significant reliance on fossil fuels for electricity production, (Adewuyi et al., 2023). Both drivers reflect Nigeria's efforts to leverage its natural gas resources for economic development and meet the growing energy demand, albeit with opportunities to enhance efficiency and sustainability through technological innovation and tactful investments.

By enhancing efficiency in both LNG production and thermal power generation, Nigeria can further strengthen its energy security, reduce greenhouse gas emissions, and contribute to global efforts towards sustainable energy development. Collaboration with international partners and investment in cleaner energy technologies can also drive progress in this direction.

(v) Process improvement

Process improvement in the oil industry refers to the systematic approach of identifying, analyzing, and enhancing operational processes to increase efficiency, reduce costs, and improve overall performance. Experts observe that the situation of process improvement in the Nigeria oil industry varies. While some companies have implemented modern technologies and best practices to optimize their operations and increase efficiency, others are still facing issues such as outdated infrastructure, bureaucratic processes, and limited investment in innovation, according to the National Extractive Industries Transparency Initiative (NEITI) Bassey, (2020), noted.

This aspect in the Nigerian oil industry has been a critical focus area for enhancing operational efficiency and productivity particularly in the upstream sub-sector. For instance, advancements in drilling technologies, such as horizontal drilling and hydraulic fracturing, have enabled more efficient extraction of oil and gas reserves, particularly in challenging offshore environments. Despite advancements in various areas, such as extraction and exploration, the refining aspect of Nigeria's oil industry has experienced a decline in recent years. This decline is evident in the reduced number of functional refineries and the overall decrease in fuel production capacity (OPEC, 2021).

Challenges such as aging infrastructure, inadequate maintenance, and insufficient investment in refinery modernization have contributed to this decline (Ogbuigwe, 2018b). As a result, Nigeria has become increasingly reliant on imported refined petroleum products to meet domestic demand, highlighting the need for revitalization and improvement in the refining sector to address the trend.

These key drivers do not only shape the policies and strategies within the Nigerian oil sector but also have broader implications for the country's economic development and environmental sustainability. Balancing these drivers is crucial for Nigeria to effectively harness its oil resources, ensure energy security, and navigate the evolving global energy landscape while addressing environmental concerns and enhancing efficiency in oil production and utilization.

5.3. NIGERIA GLOBAL OIL TRADE & IMPACTS

Nigeria, the Sub-Saharan RRC and WTO member country has a somewhat dual economy of oil and non-oil sectors, all traded globally. Records show that the importance of external trade to the Nigerian economy has increased since in the 1970s. The contribution of global trade to GDP as measured by OPEC positions the country as the 7th among member countries. In aspect of trade openness in export and imports as a percentage of GDP) it shows that the size of the country's trade relative to GDP increased substantially after the production and export of crude oil was enhanced. Between 1960 and 1969, Nigeria experienced approximately 25.8% GDP growth, leading to a significant increase in trade relative to GDP, reaching 44% in the 1970s (Student, 2020). However, the spread declined slightly in the mid-1980s to 38% when the country began to face the effects of the second oil shock and the rise of interest rates in the international financial market, leading to fluctuations in oil price, but it later witnessed improvement in the mid-1990s to about 42.5% until 2011 when it hit record high with 51.28% before marginally declining to 48.53% percent in 2015 and with further increase to 58% of external trade in 2021; while its UK trade relations also grew from 38% to 42% in the same review.

Nigeria has long been both a net exporter and net importer of petroleum products. As a net crude oil exporter, the country benefits from price increases but suffers during price declines. Conversely, as a net importer, lower oil prices reduce import bills and total fuel subsidies, whereas higher prices increase them. Both scenarios have asymmetrical impacts, causing economic shocks that can be either positive or negative (Bawa et al., 2020).

Political economists often describe Nigeria as a price taker in the international oil market due to its dependence on global price determinations. This exposure to price volatility has resulted in significant fluctuations, with crude oil prices dropping below $10 per barrel in 1998, rising to over $147 per barrel in 2008, and reaching $111.64 per barrel in July 202These changes affect the supply curve for goods and services, exchange rates, and investments.

According to the Observatory of Economic Complexity (OEC), Nigeria's top imports include refined oil products, transportation, industrial supplies, pharmaceuticals, and food & beverages, primarily from China, India, the United States, the Netherlands, and Belgium. The downstream sector's contractual structure further complicates Nigeria's status as a net importer within its petroleum trade mix.

Oil and gas have been the major resources driving Nigeria’s earnings and economic growth, accounting for over 90% of total exports over the past five decades. Since the 2000s, more than 50% of total sales have been directed towards Europe. However, in 2019, the distribution of exports shifted, with 23% going to Asia, 13% to the USA, and 12% to Africa

(Haliloglu, 2021). By mid-2022, Nigeria’s oil output shrank to 1.6 million barrels per day, causing the country to drop from its position as the 10th largest crude oil producer globally and the top producer in Africa to the second, while Angola took the top position.

The decline in Nigeria’s crude oil and refined product output in recent months and years has highlighted the downstream sector’s inability to refine sufficient crude oil for domestic consumption due to various complex factors (Ogbuigwe, 2018b). Like agriculture, the burden on oil imports began to grow significantly in the 2000s due to frequent price volatility in the international market and increased government subsidies. Between 2015 and 2019, Nigeria’s petroleum imports, valued at $264.57 billion USD, exceeded exports, which were $206.07 billion USD, resulting in a negative net balance of $58.5 billion USD

Osunmuyiwa & Kalfagianni (2020). This imbalance has had immediate impacts on the country's balance of trade and GDP, contributing to the devaluation of its currency from N200/USD to N500/USD within the same period.

Currently, Nigeria is recognized not only as a net exporter of crude oil but also as a net importer of refined oil. Additionally, Table 16 shows the country's 8th position in crude oil reserves among other OPEC member nations, while figure 21 and 22 presents Nigeria as one of the top 10 countries in crude oil production and exports in global trade.

Table 16: Nigeria’s Global trade & Crude oil Reserves among OPEC countries 2021

Item/s	Countries	Rank	Crude oil Reserves (bn)	Per cent
1	Venezuela	1st	303.47	24.4
2	Saudi Arabia	2nd	267.19	21.5
3	Iran	3rd	208.60	16.8
4	Iran	4th	145.02	11.7
5	United Arab Emirate	5th	111.00	8.9
6	Kuwait	6th	101.50	8.2
7	Libya	7th	48,36	3.9
8	Nigeria	8th	37.05	3.0
9	Algeria	9th	12.20	1.0
10	Angola	10th	2.52	0.2
11	Gabon	11th	2.00	0,2
12	Congo	12th	1.81	0.1
13	Equatorial Guinea	13th	1.20	0.1

Source: OPEC (2021)

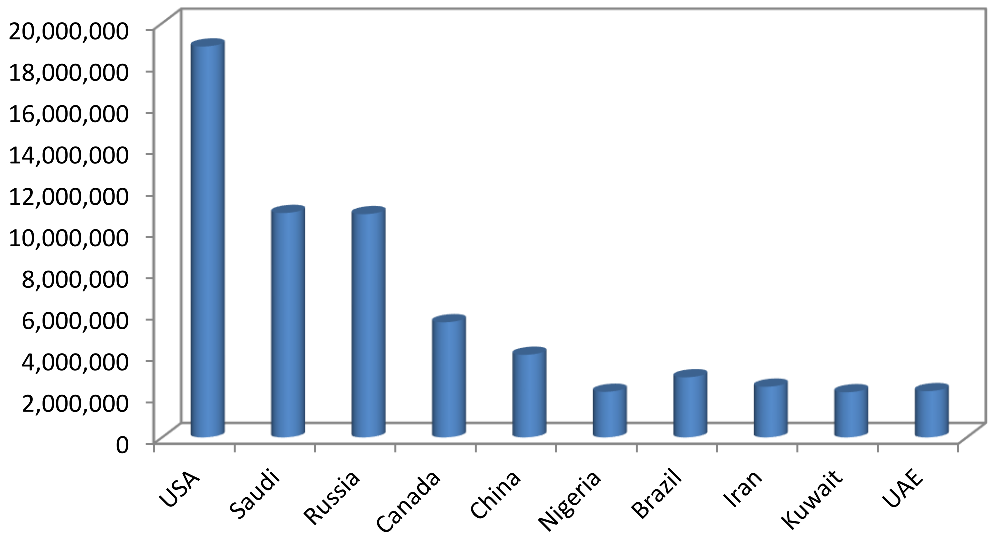

Figure 21: Comparing Crude oil Production by Global Top 10 Oil-rich Countries for 2019

Source: IEA. (2021)

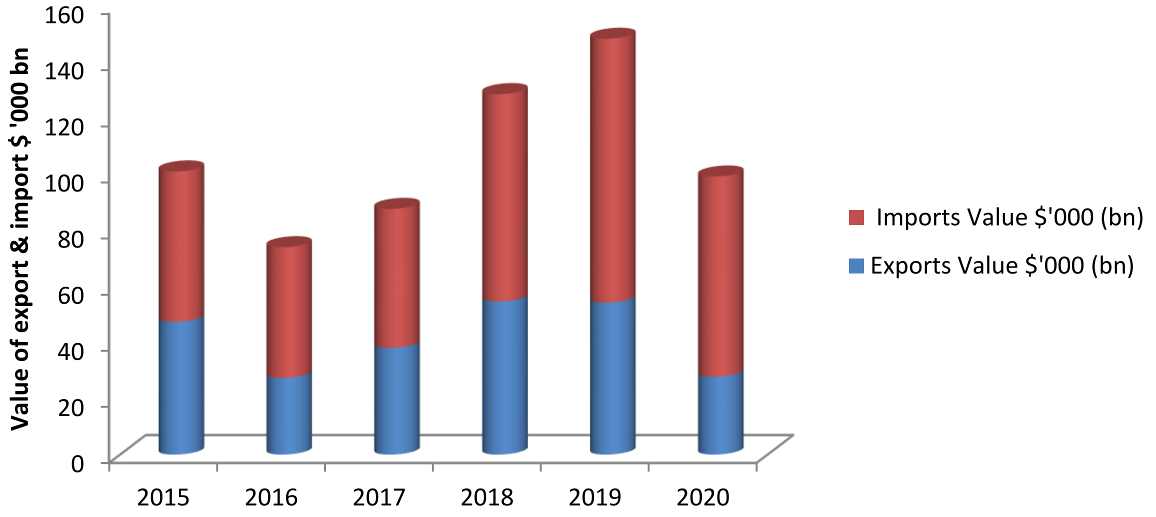

Figure 22: Nigeria's import & Export Value of petroleum 2015-2020

Source: OPEC (2021)

Figure 22 presents the scope of crude oil exports and refined petroleum imports in Nigeria from 2015 to 2020. The peak of significant importation occurred in 2019, with an expenditure of $93.97 billion, followed by $73.85 billion in 2018, and $71.28 billion in 2020. This substantial reliance on oil sector revenues is attributed to Nigeria's vulnerability to shocks, as suggested by many scholars, with Olujobi et al. (2022), specifically linking it to weak institutions, inefficient oil revenue management, and rising demand for refined fuel. According to (Bawa et al., 2020) the increase in demand has led to substantial increase in local prices, up to about 160% increase; while headline inflation shoot up from 9% to 11% (from one to two digits) during the reviewed period (Bawa et al., 2020).

According to Nigeria's Petroleum Minister, one of the major economic strategies in the increase has been on the assumption that affordable oil import would play a significant role in boosting the economy based on the estimated oil production volume of 2.2millio barrels per day (mbd) at varying oil prices. Another important reason was aimed at reducing the high dependence on oil. Despite the effort to level the playing ground surface, records indicate that the country is still unable to compete with foreign suppliers. Currently, Nigeria is the largest net importer of petroleum products in Africa with about 500,000 barrels per day and is seconded by Angola with about 300,000 bpd (Wang et al., 2022). Due to unfair competition, particularly by foreign multinationals, the country has lost out in refinery opportunities. However, its alliance with the Chinese companies seems to have brought in respite as the volume of production increases. See the excerpt on the country's crude oil production in 2020, where Nigeria was ranked 7th among OPEC member nations, as illustrated in Table 17.

Table 17: Position of Nigeria in OPEC & GPVCs 2020

Country	Export Rank	Crude Production	Value Chain Rank
Saudi Arabia	1	158,323,836	2
Iran	2	77,051,255	3
Venezuela	3	70,147,603	9
Kuwait	4	50,702,426	5
Iraq	5	48,218,807	4
UAE	6	38,748,431	1
Nigeria	7	34,420,268	6
Libya	8	30,317,094	7
Algeria	9	20,120,810	8
Angola	10	14,632,186	11
Ecuador	11	6,091,559	13
Gabon	12	4,369,926	10
Congo	13	1,73,024	12
Equatorial Guinea	14	1,704,524	14

Source: OPEC (2022)

5.4. Structure of Oil Industry in Nigeria

The structure of the oil industry in Nigeria is multifaceted, encompassing various stakeholders and components as illustrated in figure 23. At its core is the Nigerian National Petroleum Corporation (NNPC), which plays a central role in the exploration, production, refining, and distribution of oil and gas within the country. NNPC operates both independently and in collaboration with international oil companies (IOCs) through joint ventures, production-sharing contracts, and other arrangements. The key players in the industry include multinational corporations such as Shell, ExxonMobil, Chevron, Total Oil Company, and others, which are involved in upstream exploration and production activities. These companies typically operate under joint-venture agreements with NNPC or hold their own licenses for oil and gas exploration and production (PIA, 2021). The downstream sector of the oil industry involves refining, distribution, and marketing of petroleum products. Nigeria has four major oil refineries, operated by NNPC in partnership with International Oil Companies (IOCs), though they currently face challenges and operate below capacity. Additionally, there are numerous independent marketers and retailers with interconnected functions of distributing and marketing petroleum products across the country. The regulatory oversight of the industry is provided by the government and its agencies such as the Department of Petroleum Resources (DPR) and the

Petroleum Products Pricing Regulatory Agency (PPPRA), which oversee licensing, pricing, and quality control of the oil sector.

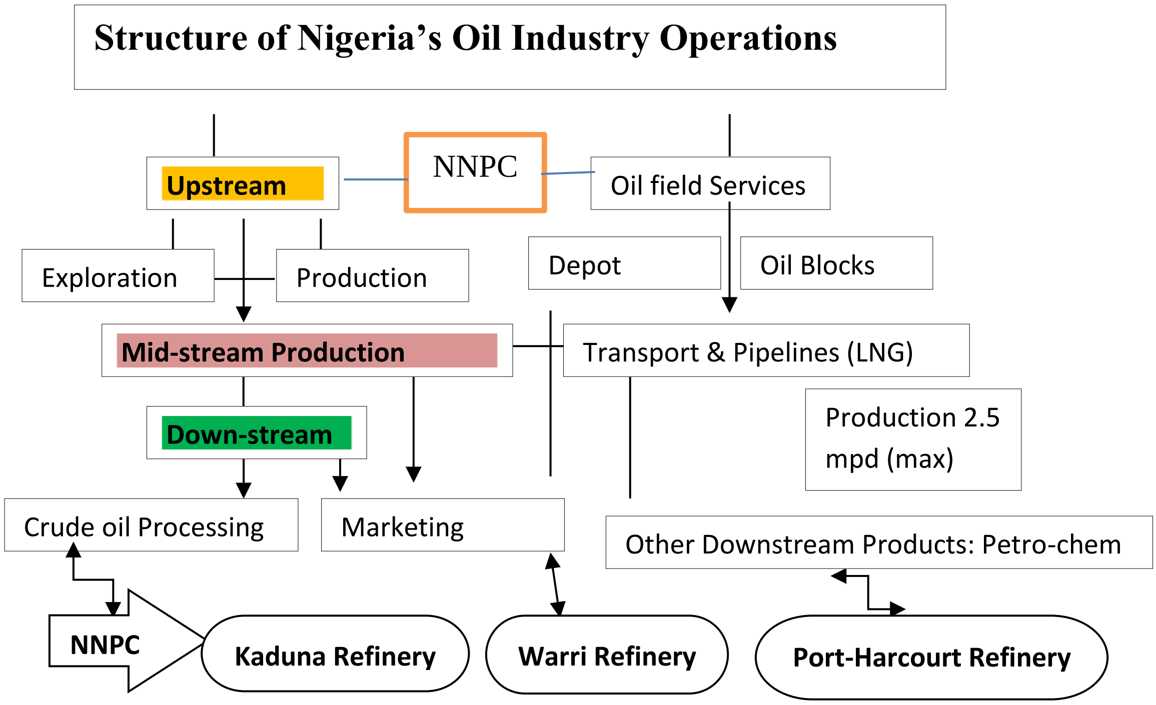

Figure 23: Nigeria's oil production activities & industry's life cycle

Source: Own Elaboration

(1) Upstream Sector: This sector, also known as the Exploration & Production (E&P) department, is responsible for exploring, drilling, and extracting oil using advanced geological surveys and drilling technologies. This process involves extracting crude oil from underground reserves located offshore, onshore, or in shallow wells, and bringing it to the surface for production. Before commencing extraction, exploration companies must negotiate agreements with the government, the sole owner of mineral rights by law, and obtain licenses from the Nigerian Upstream Regulatory Commission under the Petroleum Industry Act of 2021. The activities then begin with seismic surveys to identify potential crude oil and natural gas fields, followed by field development and drilling exploratory and operational wells to bring the resources to the surface. Also, the upstream sector includes national oil production, drilling functions, and support services, primarily in the nine oil-rich Niger-Delta States, encompassing both offshore and onshore operations. It provides significant direct and indirect employment, supports labor income, adds value to the economy, and enhances overall economic growth.

Historically, the upstream sector experienced a boom in oil production between the 1970s and 1980s during events such as the Yom Kippur War in 1973, the Arab oil embargo, the Iranian revolution in 1978, and the Iran/Iraq War in 1980. Significant production also began at deep-water fields in the 2000s, with the first deep-water field, Bonga, operated by SNEPCO, coming online in 2005. Subsequently, international oil companies, including Total, ExxonMobil, and BP, initiated production activities in various deep-water fields and continue to develop additional fields. Currently, about 65% of Nigeria's oil production comes from offshore fields. The crude oil produced contains low sulfur levels, suitable for processing light refined petroleum products. According to the latest estimates from the Energy Information Administration (EIA), Nigeria produces 1,780 billion cubic feet (bcf) of natural dry gas and approximately 22.5 million tons of Liquefied Natural Gas (LNG) per annum. The country has about 200.79 trillion cubic feet (TCF) of proven natural gas reserves. Production Sharing Contracts account for about 24% of the nation's crude oil reserve and condensate, while Joint Ventures account for about 76% (Global Energy Review, 2020).

The E&P segment is the fastest growing in the industry, with 388 awarded blocks, of which about 173 are currently functional (Iwuoha, 2021). Indigenous players account for 90 oil blocks, representing about 6% of the country's total crude oil production. In contrast, foreign players hold 83 blocks, accounting for about 94% of total crude oil output. The most productive oil fields are in the Niger Delta region, with 78 out of 159 fields fully active. The Agbami oilfield, discovered by Chevron in 1998, is the largest in the country, producing over 250,000 barrels of crude-oil per day and having an estimated oil in place of about one million barrels per day from offshore platforms (Student, 2020).

To sustain production, the Nigerian government and industry players are considering the use of modern drilling technologies, such as 3D and 4D seismic technologies, according to the Ministry of Petroleum Resources. Tenders for offshore areas are being issued to attract global explorers who had cut spending following the crude oil price crash during the pandemic and the climate change-related blanket ban on oil funding (Akpan et al., 2022). Additionally, the Nigerian government has offered tax concessions to companies developing small fields, reduced bureaucracy, and privatized parts of the state-owned NNPC to attract rapid investment (PIA, 2021).

Despite efforts to boost local content, Nigeria's oil sector remains heavily dependent on foreign capital and expertise. As noted by Itaman & Awopegba (2021), this dependence on lead firms and external technology makes Nigeria vulnerable to increased oil imports, falling GDP, and shocks from international oil price volatility. Despite initiatives to build indigenous capacity, the sector has not significantly reduced its reliance on foreign expertise.

Adewuyi et al. (2023) highlight that the primary challenge facing Nigeria's oil industry, particularly the E&P segment, is technology. Attracting top investors for energy transition and economic rent maximization is crucial. Historically, major geophysical and oil exploratory survey companies partnering with lead firms for initial field development services in Nigeria have been largely expatriates. Companies such as Geodetic Surveys Limited, Geco Prakla Surveys, Geosys Nigeria Limited, Water-Gates Oil Field Services, and Paradym Geophysical Services dominate the field. According to Siyanbola (2016), this has led to low competition, less innovation, and reduced production capacity.

The production trend from 1973 to 2022, indicated in figure 26 shows that Nigeria's crude oil production averaged 1.842 million barrels per day, reaching an all-time high of 2.475

million barrels per day in 2005. However, production saw drastic decline in 2022. This trend highlights the volatility and challenges within the upstream segment, emphasizing the need for sustained investment and technological innovation to maintain and increase production levels.

Recent initiatives include the ongoing rehabilitation of Port-Harcourt and Kaduna refineries, modular oil refinery projects, and private partnerships such as the Dangote Refinery, the Lekki Free Zone Project (LFZP), and the Bayelsa Azikel Refinery (BAR). These projects aim to increase indigenous crude oil refining capacity, meet domestic demand, reduce petroleum product imports, and potentially make Nigeria a net exporter of refined oil. However, these steps have not yet achieved the desired results (Ogbuigwe, 2018). Excerpt of production from the upstream segment between 1980-2021 is presented in figure 24 for clearer understanding.

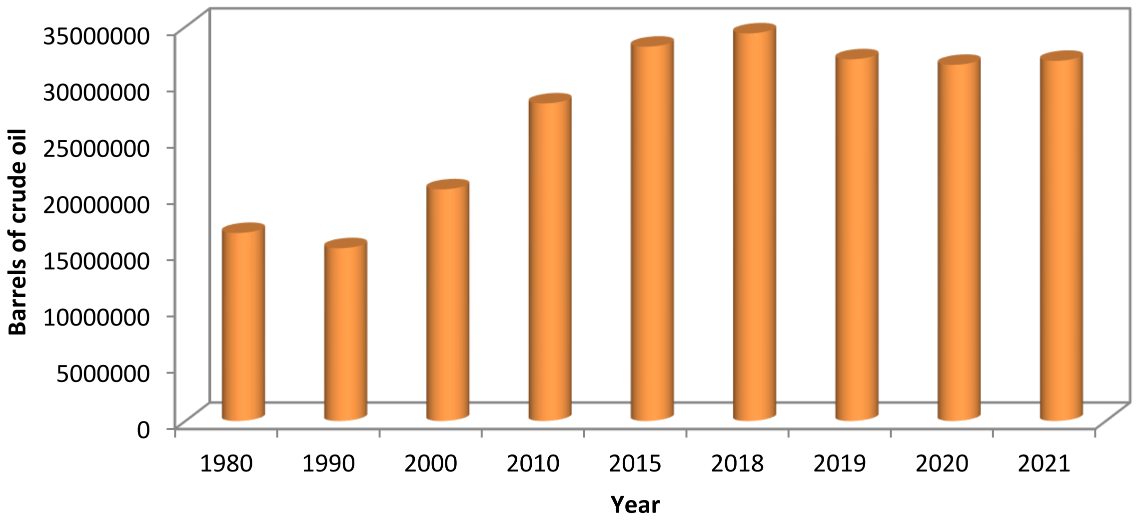

Figure 24: The Upstream Production Trend 1980-2021

Source: OPEC (2021)

(2) Midstream Sector: In Nigeria, the midstream segment of the oil industry is critical for transporting and storing crude oil, natural gas, and refined petroleum products. It acts as the bridge between the upstream and downstream sectors, ensuring that extracted resources reach refineries and distribution networks efficiently. Key components of the midstream sector include pipelines, shipping, rail transport, and storage facilities. This sector is vital for maintaining the flow of oil and gas from production sites to refineries and ultimately to end-users. The country's pipeline network is extensive, comprising thousands of kilometers of pipelines that transport crude oil and natural gas across the country. Major pipelines include the Trans-Niger Pipeline, the Escravos-Lagos Pipeline, and the West African Gas Pipeline. These pipelines are essential for moving crude oil from inland production sites to coastal refineries and export terminals. However, the pipeline network faces significant challenges, including aging infrastructure, inadequate maintenance, and frequent vandalism and oil theft, which can lead to significant financial losses and environmental damage.

The pipeline vandalism and oil theft are significant problems, costing Nigeria billions of dollars annually. These activities not only result in substantial economic losses but also cause environmental pollution and safety hazards. Addressing these issues requires enhanced security measures, community engagement, and technological solutions such as surveillance and monitoring systems.

This department or subsector also faces regulatory challenges, including bureaucratic inefficiencies and a lack of clear regulatory frameworks as they often duplicate activities with the downstream. These hurdles can delay project approvals, increase operational costs, and discourage investment. Streamlining regulations and improving governance are essential for fostering a more conducive environment for midstream operations. Environmental issues, such as oil spills and gas flaring, pose significant challenges in the midstream sector. These activities not only harm local ecosystems but also contribute to global greenhouse gas emissions. Implementing stricter environmental regulations and promoting best practices in oil and gas transport and storage are crucial for mitigating these impacts.

However, recent efforts to improve the midstream sector include the construction and expansion of pipeline networks. Notable projects include the Ajaokuta-Kaduna-Kano (AKK) gas pipeline, aimed at enhancing domestic gas supply and distribution. This project is expected to boost industrial growth and energy access in northern Nigeria. In addition, Public-Private Partnerships (PPPs) are gradually being leveraged to address midstream sector challenges. It is presumed that collaborations between the government and private sector investors can provide the necessary capital, expertise, and technological advancements to modernize infrastructure and improve operational efficiency in this sector.

In terms of technology innovation, digital monitoring systems, automated pipeline controls, and advanced pipeline fabrication solutions should be adopted to enhance the efficiency and safety of midstream operations. These technologies can help detect leaks, prevent vandalism, and optimize transport and storage processes.

The midstream sector of Nigeria's oil industry also encompasses the transportation, storage, and wholesale marketing of crude oil and refined products. An integral aspect of this sector is the export of crude oil, which forms a significant part of Nigeria's economy. Understanding the distribution of crude oil exports by destination is essential for grasping the dynamics of Nigeria's oil, as depicted in table 18.

Table 18: Nigeria's Crude oil Export by Destinations 2015-2019

Item/s	2015 %	2016 %	2017 %	2018 %	2019 %
Europe	**46.93**	**35.18**	**38.07**	**53.47**	**33.86**
North America	**3.95**	**17.67**	**18.20**	**8.69**	**1.46**
Asia Pacific	**26.05**	**28.15**	**28.17**	**19.55**	**33.17**
Latin America	**9.89**	**4.67**	**3.19**	**2.65**	**12.54**
Africa	**13.18**	**14.33**	**12.19**	**16.63**	**12.89**
Middle East	**-**	**-**	**0.18**	**-**	**6.08**
Total %	**100**	**100**	**100**	**100**	**100**

Source: OPEC (2022)

(3) **Downstream Sector:** This sub-sector of the Nigerian oil industry is responsible for refining crude oil, distributing refined petroleum products, and marketing these products to end consumers. This segment encompasses a range of activities including refining, transportation, storage, and retail distribution, ensuring that petroleum products reach consumers efficiently and reliably. In this department, the marketing functions extend beyond traditional advertising and promotion to encompass the intricate process of purchasing and distributing petroleum products from refineries to end consumers. Oil marketing companies (OMCs), including major players like Shell, AGIP, and NNPC stations, play a central role as wholesale distributors in this process. These companies often operate networks of retail outlets, such as gas stations, fuel depots, and convenience stores, where consumers can purchase gasoline, diesel, lubricants, and other petroleum products.

In addition, the independent marketers represent another significant segment of the downstream market, purchasing petroleum products directly from bulk suppliers, including refineries and OMCs, for distribution to retail outlets or bulk consumers. These independent marketers often play a crucial role in ensuring product availability and market competition, contributing to the diversification and efficiency of the downstream sub-sector in the country. Transport, storage, shipping costs and other retail distribution are also integral activities.

By understanding the intricacies of marketing functions and shipping costs within the downstream subsector, stakeholders can better navigate the challenges and opportunities, ultimately contributing to the stability and growth of Nigeria's oil industry. Figure 25 illustrates the key activities in the downstream subsector, highlighting the flow of petroleum products from refineries to end consumers and the various stages involved in this process, such as transportation, storage, and retail distribution. This visual representation helps in comprehending the complex logistics and cost factors that impact the profitability and efficiency of the downstream operations.

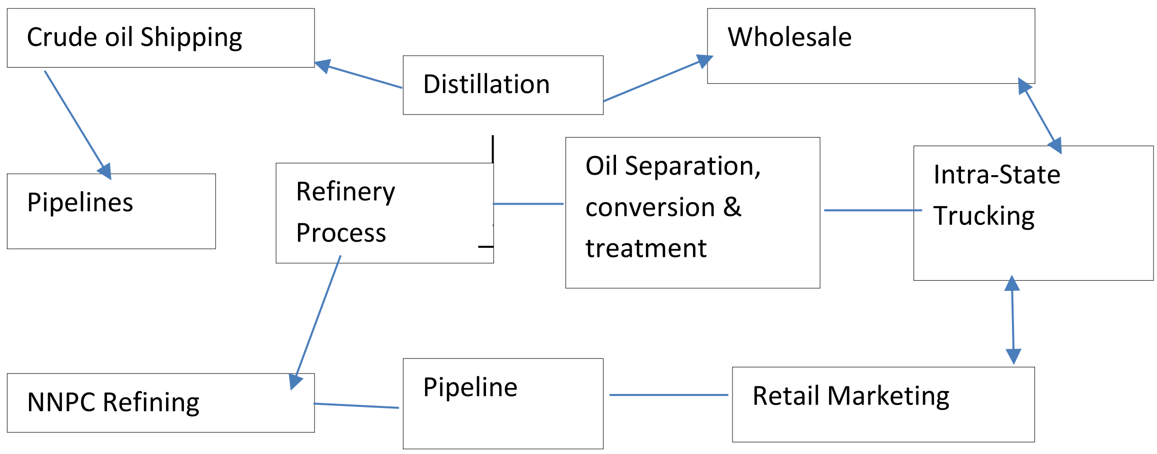

Figure 25: Downstream Petroleum Network Activities

Source: Own Elaboration

Figure 25 illustrates the network of activities in Nigeria's downstream sector of the oil industry. To understand the workings of the downstream sector, it is useful to review the initial processes of the petroleum value chain explained in chapter 2. In addition to refining crude oil, the downstream sector in Nigeria encompasses several other crucial activities for the efficient distribution and marketing of petroleum products. These activities include transportation, shipping, distribution, storage, and marketing. Each of these stages involves specific processes and cost factors that impact on the overall efficiency and profitability of the sector. By examining these elements, stakeholders can gain a comprehensive understanding of the downstream operations and the challenges and opportunities they present.

- **Transport:** This department plays a critical role in moving refined petroleum products from refineries or import terminals to distribution centers and retail outlets across the country. Also, transporting crude oil and natural gas involves shipping and rail networks. Nigeria's coastal location provides opportunities for maritime transport, with several key export terminals, including Bonny, Forcados, and Brass. These terminals are pivotal for exporting crude oil to international markets. The logistics functions involve the routing of crude oil from upstream department in the Southern Niger-Delta to Northern Nigeria in pipelines, trucks, railroads, and marine vessels. Pipelines are the primary mode for long-distance transportation, while trucks are commonly used for local distribution to remote areas not served by pipelines. Rail and marine transportation are also utilized for bulk shipments between regions or for exports.
- **Shipping Cost:** This cost in the downstream sector involves not only the direct expenses associated with transporting crude oil or refined fuel but also various additional costs incurred throughout the supply chain. Effective management strategies, such as amortization policies, have historically been employed to mitigate these costs. For instance, in the 1970s, Nigeria implemented such policies to reduce expenses associated with shipping crude oil and refined products. However, despite these management

efforts, challenges persist, particularly at congested ports like Lagos and Onne-Port Harcourt. Congestion at these ports can lead to delays in customs clearance and discharge, often resulting in demurrage charges, penalties incurred for the detention of vessels beyond the agreed-upon time for loading or unloading. These demurrage penalties contribute significantly to the overall shipping costs, impacting the profitability of petroleum transactions. Additionally, costs are incurred at terminals upon landing, including expenses related to storage, retail, and wholesale activities. These terminal operations involve handling, storage, and distribution of refined products, adding to the overall logistics expenses within the downstream sub-sector. Investors often consider not only the direct transportation expenses but also the various ancillary costs throughout the supply chain, including demurrage penalties and terminal operations. Effective management of these costs is crucial for optimizing profitability and ensuring the smooth functioning of the petroleum distribution network. By addressing these logistical challenges and implementing efficient cost management strategies, the downstream sector can enhance its operational efficiency and profitability.

- **Marketing:** The marketing functions in Nigeria's downstream oil sector extend beyond traditional advertising and promotion, encompassing the intricate processes of purchasing and distributing petroleum products from refineries to end consumers. Oil marketing companies (OMCs), including major players like Shell, AGIP, and NNPC stations, play a central role as wholesale distributors in this process. These companies often operate networks of retail outlets, including gas stations, fuel depots, and convenience stores, where consumers can purchase gasoline, diesel, lubricants, and other petroleum products. Independent marketers represent another significant segment of the downstream market. They purchase petroleum products directly from bulk suppliers, including refineries and OMCs, for distribution to retail outlets or bulk consumers. These independent marketers play a crucial role in ensuring product availability and market competition, contributing to the diversification and efficiency of the downstream sub-sector. By facilitating broader market access and maintaining competitive pricing, independent marketers enhance the overall stability and resilience of Nigeria's petroleum product supply chains.
- **Storage:** This facility forms an integral to the downstream petroleum sector in Nigeria, with key players such as the Nigerian National Petroleum Corporation (NNPC) and other major contractors maintaining strategic storage points throughout the supply chain. The practice was initiated during the administration of General Olusegun Obasanjo to mitigate the impact of supply disruptions on petroleum prices. Storage facilities are crucial for maintaining a steady supply of oil and gas. These include tank farms, storage terminals, and strategic reserves. In Nigeria, storage capacity has been a critical issue, with facilities often unable to keep up with production and import volumes, leading to bottlenecks and inefficiencies. Basically, building storage facilities is often

costly, prompting some companies to hold contingency stocks to prevent stock shortages and price spikes. These strategic measures contribute to supply chain efficiency, especially when coupled with collaboration from major oil contractors. Government agencies play a significant role in regulating the downstream petroleum sector, particularly in the refining and distribution of petroleum products. The regulatory environment, however, presents challenges for industry players and often deters major investments. Some of the immediate challenges identified by the Department of Petroleum Resources (DPR) include unsuitable oil product pricing, irregular gas supply, storage infrastructure deficits, insecurity, and bridging product supply. Enhancing storage infrastructure is vital for smoothing out supply fluctuations and ensuring energy security.

- **Market Size:** The Nigeria's downstream petroleum sub-sector is a critical segment of the country's economy, encompassing a range of activities from refining to the retail distribution of petroleum products. This section plays a vital role in ensuring energy supply, contributing to GDP, and generating employment. The refining capacity includes four major refineries: Port Harcourt I and II, Warri, and Kaduna, with a combined capacity of about 445,000 barrels per day (bpd) (Haliloglu, 2021). This makes the distribution and retail network in Nigeria's downstream sector extensive. Oil marketing companies (OMCs) such as Shell, AGIP, and NNPC operate numerous retail outlets across the country. These stations distribute gasoline, diesel, lubricants, and other petroleum products to end consumers. Independent marketers also play a crucial role, purchasing products from bulk suppliers and ensuring product availability and market competition nationwide. With the total consumption of petroleum products estimated at approximately N4.7 trillion Nigerian Naira, according to data from the Petroleum Products Pricing Regulatory Agency (PPPRA), the market is considered substantial (Haliloglu, 2021). This market includes seven major petroleum products traded and consumed locally including Petroleum Motor Spirit (PMS), Automotive Gas Oil (AGO), Aviation Turbine Kerosene (ATK), Low Pour Fuel Oil (LPFO), Household Kerosene (HHK), diesel oil, and lubricating grease motor oil. Its capacity also involves the provision of direct and indirect employment to thousands of Nigerians, supports numerous ancillary industries, and contributes significantly to government revenues through taxes and levies. The sector's activities impact various aspects of daily life, from transportation and power generation to industrial production (Ahmad & Zhang, 2020). Moreover, West Africa consumes approximately 11 billion liters of AGO annually, with imports constituting over 70% of the supply to the region. This underscores Nigeria's role as a major player in the regional petroleum market and highlights the opportunities for inclusive energy transitions in oil-producing nations across Africa.

Despite the importance, the sector faces several challenges, including regulatory hurdles, infrastructure deficits, and market inefficiencies. However, the ongoing reforms and investments present opportunities for growth. Enhancing local refining capacity, improving distribution logistics, and fostering a competitive market environment can significantly expand the sector's economic footprint.
Adeyanju et al. (2020) remark that Nigeria and other oil-producing nations in Africa have a unique opportunity to drive inclusive energy transitions for sustainable future economic growth. This transition involves leveraging the country's abundant energy resources to foster innovation and promote renewable energy adoption, thereby ensuring long-term economic resilience and environmental sustainability.

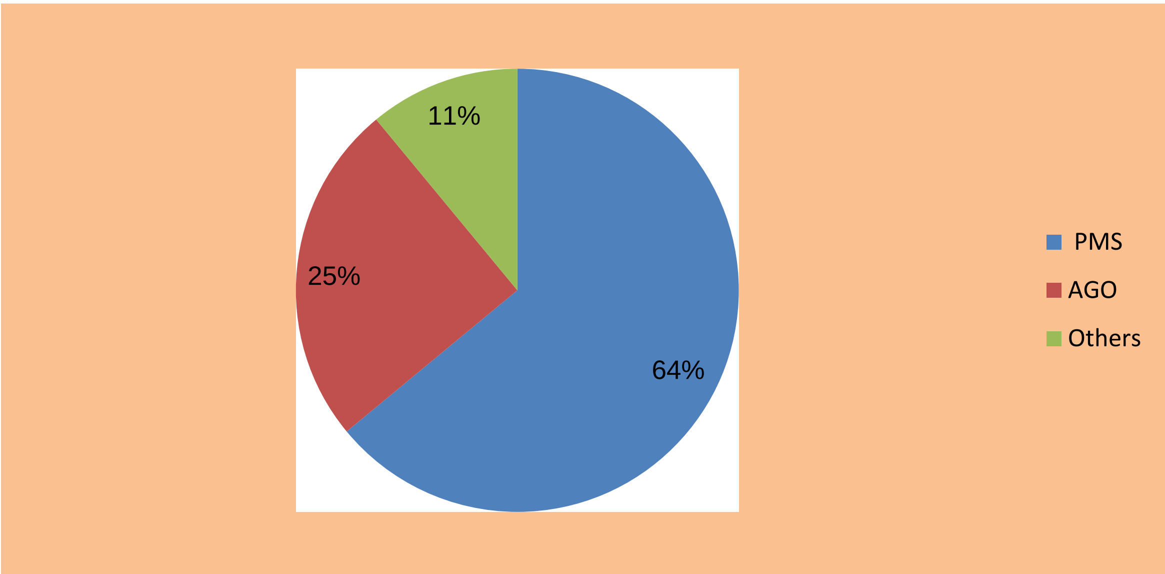

Figure 26: Market Size for Gasoline, Diesel & Others in 2019

Source: Own Elaboration

Figure 26 presents a pie chart showing the analysis of Nigeria's petroleum product consumption for the year 2019. According to industry data, gasoline and jet fuel together represent the largest portion of consumption, making up 64% of the total usage of refined petroleum products. Following this, diesel, mainly used for industrial purposes, accounts for 25% of the consumption. The remaining 11% consists of kerosene, coal, and other petroleum products.

In Africa, according to reports from the Organization of the Petroleum Exporting Countries (OPEC), the continent had a total refining capacity of 3.544 million barrels per day (mbd) in 2018. This represents a slight increase from the previous year's volume of 3.423 mbd, reflecting a modest growth trend in the continent's refining sector. This concentration of refining capacity underscores the importance of Africa as a key player in the global oil and gas industry. With strategic geographic locations, abundant energy resources, and growing economies, countries such as Egypt, Libya, Algeria, South Africa, and Nigeria continue to drive growth and innovation in the continent's oil sector, further solidifying Africa's position in the global energy market.

Nigeria has ambitious plans to increase its refinery capacity by 2025, with expectations to add significant additional capacities through the construction of newly built and upcoming refineries. These projections are anticipated to enhance Nigeria's domestic refining capacity and reduce reliance on imported petroleum products. Details of the existing four major refineries and their locations are provided in Table 19, which outlines their current capacities and geographic distribution.

Table 19: Major Refineries in Nigeria.

Refinery	Location	Capacity	Capacity Utilization	Refined Products	Crude Source	Destination
Kaduna Refinery	Kaduna State	110,000 bpd	7.9	PMS, AGO, DPK &FO	Escravos &Forcados: Kuwait, Saudi Arabia & Venezuela	Northeast, Northwest & North Central Regions
Warri Refinery	Delta State	125,000 bpd	12.7	PMS, AGO, DPK	Escravos Terminal	Southwest region
Port-Harcourt Refinery I&II	Rivers State	210,000 bpd	10.8	PMS, AGO, & FO	Bonny Terminal	Yiola, South-South, South-East & North Central
Niger-Delta Refinery	Rivers State	1,000 bpd	64.4	AGO	Ogbele & Omerelu Fields	Southeast region

Source: NBS (2022)

(i)Kaduna Refinery

The Kaduna Refinery, situated in Kaduna State, boasts a refining capacity of 110,000 barrels per day (bpd). Operated by the Kaduna Refining and Petrochemicals (KRPC) Limited, a subsidiary of the Nigerian National Petroleum Corporation (NNPC), the refinery underwent a capacity expansion in December 1986, increasing its design capacity from 50,000 bpd to 60,000 bpd. This upgrade brought the total installed capacity of the refinery to 110,000 bpd. Equipped with two distillation units, the refinery utilizes a blend of Escravos and Ughelli crude oils for fuel production, while heavy crude oil imports are employed to produce lube base oil, asphalt, and waxes. Among the products derived from the KRPC are Liquefied Petroleum Gas (LPG), Premium Motor Spirit (PMS), Household Kerosene (HHK), Aviation Turbine Kerosene (ATK), Automotive Gas Oil (AGO), and Fuel oil.

(ii) Warri Refinery
The Warri refinery, established in 1978, initially had a refining capacity of 100,000 barrels per day (bpd), later increased to 125,000 barrels per stream day in 1987. Situated at Ekpan, Warri, Delta State, the refinery operates under the direct auspices of the Nigerian National Petroleum Corporation (NNPC). This complex conversion plant has the capability to process a blend of Escravos and Ughelli crude oils, yielding a variety of petroleum products including Liquefied Petroleum Gas (LPG), Premium Motor Spirit (PMS), Dual Purpose Kerosene (DPK), Automotive Gas Oil (AGO), and Fuel Oil. Additionally, it features a petrochemical plant complex producing Polypropylene, carbon black sourced from propylene-rich feedstock, and lubricants oil extracted from the Fluid Catalytic Cracking unit (FCC

(iii) Port Harcourt Refinery (Eleme & Onne locations)

Port Harcourt is home to two refineries operated by the Port Harcourt Refining Company (PHRC) Limited, a subsidiary of the Nigerian National Petroleum Corporation (NNPC), boasting a combined 210,000 barrels per day complex conversion capacity. These refineries employ Bonny Light crude oil to produce a range of petroleum products including Liquefied Petroleum Gas (LPG), Premium Motor Spirit (PMS), Dual Purpose Kerosene (DPK), Automotive Gas Oil (AGO), Low Pour Fuel Oil (LPFO), and High Pour Fuel Oil (HPFO).

(iv) Niger-Delta Refinery with a 1000-barrels-per-day installed capacity, is situated near the River State University of Science & Technology in Ogbele, where it commenced operations. Primarily, the refinery produces diesel oil for local consumption within the state, with any surplus being sold to the immediate vicinity. Functioning as a vital component of the local oil ecosystem, the refinery distills crude oil sourced from the nearby flow station operated by its upstream affiliate. Notably, NDPR holds the distinction of being the first private refinery in Nigeria to receive an independent License to operate from the government, contributing significantly to the country's overall oil industry capacity, which stands at 456,000 barrels per day. Currently, the refinery is undergoing an expansion project aimed at increasing its processing capacity to 11,000 barrels per day.

(v) Other types of Refineries - Modular Refineries

Modular refineries are refineries with capacities between 1,000 and 30,000 barrels per day (bpd). Modular refineries are smaller refineries that serve the immediate needs of the area where they operate, and some are better suited for AGO and DPK. In Nigeria those with less than 20,000 capacities are mostly licensed to build and refine other petroleum products other than PMS. This type of refinery can be in 2 forms: the special purpose (construction and establishment is from both the marketer and the upstream company at an agreed interest share). While the second type is known as the traditional model (market partner with an operator of an onshore field agrees to run the refinery). Both are assumed to be lucrative at results.
Currently, the DPR has awarded license to 23 companies with cumulative capacities of 340,000 bpd for the establishment of modular refineries in Nigeria (Okorobia, 2018) . The potential successes of these refineries according to DPR, will largely depend on their nearness to market

sources aside from crude oil raw materials for logistical purposes. Despite the following advantages of Modular refinery over conventional refineries it also has some disadvantages as listed in table 20.

- Flexibility in upgrading as it can be constructed in phases.
- Acts as exemplary model to supply products to regional markets thereby reducing logical costs.
- The capital expenditure for the construction is cheaper than the conventional refineries
- The requirements for land use are also minimal.

Table 20: Difference between Conventional and Modular refineries

Type of Refinery	Advantages	Disadvantages
Modular Refineries	Flexible to meet the Nigeria's needs	Requires fewer configuration options (e.g. topping or hydro skimming plant)
	Minimum space	More employment for more distillation capacity
	Lower capital	Restricted to middle distillates, naphtha and lights
	Greater control over the environment and work procedure during installation	Lower production capacity; hence more suitable for meeting local demands, not necessarily exports
Conventional Refineries	Comprehensive functions such as topping, coking, hydro-skimming and cracking.	Less spread (one location for various marketing functions)
	More technologically driven with fewer number of staff	Require substantial capital outlay
	Higher production capacity and quality	Larger storage facilities for a variety of product yields
	Economies of scale for innovative functions & profits	Requires momentary turn-around time for construction and services

Source: Own Elaboration

(vi) Private Refineries in Nigeria - Dangote Private Refinery

An integrated petrochemical refinery owned by Aliko Dangote, currently under construction in the Lekki Free Zone of Lagos State, was launched in 2023 with completion expected by that year. Once fully operational, it will have the capacity to process approximately 650,000 barrels of crude oil per day, making it the largest single-train refinery globally. This ambitious project represents an investment of over $25.0 billion USD and is designed to refine various grades of crude oil, producing high-quality Euro V gasoline, diesel, kerosene, jet/kerosene fuel, polypropylene, and other petrochemical products.

The refinery's infrastructure includes a sophisticated pipeline system spanning 1,100km, access roads, extensive tank storage facilities, and state-of-the-art crude oil and product handling facilities. Additionally, it features a comprehensive marine terminal with a breakwater, jetty, and harbor. Notably, the refinery's fertilizer plant has been functional(Itaman & Wolf, 2021). Upon full operation, the project is expected to generate approximately 150,000 jobs, both directly and indirectly, contributing significantly to human capital development not only in Nigeria but also across the region.

Industry sources indicate proactive measures such as sponsoring two batches of engineers trained in India to manage refinery operations, emphasizing skill development and capacity building. The refinery is anticipated to create a robust market for Nigerian crude oil and reduce the country's dependence on imported petroleum products. Managed effectively, it promises to increase foreign exchange reserves and facilitate technology transfer through employee training abroad. However, like any large-scale project in the oil industry, the refinery, currently under construction, may face challenges, particularly in navigating fluctuations in international oil prices.

The full completion of the Dangote refinery is eagerly anticipated as a potential solution to Nigeria's longstanding issue of excessive fuel oil imports. It represents a pivotal development in the country's quest for energy self-sufficiency and economic resilience in the global energy terrain.

5.5. THE WEIGHT OF THE NIGERIAN OIL INDUSTRY ON THE ECONOMY

The Nigerian oil industry holds significant sway over the nation's economic landscape, exerting substantial influence on fiscal stability, revenue streams, and overall economic performance. According to Itaman & Wolf (2021) the weight of the oil sector in an economy can substantially influence various macroeconomic indicators and socio-economic conditions. In Nigeria, the oil sector has historically been the backbone of the economy, dictating the country's economic performance and development trajectory. Its contributions extend beyond financial metrics, influencing employment levels, infrastructure development, and national development agendas. As we delve into the data on petroleum production, further analysis on how these economic impacts manifest in practical terms is explored.

Figure 27 illustrates the average daily exports of crude oil from 2010 to 2020, highlighting peaks and troughs in export volumes. The highest export recorded was in 2010, exceeding 2.4 million barrels per day (mbd), while the lowest occurred in 2016, amidst an economic recession, with exports dropping to 1.7 mbd. These fluctuations underscore the volatility of Nigeria's oil sector, influenced by both global market dynamics and domestic economic conditions.

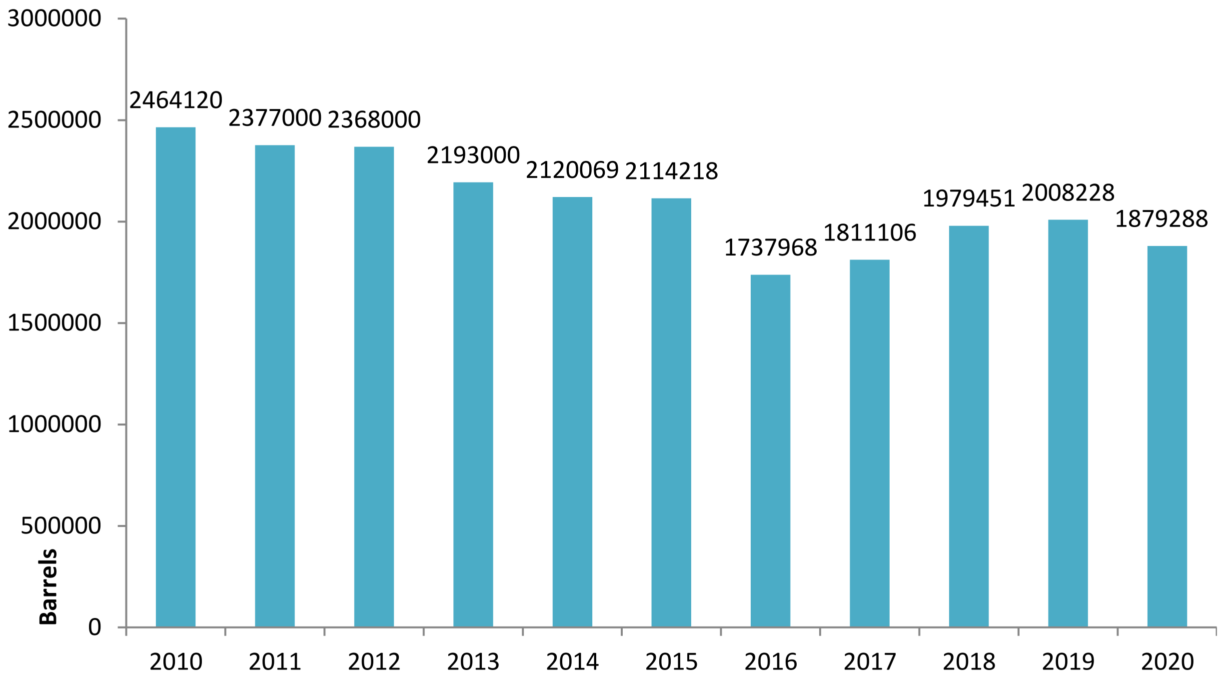

Figure 27: Nigeria's Average daily crude oil export 2010-2020

Source: OPEC. (2022)

In contrast to figure 27, figure 30 provides an overview of Nigeria's annual crude oil production, reserves, and exports from 2010 to 2020. The data reveals fluctuations in production and reserves, with the lowest recorded below 5.0 million barrels and the highest in 2018, reaching 34.0 million barrels of production and 37.9 million barrels in reserves. Notably, 2010 marked the peak export year, with over 2.4 million barrels per day (mbd). These variations reflect the diverse economic and geopolitical factors influencing the oil industry over the decades.

During the 1970s, Nigeria saw modest crude oil production, which peaked in the mid-1970s. The 1980s exhibited mixed growth, including periods of negative growth amidst volatility. From 1988 to 1994, the economy sustained an annual growth rate of approximately 4%, which tapered off to less than 3% in subsequent decades. A notable acceleration occurred between 2007 and 2011, with real GDP growth averaging between 6.27% and 7.57%. This period also witnessed improvements in GDP per capita, rising from 2.4% to 4.78%.

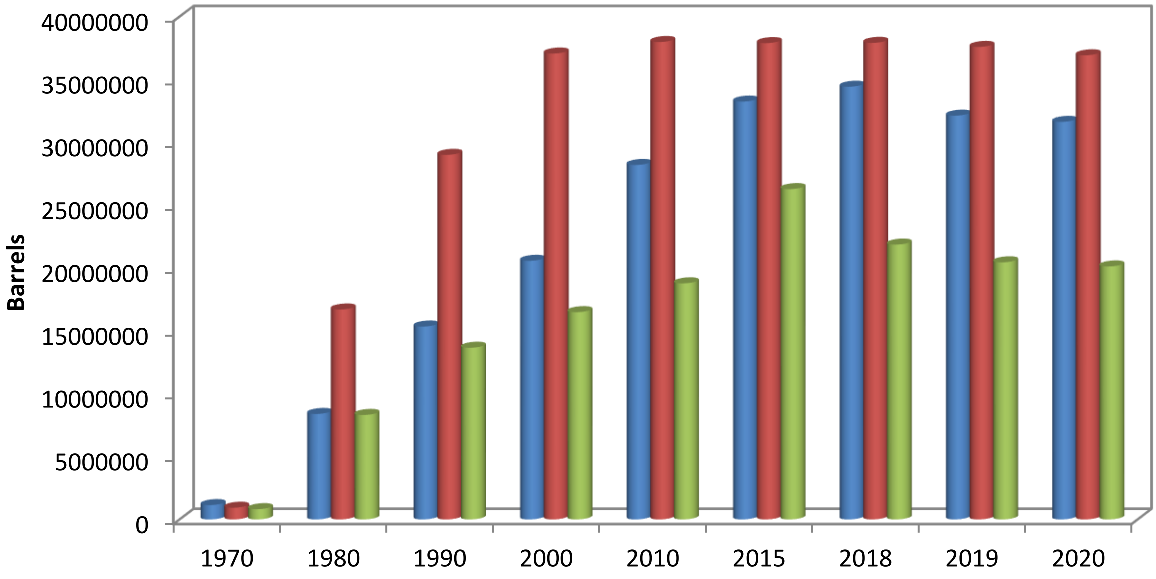

Figure 28: Annual crude oil Production, Reserves & Supplies 1970-2020

Source: Global Energy Review 2020 – Analysis - IEA (2021)

Both trends in figures 27 and 28 underscore the significant role of Nigeria's oil sector in shaping economic outcomes. Fluctuations in production and exports directly impact government revenue, foreign exchange earnings, and overall economic stability. Moreover, the sector's performance is intricately linked to global oil market dynamics and internal policy measures aimed at optimizing production and managing reserves effectively.

5.5.1. The distribution of real GDP by Sector

The distribution of real GDP by sector provides a comprehensive view of Nigeria's economic terrain, highlighting the contributions of various sectors to the nation's overall economic output. This data is pivotal in understanding the relative importance of industries such as oil and gas, agriculture, manufacturing, services, and others in shaping Nigeria's economic performance for global trade.

Table 21 illustrates the evolution of Nigeria's GDP sectoral distribution from 1970 to 2020, highlighting significant shifts across primary, secondary, tertiary sectors, and others. The primary sector, dominated by agriculture and natural resources such as oil and gas, has been leading the economy for the past 5 decades but is gradually seeing a marked decline in its GDP contribution over the decades. Starting at 62.70% in 1970, its share dropped to 43.35% by 2020, reflecting efforts to diversify the economy away from heavy reliance on oil exports. Also, the figure indicates that the primary sector's peak was in 1970 (62.70%), driven by strong agricultural and oil production. Its lowest point was in 2020 (43.35%), influenced by fluctuating oil prices and efforts to diversify the economy.

Table 21: Distribution of real GDP by Sectors 1970-2020

Sector/s	1970	1980	1990	2003	2009	2011	2020
Primary- Hydrocarbon & other raw mineral exports (total Agric & Min):	62.10	58.40	60.25	68.36	58.44	55.30	43.39
Agric	30.10	28.37	29.23	34.62	41.69	40.2	23.3
Mining/Oil	32.00	30.03	31.02	33.74	16.75	15.1	20.09
Secondary	13.05	12.14	12.60	10.77	9.05	6.2	10.22
Manufacture	6.30	5.60	5.95	4.32	3.72	4.2	5.1
Building	2.90	2.83	2.87	2.96	2.01	1.0	2.21
Utilities	3.85	3.71	3.78	3.49	3.32	1.0	2.91
Tertiary	24.85	29.46	27.16	21.13	32.51	39.0	46.39
Wholesale/ret	14.21	14.17	12.19	12.92	18.14	19.4	19.1
Others	10.64	15.29	14.97	8.21	14.37	19.6	27.29
Total GDP	100	100	100	100	100	100	100

Source: NBS (2022)

The secondary sector, comprising manufacturing and industry, has exhibited modest growth but remains overshadowed by the dominant oil and gas industry. It experienced fluctuations in its GDP share. Peaking at 13.05% in 1970 and reaching a high of 12.60% in 1990, it declined to 10.22% by 2020. This decline reflects challenges in industrial development amidst global competition and economic policy shift.

The tertiary sector encompassing services like finance, trade, and telecommunications has shown robust growth. Its contribution expanded from 24.85% in 1970 to 46.8% in 2020. This sector consistently expanded, reaching its highest share in 2020 (46.8%). This reflects the growing importance of service industries, thus underscoring Nigeria's shift towards a service-oriented economy driven by urbanization and technological advancement.

Overall, the finding indicates that the manufacturing activities in Nigeria have been struggling with infrastructure deficits and regulatory constraints, thus limiting their contribution to GDP. Similarly, the tertiary sector, including wholesale, retail, and other services, has expanded but faces challenges due to infrastructural deficiencies and regulatory bottlenecks. Consequently, while efforts to diversify the economy away from oil dependence are ongoing, the primary sector, driven by oil and gas, continues to play a significant role, although struggling to meet domestic consumption needs, participating in global value chains, and fulfilling regional demands.

5.5.2. Capacity Utilization of the Nigerian Oil Industry

The capacity utilization of Nigeria's oil industry is a crucial aspect that reflects the efficiency and productivity of its oil production and refining processes. With four refineries having a combined installed capacity of 445,000 barrels per day, Nigeria's refining capacity has faced significant challenges over the years. Despite this substantial installed capacity, actual production has consistently been below optimal level.

In recent years, the number of functional refineries has decreased from four to one, with only the Port Harcourt refinery IN operation. This decline has resulted in a reduction of fuel production by 15%-20%, accompanied by a slight decrease in feedstock. The utilization rates of these refineries have fallen to less than 20% over the last two decades, highlighting the inefficiencies and operational challenges within the sector.

Table 22: Import Level & Oil Industry Capacity Utilization Rates 2015-2022

Oil Market Snapshots (mblls)	2015-2019 Average ‘000	2022 Annualized’000
Total oil demand	650	650
Annual Capacity	455	780
Annual Production	2.0mbpd	1.5mbpd
Capacity utilization (Rate%)	55.20	40.19
Import and Export (mbpd)		
Import of refined oil (%)	80%	85%
Export crude oil %	90%	95%
Import penetration %	90.3%	93.82%
Proposed reduction of petroleum imports 2025		
Maximum import	30.5%	
Estimated Import penetration	37.8%	
Estimated production	65.5%	

Source: Own Elaboration

The data in Table 22 highlights a concerning trend of escalating oil import levels in Nigeria from 2015 to 2022, driven primarily by domestic refining challenges and fluctuating economic conditions. In terms of capacity utilization, Nigeria's refinery capacity utilization rates have remained critically low. From 2015 to 2016, the rates often fell below 30%, primarily due to operational inefficiencies, maintenance issues, and pipeline vandalism. Although there was some improvement in 2017 and 2018, utilization rates were still suboptimal, hovering around 20-30%. The NNPC's refineries continued to grapple with significant operational challenges during this period. Between 2019 and 2020, capacity utilization rates remained consistently low, fluctuating between 10-25%. Persistent maintenance problems and a lack of investment hampered efforts to improve refinery performance. Despite ongoing refinery rehabilitation projects in 2021 and 2022, capacity utilization rates generally did not exceed 25-30%.

Looking ahead, the anticipated completion of the Dangote refinery is expected to significantly enhance capacity utilization. Projections suggest that by 2025, oil import levels may rise to 30.5% of daily fuel consumption, while capacity utilization rates could reach 65.5% at 80% demand levels, according to estimates from the country's Bureau of Statistics (Olujobi, 2017).

5.5.3. Oil Demand & Consumption

Nigeria's oil consumption level is characterized by significant demand growth driven by economic expansion and population increase. The primary petroleum products consumed include gasoline, diesel, kerosene, and jet fuel, with gasoline being crucial for transportation, and diesel essential due to unreliable power supply that necessitates diesel generators. According to the National Bureau of Statistics (NBS), oil consumption in Nigeria rose from 266,000 barrels per day (b/d) in 2015 to 780,000 b/d in 2022, reflecting robust economic activity and population growth trends. However, Nigeria's domestic refineries have struggled to keep pace with this demand surge, resulting in a reliance on imports to bridge the supply gap.

This heavy dependence on imported refined petroleum products underscores Nigeria's vulnerability to global market fluctuations and supply disruptions. With inadequate refining capacity, the country imports a substantial portion of its refined oil needs, contributing to trade imbalances and economic challenges. OPEC data from 2015 to 2017 reveals a significant disparity between Nigeria's imports and exports of petroleum products, with imports consistently surpassing exports. This trade imbalance exerts pressure on Nigeria's balance of payments, affecting economic stability and growth prospects negatively.

Efforts to enhance domestic refining capacity and reduce import dependency are crucial for Nigeria's energy security and economic resilience as highlighted by Ogbuigwe (2018). To achieve self-sufficiency in petroleum products and minimize the economic risks of relying on imports, it is essential to address infrastructural deficiencies and enhance operational efficiency in the refining sector.

Table 23: Oil Consumption by States 2020-2021

States	Contribution %	States	Cont. %	States	Cont. %	States	Cont. %
Lagos	**19.9**	**Enugu**	**3.0**	**Gombe**	**1.4**	**Katsina**	**0.4**
Kano	**8.4**	**Zamfara**	**2.9**	**Cross R**	**1.3**	**Taraba**	**0.4**
Ogun	**5.8**	**Adamawa**	**2.5**	**Borno**	**1.2**	**Bauchi**	**0.3**
Rivers	**4.7**	**Ondo**	**2.4**	**Kogi**	**1.0**	**Jigawa**	**0.2**
Niger	**4.6**	**Akwa-Ibom**	**2.4**	**Nasarawa**	**0.6**	**Yobe**	**0.2**
Oyo	**4.5**	**Abia**	**2.2**	**Sokoto**	**0.6**	**Plateau**	**1.9**
Delta	**4.5**	**Imo**	**2.2**	**Ebonyi**	**0.5**		
Abuja	**4.3**	**Benue**	**2.1**	**Kebbi**	**0.5**		
Kaduna	**3.3**	**Osun**	**2.0**	**Ekiti**	**0.5**		
Edo	**3.1**	**Anambra**	**1.9**	**Bayelsa**	**0.5**		

Source: NNPC. (2022)

Nigeria comprises 36 States within its federation. Table 23 provides a detailed breakdown of the annual oil consumption rates for each state across the country. Lagos State, being the commercial and economic hub, exhibits the highest consumption rate of 19.9 million barrels annually. This high demand is driven by extensive transportation needs, industrial activities, and a large population reliant on petroleum products for daily use and business operations. Kano State, known for its significant commercial activities and industrial sector, follows with an annual consumption of 8.4 million barrels. The state's vibrant manufacturing base and bustling trade contribute to its substantial oil consumption, meeting both local industrial demands and transportation needs.

Conversely, states like Jigawa and Yobe have the lowest consumption rates at 0.2 million barrels annually each. These states typically have smaller populations, less developed industrial bases, and lower overall economic activity compared to their counterparts. Consequently, their lower oil consumption reflects their relative economic scale and industrial output in the national context.

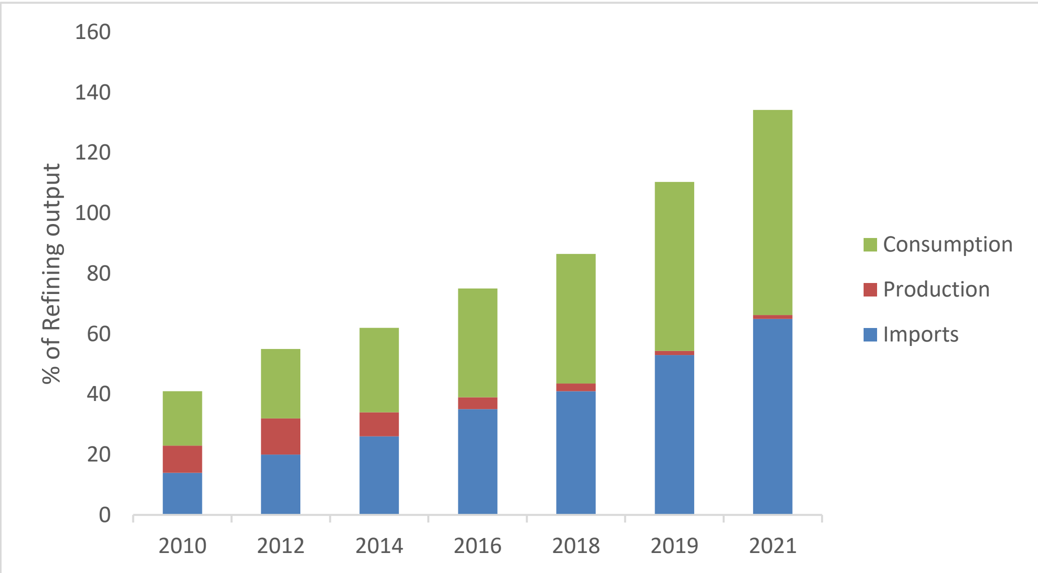

Figure 29: Refined Oil Production Analysis in Nigeria 2010-2021

Source: NNPC - NBS (2022)

Following the table listing Nigeria's 36 states and their respective oil consumption rates, figure 29further illustrates the dynamics of refined oil production in Nigeria from 2010 to 2021. In 2021, Nigeria experienced its peak in refined oil importation, reaching a value of 65%, while consumption peaked at 68%. Conversely, 2010 marked the lowest import value of 14%. The highest refined oil production year within the period analyzed was in 2012, with a production value of 12%, accompanied by an import value of 20% and consumption of 23%. The fluctuations in Nigeria's refined oil production and consumption underscore the country's dependence on imports, a scenario that aligns with OPEC's observations on the challenges facing domestic refining capabilities across its member state (OPEC, 2020).

5.5.4. Fuel shortages and subsidies

Fuel scarcity and oil subsidies are interrelated issues that have significant implications for Nigeria's economy and society. Fuel scarcity and oil subsidies are intertwined issues that have significant implications for Nigeria's economy and society. Fuel scarcity often occurs when there is an insufficient supply of petroleum products such as gasoline (petrol), diesel, and kerosene to meet the demand of consumers and businesses. This scarcity can be caused by various factors including disruptions in supply chains, inadequate refining capacity, logistical challenges, and sometimes deliberate hoarding or market speculation. In Nigeria, fuel scarcity episodes have been recurrent, leading to long queues at filling stations, transportation disruptions, and increased costs for businesses and households reliant on petrol and diesel for daily activities and electricity generation.

On the other hand, oil subsidies involve the government providing financial support to keep fuel prices artificially low for consumers by subsidizing the difference between the market price and the retail price. Subsidies are intended to make fuel more affordable for the general population and to mitigate the impact of high global oil prices on domestic consumers. In Nigeria, fuel subsidies have been a contentious issue due to their significant cost to the government budget and concerns over transparency and efficiency in subsidy administration.

Despite being a major oil producer, Nigeria imports most of its refined petroleum products due to inadequate refining capacity and operational challenges in its domestic refineries. This reliance on imports, coupled with subsidies, has strained government finances and contributed to fiscal deficits, as the cost of subsidizing fuel often exceeds budgeted amounts, leading to increased public debt and macroeconomic instability (Osunmuyiwa & Kalfagianni, 2017).

In Nigeria the supply of refined fuel products primarily comes from two sources (domestic refineries and imports). However, with only 20% produced locally since 2017, marking a remarkable decline from previous levels, periodic fuel shortages has been experienced notably in 2015, 2019, 2021, and 2022, resulting to disagreements in prices, production shortfalls, refining output declines, and poor subsidy management. Constraints in fuel supply from various regions, coupled with disputes between importers, marketers, and the government, exacerbate fuel shortage crises in Nigeria.

The implications of fuel scarcity and oil subsidies for Global Value Chains (GVCs) and National Innovation Systems (NIS) in Nigeria are significant and multifaceted. In terms of GVCs, fuel scarcity disrupts the smooth operation of supply chains, particularly those reliant on transportation and logistics. Industries dependent on consistent fuel supply, such as manufacturing and agriculture, may face increased operational costs, delays in production, and challenges in meeting delivery deadlines. This can negatively impact Nigeria's participation in GVCs by reducing efficiency, increasing production costs, and potentially affecting the country's competitiveness in global markets (Osunmuyiwa & Kalfagianni, 2017).

For NIS, the issue of oil subsidies diverts significant financial resources that could otherwise be invested in innovation and technological advancements across various sectors, including energy. Subsidies often distort market signals and discourage private sector investments in alternative energy sources and efficiency measures. This can hinder the development of indigenous technological capabilities and innovations within Nigeria's energy sector, limiting the country's ability to achieve sustainable energy goals and reduce dependency on imported refined petroleum products. Addressing fuel scarcity and reforming oil subsidies is crucial to enhance Nigeria's integration into GVCs by improving supply chain reliability and reducing operational costs. Similarly, reforming subsidies can unlock resources for investment in NIS, fostering innovation, and technological advancements that are essential for sustainable economic growth and energy security in Nigeria.

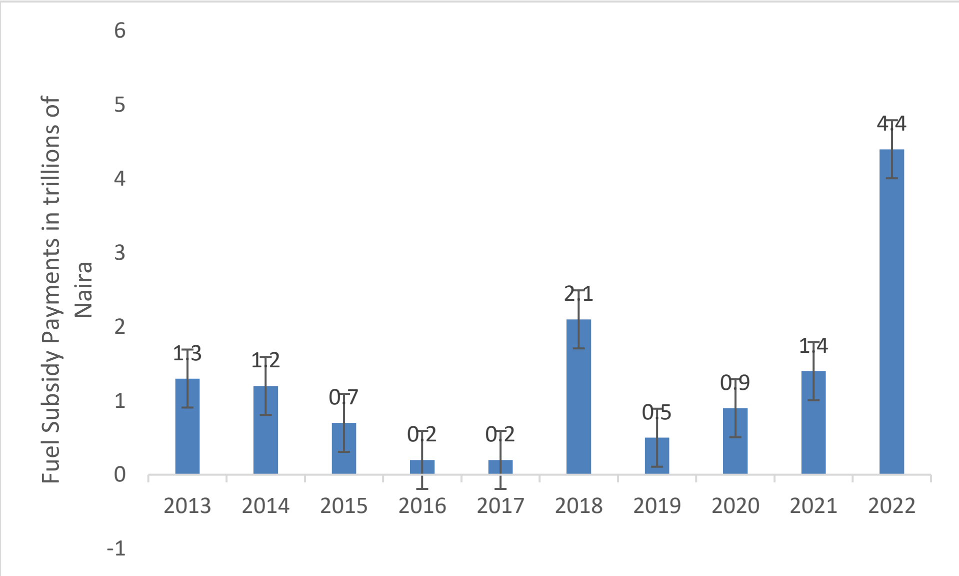

Figure 30: Nigeria's Federal Budget allocated to fuel subsidy 2013-2022

Source: NNPC - NBS (2022)

Figure 30 highlights the annual fuel subsidy expenditure in Nigeria from 2013 to 2022. The data reveals significant fluctuations, with a sharp increase in recent years. The highest expenditure occurred in 2022, reaching 4.4 trillion Naira, while the lowest was in 2016 and 2017, with only 0.2 trillion Naira spent each year. This dramatic rise in subsidy spending, particularly in 2022, highlights the growing fiscal burden on the government. The increase is partly driven by external factors such as rising international oil prices and domestic factors like population growth, which have led to higher consumption of subsidized fuel.

The economic implications of these trends are profound, as a significant portion of the federal budget is being allocated to fuel subsidies, limiting resources for critical sectors such as infrastructure, education, and healthcare. High fuel consumption by public transport, businesses, and government agencies, along with the use of kerosene for domestic purposes, further exacerbates the issue. Additionally, challenges such as corruption, smuggling, theft, and mismanagement continue to plague the subsidy system, potentially inflating costs and undermining the intended benefits. These factors contribute to a complex economic environment where the true financial burden of subsidies may be even greater than reported, Chete et al. (2014).

Subsidies were initially introduced as welfare measures to reduce the cost of consuming fossil fuel. While they offer short-term benefits to consumers, they also have several negative effects. Firstly, they contribute to fiscal imbalances, crowding out other essential government spending. Secondly, subsidies encourage excessive fossil fuel consumption, leading to increased carbon dioxide emissions. Additionally, low oil prices spurred by subsidies promote the development of energy-intensive sectors while discouraging investment in renewable energy sources. Despite these negative consequences, removing fossil fuel subsidies in Nigeria has proven challenging due to the initial intent to improve consumer welfare. Proposals to eliminate these subsidies often lead to public protests, as seen in past instances. Experts argue that removing subsidies could benefit the country by allowing it to sell oil in international market at higher prices, thereby improving overall welfare (McCulloch et al., 2021).

Comparing the expense of fuel subsidies with federal government allocations to other critical sectors reveals a significant disparity. Between 2020 and 2022, fuel subsidies accounted for about 90% of Nigeria's combined health and education expenses. Furthermore, the top 20% of households receive twice as much subsidy benefit as the lower-income population. The continuation of subsidies poses threats to the downstream oil sector and encourages smuggling to neighboring countries where fuel prices are higher. While many observers advocate for subsidy removal, concerns about potential economic fragility persist. Removing subsidies could lead to inflation, reduced economic welfare, disrupted economic growth, and decreased household incomes, making firms less competitive and increasing unemployment. Nonetheless, protecting the most vulnerable populations remains a critical consideration. In the 2021 budget, fuel subsidies held the largest share at 11.5%, followed by the Ministry of Defense at 7%, while education and health received 4.2% and 6.2%, respectively (Abdul-Baki et al., 2021).

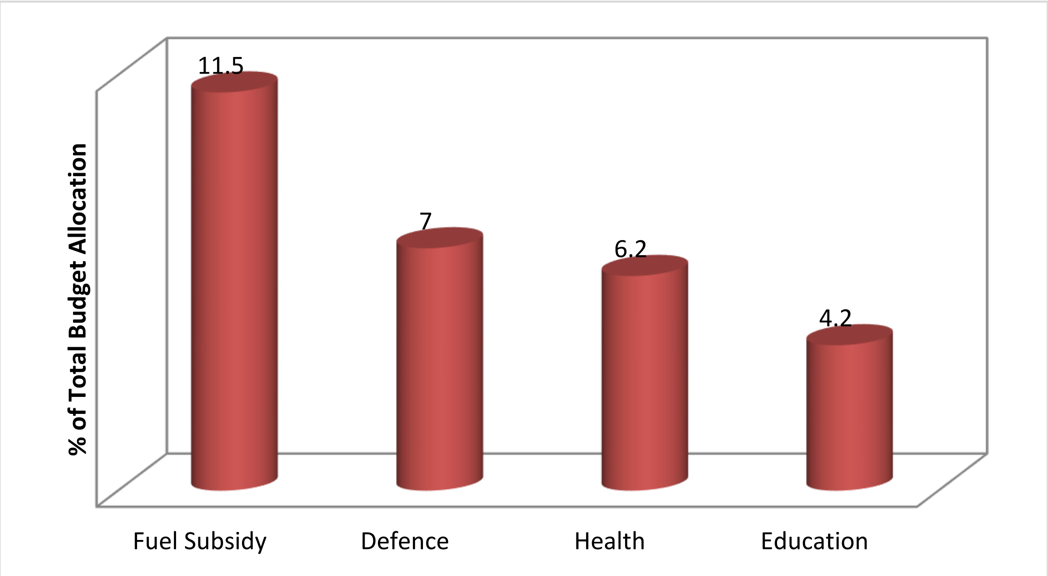

Figure 31: Fuel subsidy & other sectors' Allocation 2013-2021

Source: Own Elaboration

5.5.5. The two-way oil trading: Export, Import and Impacts

Oil and gas trading has significantly grown in Nigeria over the past decades, becoming a cornerstone of the nation's economy. However, fluctuations in the value of petroleum trading have impacted various macroeconomic variables, including employment, GDP, and income levels. Many studies have reported that oil exports play a crucial role in the economic development and foreign policies of Resource-Rich Countries (RRCs). In Nigeria, a substantial portion of export trade comes from petroleum, and increases in crude oil production and export have been linked to boosts in the country's economic performance and government revenue. Conversely, high levels of petroleum imports have been noted to reduce Nigeria’s revenue potent.

Despite efforts to increase oil exports and reduce imports for profit and self-sufficiency, Nigeria remains heavily dependent on imported refined oil products due to inadequate domestic refining capacity. The four domestic refineries can barely refine 20% of local consumption needs. This dependency on imports, which averages $28 billion USD annually, has led to substantial expenditures that exceed crude oil export revenues, negatively affecting the country's balance of trade and economic stability (Abdul-Baki et al., 2021).

In Nigeria, oil exports have subjected supplier firms, including NNPC, to intense international competition, motivating them to become more efficient and cost-effective Xiaoqing, (2023). Recent theoretical models propose that profits from crude oil can be linked to offshoring, facilitated by technology changes that enhance productivity (Álvarez et al., 2018). Digital oil fields, reductions in trade costs, and the rise of ICT co-creation hubs have significantly expanded the scope of tasks that can be offshored. This trend has allowed oil multinationals and related firms to focus on specialized tasks where they have core competencies, while offshoring other tasks, thus making specialized labor a factor in oil export competition (Murat et al., 2018).

Experts have long recommended that Nigeria should refine its crude oil domestically to meet local demands, save foreign exchange, and enhance economic diversification. However, challenges related to cost, technology, and expertise continue to impede progress in the refining sector. The general belief is that domestic refining could potentially eliminate the need for petrol subsidies and lower market prices, but Nigeria currently imports most of its refined oil products (Ogbuigwe, 2018b). This situation has led to significant expenditures on petroleum imports, which exceeded crude oil export revenues by $43.56 billion USD in 2020.

Overall, Nigeria's oil industry significantly impacts both global value chains (GVC) and national innovation systems (NIS). As a major crude oil exporter, Nigeria's integration into GVCs influences global energy supply and pricing. However, the country's reliance on imported refined petroleum products, due to inadequate local refining capacity, creates trade imbalances and limits the value derived from its resources. Enhancing local refining capabilities and addressing operational inefficiencies can improve Nigeria's position within GVCs, reduce dependence on imports, and create more value domestically. Additionally, the oil sector's need for advanced technologies and skilled labor highlights the importance of innovation and human capital development within Nigeria.

5.6. NIGERIA OIL INDUSTRY GVC PARTICIPATION & TRADE IN VALUE-ADDED (TIVA)

Nigeria's participation in global value chains (GVCs), measured through Trade in Value-Added (TiVA), highlights the country's role and the contributions of its industries within the global production network. This section focuses on Nigeria's GVC participation in the petroleum sector, aiming to assess the level of its integration into the global production network. The analysis covers the industry's involvement across various stages of the value chain, from upstream activities like exploration and production, to downstream processes such as refining, distribution, and marketing.

Trade in Value-Added (TiVA) is used to measure the contribution of both domestic and foreign value-added to Nigeria's exports and imports, providing deeper insights into the country's integration into global value chains. Unlike traditional metrics that focus on gross exports, TiVA captures the value added at each stage of production, giving a more comprehensive understanding of Nigeria's role in global oil trade.

This section also addresses the paradox of Nigeria as a net exporter of crude oil while also a net importer of refined fuel**.** By examining both backward and forward participation in GVCs, alongside total GVC participation, we will better understand the distribution of value-added in Nigeria's oil industry and its role in the global market. This approach will help clarify the extent of domestic value addition, the role of foreign inputs, and potential opportunities for **diversification** and greater value capture within the oil sector.

5.6.1. Measurement of Nigeria GVC Participation Using TiVA

The measurement of Nigeria's participation in Global Value Chains (GVCs) is based on data from the OECD TiVA database of 2023**,** with Figures 32-34 illustrating Nigeria's overall GVC participation, as well as its backward and forward linkages from 1995 to 2020. These visual representations provide a clear picture of Nigeria's engagement in GVCs over time, focusing particularly on its role in the petroleum sector.
Two key sectors were selected for this analysis:

(i) Mining, quarrying, crude and energy
(ii) Coke and refined petroleum products

These sectors were chosen due to their significance in the broader extractive industry and their relevance to Nigeria's economic development in petroleum. To comprehensively assess Nigeria's integration into global value chains, three primary calculations were performed:

(i) Total Global Petroleum Value Chain (GPVC) Participation**:** This assesses Nigeria's overall involvement in global value chains across the petroleum sector. It quantifies Nigeria's participation in both upstream (exploration and production) and downstream (refining, distribution, and marketing) activities, reflecting the country's role in international trade within the oil industry.
(ii) Backward GVC Participation**:** This measures Nigeria's reliance on foreign inputs in upstream activities such as extraction, production, and the initial phases of the

petroleum supply chain. It evaluates the extent to which foreign technologies, materials, and services contribute to Nigeria's export activities.

(iii) Forward GVC Participation: This evaluates Nigeria's contribution to downstream activities, such as refining, marketing, and distribution, within global value chains. It reflects the domestic value added to Nigeria's exports that other countries use in their own production processes.

Measuring both backward and forward linkages provides critical insights into Nigeria's position within global value chains, showing the country's role in adding value at different stages of the petroleum production process. This analysis is particularly significant for addressing the research question regarding Nigeria's status as a major exporter of crude oil yet an importer of refined petroleum products. By evaluating Nigeria's GVC participation, we aim to uncover the factors driving this paradox and thereafter highlight opportunities for strengthening the country's role in the petroleum value chains. Also, this analysis can guide policymakers and stakeholders in identifying strategies to improve Nigeria's competitiveness, enhance supply chain resilience, and strengthen the National Innovation System (NIS).

The formula for measuring Global Petroleum Value Chain (GPVC) participation is:

$$GPVC = \frac{FVA + DVX}{\text{Gross Exports}}$$

This formula calculates a country's GVC participation by combining two key indicators:

(i) Foreign Value Added (FVA): This represents the value of imported components or materials used in the country's exports. It represents "backward participation" because it shows how much the country relies on foreign input to produce its exports.

(ii) Domestic Value Added (DVX): This measures the value of the country's exports that are used as inputs by other countries to produce their own export goods. It represents "forward participation" because it shows how much the country's exports contribute to other countries' production processes.

By adding FVA and DVX and dividing by Gross Exports, the formula provides a ratio indicating the level of participation in the global petroleum value chains. To delve deeper into Nigeria's integration in global petroleum value chain, we now examine the Total Global Petroleum Value Chain (GPVC) Participation**.** This analysis covers data from 1995 to 2020, providing a comprehensive view of how Nigeria's involvement in GVCs has shifted over time. This assessment provides a comprehensive overview of how Nigeria's involvement in the GVC has evolved over time, reflecting both progress and challenges within the petroleum sector:

(i) The Nigerian GPVC Total Participation:

Using data from 1995 to 2020**,** Figure 32 shows that Nigeria's total GPVC participation peaked at 44% in both 2014 and 2020, representing the highest levels of integration during this 25-year

period. However, the country experienced a decline to 40% in 2015 and 38% in 2016, reflecting the impact of global economic crises and external shocks on the sector. A recovery was noted in 2018, with participation rebounding to 42%.
However, the earliest recorded participation was 26% in 1995, marking the initial year of analysis. The general trend shows fluctuating participation. The total GVC participation experienced slight increases and declines over the 25-year period, indicating the dynamic and variable nature of Nigeria's integration into global value chains. These fluctuations are likely influenced by both external factors (e.g., global market conditions, foreign demand) and domestic factors (e.g., production capacity, technological investment, policy changes).

Overall, the fluctuation in GVC participation over time illustrates Nigeria's evolving role in global trade. The peaks and troughs suggest periods of high and low engagement in GVCs, depending on external economic conditions and domestic economic policies. While the peaks in 2014 and 2020, and the decline in 2015-2016, likely correspond with changes in global oil prices and economic factors, the peak in 2020, may also be attributed to changes during the COVID-19 pandemic, where oil markets experienced significant volatility, and countries like Nigeria saw shifts in demand for exports. Generally, the total GVC participation can be judged vulnerable due to the country's reliance on oil and limited value-added activities directly impact its GVC participation. Improving total GVC participation will require greater diversification of exports, reduced reliance on raw material exports, and increased domestic value addition in key sectors like refining and manufacturing. This will help Nigeria achieve a more stable and sustainable presence in global value chains.

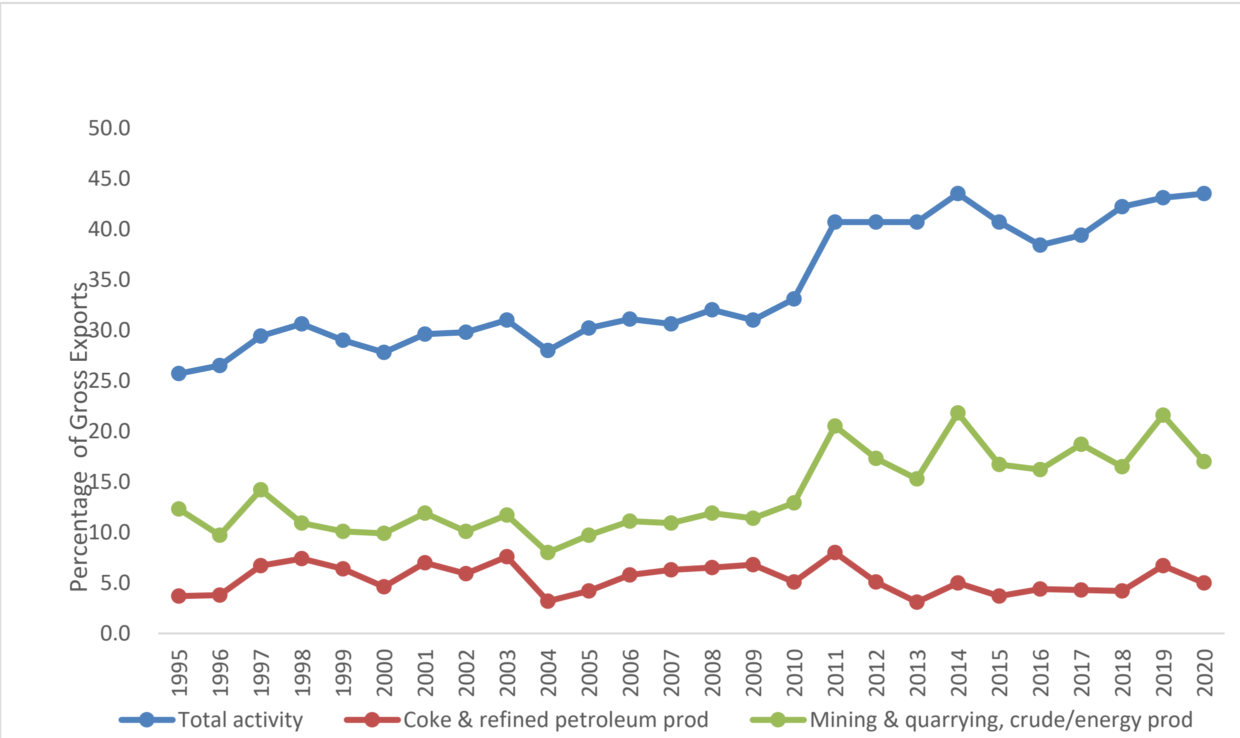

Figure 32: Total GVC Participation Analysis 1995-2020

Source: Own Elaboration from OECD. (2023)

(ii) Nigerian Backward GVC Participation: This represents the percentage of foreign inputs used to produce crude oil and other petroleum products for exports. The analysis focuses on economic activities within mining, quarrying, and energy production, including coke and refined petroleum products, within the context of the country's gross exports from 1995 to 2020.

Figure 33 shows that Nigeria's oil sector relied on a minimal quantity of foreign value-added components for its petroleum production and exports, peaking at 9.4% in 2011 before sharply declining to 2.5% in 2013 and 4.9% in 2015. This decline, amidst negative global oil prices and economic crises, contributed to the country's first recession in over two decades. Despite a rebound to 9.7% in 2019, the GVC participation decreased again to 4.2% in 2020, indicating fluctuating dynamics and emphasizing the sector's vulnerability to external shocks. These fluctuations tend to reflect various factors influencing the Nigerian oil sector, including changes in global oil market conditions, shifts in production technologies and practices, and domestic policy interventions.

The Backward GVC shows that a lower percentage of foreign input is utilized for the extraction and production of crude oil for exports, thus indicating a higher level of domestic contribution to the production process. This would mean that Nigeria relies less on foreign inputs and contributes more domestically at the primary level for export. This is consistent with its position as a major oil producer. However, this also highlights a challenge for Nigeria, as it shows limited value addition in the oil sector. While the country excels at producing crude oil, it relies heavily on exporting raw materials without significant engagement in downstream activities such as refining or petrochemical production. Increasing its forward GVC participation by refining more oil domestically and producing value-added products like gasoline or petrochemicals could help Nigeria capture more value from the global oil market and reduce its reliance on imported refined oil, thus enhancing overall economic growth.

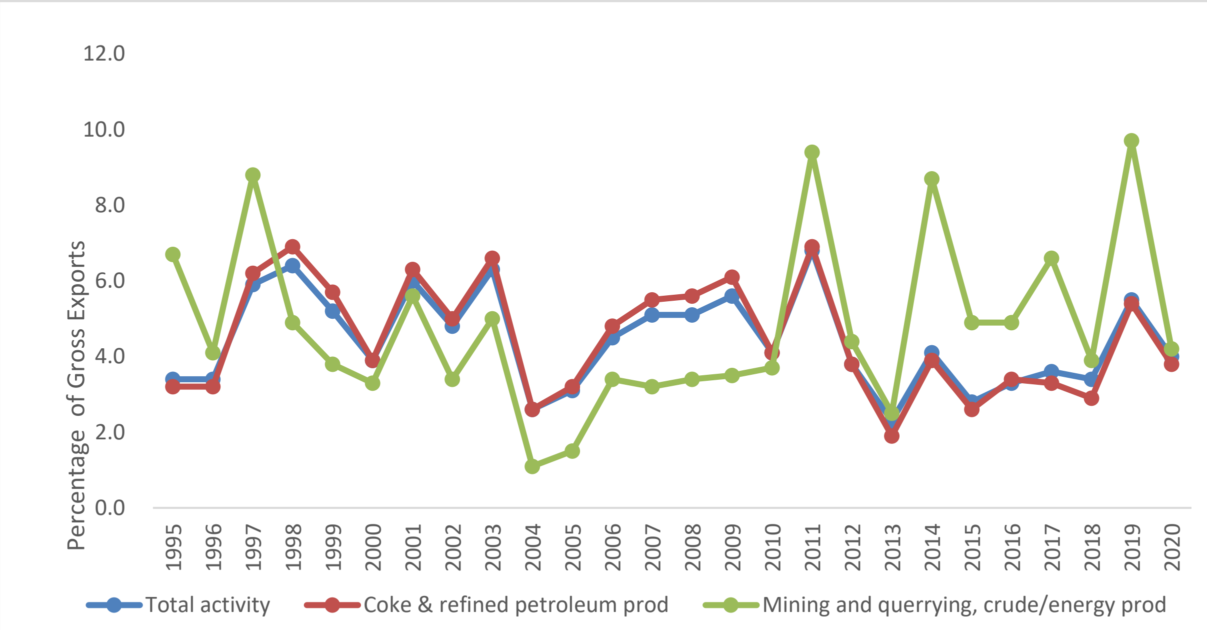

Figure 33: Backward GVC Participation

Own Elaboration from OECD. (2023)

However, despite the country's significant primary production contribution, challenges such as infrastructure deficiencies, operational inefficiencies, and reliance on imported technologies have been noted in literature, particularly by sources like the International Monetary Fund (IMF) and Ogbuigwe (2018). These fluctuations tend to reflect various factors influencing the Nigerian oil sector, including changes in global oil market conditions, shifts in production technologies and practices, and domestic policy interventions. These factors underscore the paradox of Nigeria being a net crude oil exporter but a net importer of refined fuel, emphasizing the urgent need for investments and improvements in downstream capabilities to address these challenges and unlock the full potential of the country's oil sector.

(iii) Nigeria Forward GVC Participation

In Nigeria, this type of participation involves the later stages of the petroleum production process, closer to the final consumer. It typically involves activities such as refining, branding, marketing, and distribution of petroleum products to end consumers. This would allow the country to capture more value-added in the downstream stages of the oil supply chain, beyond just extraction and production. It serves as an alternative approach to the backward perspective, implying that the forward-looking approach is the share of domestic value-added driven by foreign demand. In this computation, it tends to have little or no significant economic activities as depicted from the red legend in figure 34.

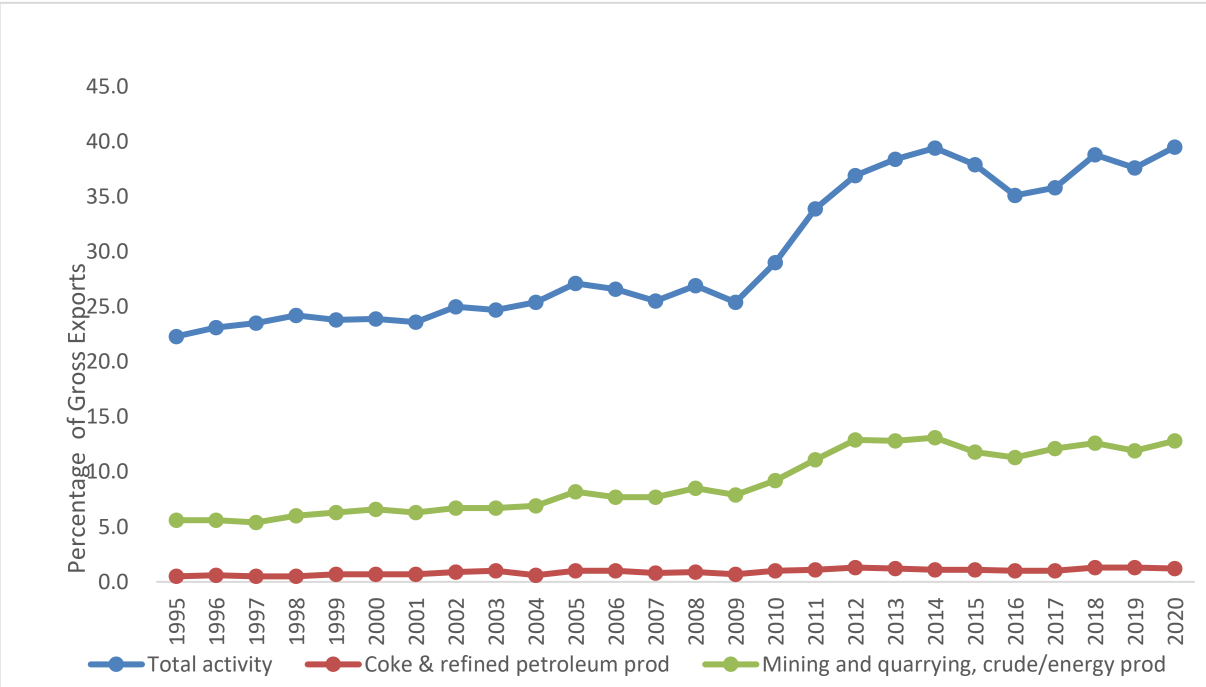

Figure 34: Forward GVC Participation

Own Elaboration from OECD. (2023)

Figure 34 represents the forward GVC participation of the country between 1995-2020. The sectoral indicators are the same as those of the backward GVC. Nigeria's Forward GVC participation refer to the share of domestic value-added in intermediate exports that are further re-exported to third countries. In this context the data shows the role in the downstream stages of the oil production process, where its exports act as inputs in the production of goods or services in other countries.

The data analysis reveals a consistently minimal contribution over the 25-year review period, with both the mining and quarrying sector and the refining sub-sector within the downstream sectors showing proportions ranging from 5.6% to 13%. Similarly, the coke and refining sub-sector fluctuates between 0.5% and 1.3%, representing the minimum and maximum thresholds. These findings suggest a lack of significant technological expansion, low competitiveness, and a diminished capacity for Nigeria to add substantial value to its raw crude oil products through forward linkages.

The measures further reveal Nigeria's robust backward GVC participation, particularly evident in the significant volume of crude oil exported as a primary product. However, the data also underscores a substantial reliance on imports for refined petroleum products, indicating a notable lack of specialization in the refined petroleum sector. This pattern confirms weaknesses in trade infrastructure connectivity and the knowledge ecosystem, highlighting deficiencies in institutional features such as policies and infrastructure quality (Leo, 2022). Furthermore, Chapter 6 provides supporting data indicating weaknesses in Nigeria's National Innovation System (NIS), which further contributes to the challenges faced in improving participation in the global oil value chains.

(iv)Nigeria Comparative Foreign Value-Added Assessment

Introducing a comparative analysis of foreign value-added content in gross exports involving Nigeria and other global regions also offer insights into Nigeria's position in the global trade landscape. This examination delves into the extent of Nigeria's integration into global value chains, contrasting its performance with that of prominent regions worldwide. Figure 35 provides the breakdown of Nigeria's contributions across different stages of production, compared to those of other countries/regions such as the EU 27, OECD, and G20.

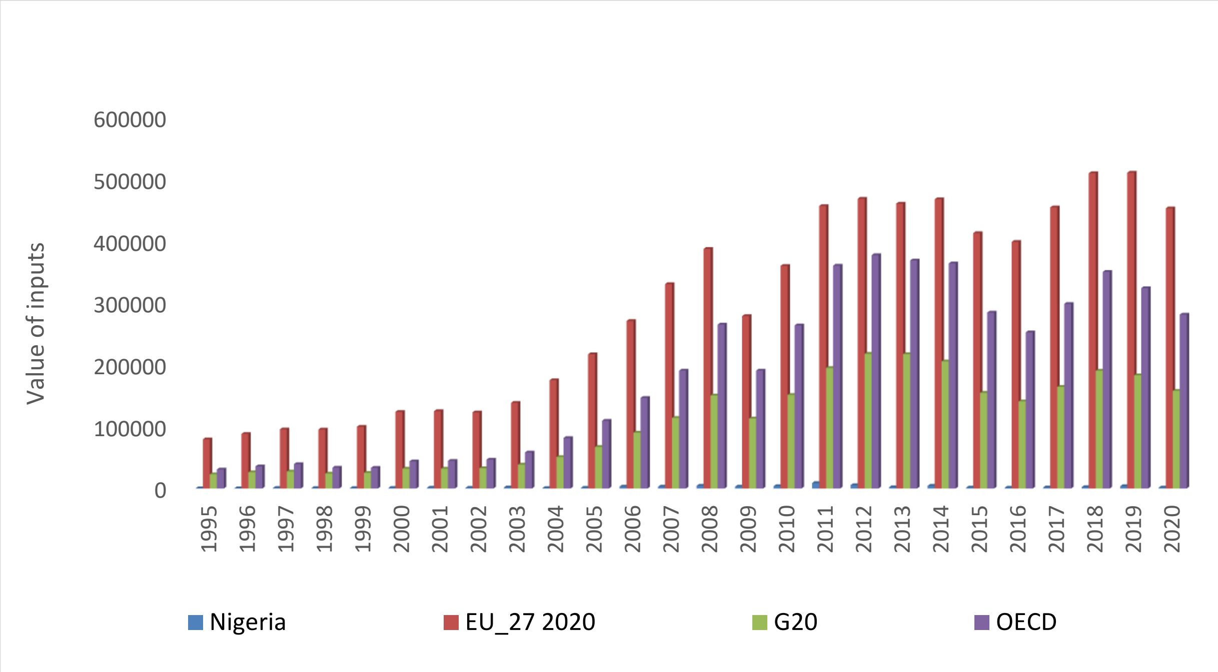

Figure 35: Comparing Nigeria with Other Regions 1995-2020

Own Elaboration from OECD. (2023)

Figure 35 shows how much value is added by Nigeria or other countries/regions in the production of goods and services that are eventually consumed globally. In this context, the data highlights Nigeria's relatively low foreign content in exports, reflecting a significant aspect of the country's economic structure. It also reveals a decrease in the foreign content of Nigeria's exports from 5.1% in 2008 to 4% in 2020, which is substantially below the OECD average of 26.7%**.** This low percentage predominantly pertains to Nigeria's crude oil and petroleum products**,** which are major exports.

This indicates that Nigeria's exports, particularly crude oil, rely less on foreign inputs compared to other regions. While regions like the EU 27 and the broader OECD countries integrate higher proportions of foreign components into their production, Nigeria's exports involve a smaller share of international inputs. This scenario underscores Nigeria's more self-reliant approach in the production of its primary exports but also points to a relatively weaker integration into global value chains.

The low foreign content of Nigeria's exports suggests that while the country is a major exporter of raw materials, such as crude oil, it is less embedded in the international network of value-added production. This reflects both a strength in maintaining domestic control over its resources and a limitation in terms of global value chain integration, highlighting areas for potential growth and diversification in Nigeria's economic strategy. This deficiency according to Hammoudeh et al. (2023) is underscored by inadequate institutional features, including policies and infrastructures which hinder Nigeria's full integration into GVCs, thus limiting its ability to sufficiently leverage global trade opportunities for economic growth. This finding also addresses the question on why Nigeria is both a crude oil exporter and a net importer of refined oil. It sheds light on the distinctive nature of value-added activities in Nigeria's petroleum sector, a key element within the global value chain framework, and aligns with the first research question on "why Nigeria is a net exporter of crude oil while also being a net importer of refined oil".

In general, this section, through the Trade in Value-Added (TiVA) analysis, addresses Objective 1 by examining Nigeria's participation in global value chains (GVCs) and its implications for the country's economic positioning. Despite being a major crude oil exporter, Nigeria's GVC involvement is primarily characterized by backward participation, indicating reliance on foreign inputs such as machinery, technology, and technical expertise for oil production. Conversely, forward GVC participation is minimal, reflecting weak engagement in downstream activities such as refining, branding, and marketing.

Although Nigeria's total GVC participation peaked at 44% in both 2014 and 2020, it remains below the levels observed in regions like the EU and OECD**.** These findings highlight Nigeria's ability to retain control over its natural resources but also expose its limited integration into global production networks**.** The TiVA analysis provides a deeper understanding of these trends, emphasizing the need for strategic interventions to strengthen forward linkages, enhance domestic value addition, and improve Nigeria's overall position in GVCs.

5.6.2. Obstacles to GVCs Participation in Nigeria

Exploring the impediments to Nigeria's integration into global value chains sheds light on critical barriers affecting the nation's economic engagement on the international stage. This examination delves into the multifaceted challenges hindering Nigeria's participation in global value chains, thus, offering insights into the complexities faced by the country's economic terrain.

In contextualizing these impediments within Nigeria's economic landscape, Galadima (2019) recounts that the Nigerian economy experienced a modest recovery after the IMF's endorsement in 2018 but faced a decline afterwards. Aimed at rectifying macroeconomic imbalances, the exchange rate system and currency devaluation provided some benefits, such as improved export competitiveness. Despite these efforts, the nation continues to grapple with structural barriers that hinder its effective participation in global value chains.

Nigeria's primary exports include crude oil and gas, supplemented by commodities like cocoa, rubber, antiques, boats, timber, and food waste. Nearly half of active trading firms cite customs and trade regulations as significant hurdles. The World Bank's Doing Business report ranks Nigeria relatively low, placing it at 179 out of 190 countries in the "Trading across Borders" category in 2019. Trading firms face exorbitant costs and protracted procedures related to customs and document compliance, resulting in only about ten percent of Nigerian firms actively engaging in both importing and exporting activities. This contributes to a lower rating of the national innovation system, as reported by the National Center for Technology Management - NACETEM (2021).

In addition to these economic challenges, Nigeria faces limitations in its downstream oil sector, including limited refining capacity, infrastructure constraints, heavy dependence on foreign technologies, and subdued market competitiveness (Edeh et al., 2020). Furthermore, environmental and social concerns loom large, as the oil industry's impact on local communities and ecosystems remains a pressing issue. These factors exacerbate the challenges faced by Nigerian businesses, hindering their ability to fully participate in global value chains and tapping into the full potential of the country's abundant natural resources.

Strengthening Global Value Chain (GVC) integration therefore requires a robust National Innovation System (NIS) supported by policies facilitating improved access to foreign inputs and efficient export processes for firms. The existing complexity of regulatory frameworks and the economic dichotomy between importing firms and those operating in the domestic market seemingly creates a challenging environment that leads to diverse supply chains constraint among firms. This is reinforced by unfair competition, the significant presence of state-owned enterprises and a sizable informal sector within the economy. Furthermore, the scarcity of qualified labor due to the shortage of vocational training schools, a lack of alignment to international standards coupled with inadequate quality control and brain drain tends to reduce the opportunities for firms to enter new value chains, upgrade along existing value chains and to benefit from the vast market access and particularly, the preferential crude oil market.

5.7. OIL INDUSTRY & STAKEHOLDERS

Having examined the various obstacles that hinder Nigeria's integration into global value chains, it is crucial to explore the role of the oil industry and its stakeholders. Understanding the dynamics between the industry and its stakeholders provides insight into how these challenges are navigated and the potential pathways for overcoming them. This section will delve into the key players in Nigeria’s oil sector, including government bodies, private companies, and local communities, and analyze their roles, interactions, and impact on the country's economic and strategic positioning within the global value chains.

Nigeria's oil industry holds an institutional characteristic of being a major player in the domestic energy market, while also exerting influence in the global economy. The country's rich natural resources grant it a rentier status akin to other oil and gas export-dependent nations in the Middle East and North America (Rui et al., 2018). However, unlike the Arab and Gulf States, Nigeria is often characterized by modern political economists as having a fragmented political structure, impacting its oil sector and stakeholders.

The critical actors with stakes in the Nigerian oil industry include the state-owned NNPC, International Oil Companies (IOCs), local oil firms, organized labor, regions, host communities, and government. While the major stakeholders in the oil trade are typically the direct operators influencing supplies, they are also described by some sources as including state-owned companies, intergovernmental organizations, and major petroleum investors.

(i)Lead Firms

Lead firms in the petroleum typically large multinational corporations (MNCs), wield significant control over various stages of oil production and distribution in Nigeria. Their influence extends over smaller domestic firms and shapes global market dynamics. Multinational oil companies play a pivotal role in spearheading exploration, production and trade activities, driving growth and development in Nigeria's petroleum sector. Their expertise, resources, and technologies enable them to access new markets, enhance production efficiencies, and foster innovation, thus shaping the global oil landscape. As oil supplants agriculture as Nigeria's primary economic driver, it generates substantial foreign earnings and revenue.

The country has reaped significant benefits from the roles played by lead firms, including increased global trade opportunities and substantial earnings from petroleum exports, driving productivity growth, job creation, and improved living standards. Moreover, the importation of skills and technology has facilitated greater participation in global petroleum value chains (GPVC). Regions engaged in it experience accelerated poverty reduction compared to non-participating regions (Bolea et al., 2022). While Nigeria has adopted modern drilling and exploration technologies, particularly in the upstream sector, and specialization has bolstered competitiveness and attracted investments from major global oil corporations, challenges persist in the downstream sub-sectors.

Also, despite the revenue and other contributions from oil companies through larger royalties, higher taxes, and unilateral pricing agreements, that tends to benefit indigenous oil operators like the NNPC, significant social and environmental concerns prevail. This includes the challenges related to environmental degradation, community displacement, conflicts and health hazards.

In addition, the analysis from current literature suggests that most of the lead firms' role in Nigeria's crude oil trade are influenced by the relative strengths and interests of market participants, particularly in response to intensified control efforts by importing countries. Although this relationship has established a connection between the oil importing countries, Nigeria, and the multinational oil companies, Olujobi (2017) reveals that there are drawbacks associated with the involvement of these links. These risks include profit repatriation, increased environmental costs, competition for skilled labor resulting in challenges for local oil firms, and concerns regarding labor rights and human rights, as well as environmental impacts. Additionally, the focus on one-way raw material production (primary production) presents significant challenges hence the need for at least institutional economic diversification. These issues underscore the complex relationship between the lead firms and the Nigeria's oil industry. Balancing these concerns with economic imperatives remains a key challenge for policymakers and industry stakeholders.

(ii)International Oil Companies (IOCs)

The IOCs are large, multinational corporations that operate in the oil and gas industry across different countries around the world. They typically engage in various activities such as exploration, production, refining, and marketing of petroleum products. Examples of IOCs include ExxonMobil, Shell, Chevron, Total, and Bp. In Nigeria today, the upstream oil and gas sector is highly technology-driven and is largely dominated by International Oil Companies which some also play the role of MNCs such as: Shell, Chevron, Mobil, AGIP oil Company, Addax and Total Oil Company. The distinction between International Oil Companies (IOCs) and Multinational Corporations (MNCs) lies in their primary focus and operations. While MNCs encompass a broader spectrum of industries and sectors beyond oil, IOCs particularly specialize in the exploration, production, and distribution of oil and gas resources. Currently, IOCs exert significant dominance in Nigeria's oil industry, contributing to over 80% of the country's crude oil production, operating assets and reserves (Andrew & Baker, 2020). Their activities are facilitated through various contractual arrangements, including Joint Ventures (JVs) and Production Sharing Contracts (PSCs) with the Nigerian National Petroleum Corporation (NNPC). Other contractual arrangements include sole risk contracts and major service contracts conditioned by the number of oil wells and technical service quality provision/s. However, in the past 10 years, oil production activities by IOCs have shrunk by an annual average of 4%, while marginal field players have increased production by up to a 15% annual growth rate.

There are about 100 oil firms in Nigeria and out of these, the most prominent are six. They include Shell Petroleum Development Company, ExxonMobil, Chevron Oil, Total Oil Nigeria, AGIP and Addax Oil. Generally, the upstream sector is dominated by International Oil Companies (IOCs) which also hold about 90% of the total oil reserves and other operating assets. Total Oil Cooperation currently occupies the largest share of the oil industry and accounts for 80% of the country’s crude oil production according to industry data. The activities of the industry are carried out under various related arrangements and guidelines including the joint venture and production sharing contracts. Other stakeholders within the Nigerian oil trade that play crucial roles include the NNPC, IOCs, and host communities. Their specific duties are discussed as follows:

(iii) The Nigeria National Petroleum Cooperation (NNPC)

NNPC is the state-owned oil company in Nigeria. The corporation plays a central role in the Nigerian oil trade by overseeing the exploration, production, refining, and distribution of petroleum products in the country. It also manages partnerships with international oil companies, regulates the industry, and represents Nigeria's interests in global oil market. It operates as a major joint venture partnerships in the Nigerian oil industry, involving Shell, Total, and AGIP. This joint venture primarily operates onshore in Nigeria, focusing on land-based oil exploration, production, and other related activities. The agreement allows NNPC to own 55%, Shell Petroleum Development Company (also known as Shell Nigeria) 30%, Total 10% and AGIP 5% to operate on land and swampy area of the oil basin in the Niger-Delta region of Nigeria. However, the joint venture Agreement (JVA) involving cash calls were the prevailing type of Agreement until 2018 when a different arrangement was introduced to unbundle the Corporation. In this new agreement, known as “NNPC Unbundling Contract Agreement”, the foreign companies are no longer concessionaires but contractors to NNPC. In return, both parties were allowed to raise capital to finance oil operations on their own separate accord hence certain agreed percentage was allowed for the contractors to lift certain proportion of oil discovered at a price halfway between the standardized and realizable pricing structure. The agreement was signed between the Federal Government of Nigeria through the then

Minister of State for Petroleum Resource Mr. Ibe Kachikwu and Shell, AGIP, Chevron, Oando and Total (Olujobi, 2017).

Further propositions remarked that the agreement on incremental oil production of 2.2 million barrels per day, royalties, amortization, petroleum operating tax and others would not be affected. However, the management of the new set up board according to the Managing Director of the Corporation, (Abba Kyari), is not different from the former except on cash call and new oil well discovery matters. Also, under mutual agreement between the parties, one-half of the total oil discovered in any new oil field was allocated to the national reserve. Also, commercial oil fields are based on realized prices where there is a discounted value of not less than 20% on the present worth of 25 years cumulative production valued at the applicable realized term after production thus allowing foreign partners to get relatively smaller amount of the crude oil produced in the new JVC agreement. For NNPC, the availability of such known reserve kitty was an encouragement as it allows more active marketing role between NNPC and buyer countries under OPEC regulatory price (Wang et al., 2022). Besides, the agreement process was also aimed at providing opportunities for qualified personnel at the NNPC to display talent and experience as well as create employment with the national content ambit. However, whether the opportunity is fully utilized by NNPC to learn remains a puzzle to be examined, especially with the increase in the amount of petroleum product imported into the country in recent times.

(iv) Shell Petroleum Development Company (SPDC)

Shell is a significant stakeholder in the Nigerian oil industry, playing a crucial role in various aspects of the sector. As one of the major multinational oil companies operating in Nigeria, the company is involved in upstream exploration and production activities, as well as downstream operations such as refining and marketing of petroleum products.

Shell commenced business in Nigeria in 1937 as Shell D'arcy after being granted exploration license in 1936. The Company discovered the first commercial oil field in "Oloibiri" the Niger-Delta region of the country in 1956 and began oil exports from Nigeria in 1958. It currently operates as a holding company which consist of Shell Petroleum Development Company of Nigeria limited, Shell BP, Shell Nigeria exploration Company, Shell Nigeria Gas and Shell Nigeria Oil Production, in a joint venture accounting for 50% of Nigeria's total production with over 900,000 barrels of crude oil per day from more than 80 oil fields since 1979 (Student, 2020). With a network of over 6000 kilometers of pipelines, the Company also has over 87 flow stations, 8 natural gas plant and more than 1000 producing wells. It currently operates 2 coastal export terminals and holds a major stake in the Nigeria's Liquefied Natural Gas Company (NLNG). It is an operator with the onshore Joint Venture family that composes of the NNPC (55%), Shell (30%), Total S. A. (10%) and Eni (5%) of the Oil Company in Nigeria.

Other companies under its subsidiary includes Shell Exploration Company (SNEPCO) established in 1993 for the purpose of operating 2 major offshore fields (Bonga and Bonny fields). As an avenue to support the marketing & distribution of refined products the company operates under the umbrella of Shell Nigeria Oil Products Company (SNOP). It also acts as an operator and technical adviser to the Nigeria's Liquefied Natural Gas Company (NLNG), holds

25.6% share as well as a transmission system Operating Company established under license in 1998.

The company which is known for being the largest oil company in Nigeria is not without blemish. Its non-conformist activities on the issues of environmental degradation especially in the Niger-Delta region, Urhobo, Ogoni and Ijaw in the 1990s, 2001 and 2003 respectively attracts recorded history of the militarization of River State and Delta region in Southern Nigeria as they attempted to enforce their own political agenda (Uduji et al., 2021). Shell has been alleged as being responsible for some of the most significant oil spills in the country and both Nigeria and European courts have held them liable, Nigeria Human Right Council (Ukhurebor et al., 2021).

(v) ExxonMobil

Exxon-Mobil Oil Company is another prominent stakeholder in the Nigerian oil industry, known for its significant presence in upstream exploration and production activities. The company started oil exploration in Nigeria in 1955 under the name Mobil Exploration Incorporated". The company, through a joint venture with NNPC, primarily operates in shallow water operations in Akwa Ibom State, Nigeria. With NNPC owning 60% of the venture and ExxonMobil holding the remaining 40%, this collaboration reflects a partnership between the Nigerian government and a multinational corporation aimed at leveraging the region's hydrocarbon resources for economic development. Basically, the company produces an average of 632,000 barrels of crude oil per day in 100,500 cubic meter space thus making it the 2nd largest oil producer in Nigeria. It holds a 50 % interest in Production Sharing Contract with further offshore plans to increase production to900, 000 in the next 3 years (PIA, 2021.) With its recent offshore discovery of significant crude oil deposits which have the potential of recovering between 500 million -1.0 b (one billion) barrels of oil at the Owowo field offshore, from 3 wells which started in 2017, other oil resource like oil sand tar of over 515 meters have also been discovered. Acknowledging the big catch, Stephen M. Greenlee (President ExxonMobil Exploration Limited) in their end of year annual report pledged to work with partners (Nigerian Government inclusive) to enhance full potential of the field (Graham & Ovadia, 2019). If current trend continues, the company may be overtaking Shell as the largest oil producer in Nigeria within the next 5 years mainly due to its edge in its offshore business and for being away from the strife that Shell is facing onshore.

(vi) AGIP Oil Company

AGIP Oil Company, a subsidiary of the multinational corporation Eni, operates in Nigeria through various joint ventures with the Nigerian National Petroleum Corporation (NNPC) and other partners. Involved in both onshore and offshore oil and gas exploration and production, AGIP significantly contributes to Nigeria's petroleum industry. The company began its operations in Nigeria in 1962 with its wholly owned subsidiary, the Nigeria AGIP Oil Company (NAOC) (Uduji et al., 2021). The joint venture agreement includes 20% AGIP, 60% NNPC, and 20% ConocoPhillips PSC. The group produces an average of 150,000 barrels per day from small onshore fields, operating as a conglomerate under Eni Global Oil Company. Notably, AGIP was the first international oil company to offer the Nigerian government participation in its operations upon any commercial discovery, a strategy adopted by the Federal government in 1973 (Graham & Ovadia, 2019).

Over the years, AGIP's activities have expanded, leading to the establishment of two subsidiaries: AGIP Energy & Natural Resource Company (AENR) in 1980, and Nigeria AGIP Exploration Company (NAE) in 1996, which contribute to the upstream shallow and deep offshore areas, respectively. Additionally, the company has made significant investments in Nigeria's gas and power sectors, holding equity stakes in Nigeria NLNG (10.4%) and Brass LNG Limited (20.8%). AGIP was the first international oil company to invest in an independent power plant project in the country. The company's recent innovative Green-River Project, aimed at promoting food and agriculture in the Niger Delta, has enhanced its standing in Nigeria's oil industry CSR portfolio.

(vii) Total Oil Company (now Chevron):

Total Oil Company is a major multinational oil and gas company that operates in Nigeria through various joint ventures with the Nigerian National Petroleum Corporation (NNPC) and other partners. It also has both onshore and offshore oil and gas exploration and production activities in Nigeria, playing a significant role in the country's petroleum industry. The company operates as a Joint Venture between Texaco and NNPC and has ownership distributed as follows: NNPC holds 60%, Texaco holds 20%, and Chevron holds 20% in the Production Sharing Contract (PSC). The joint venture operates offshore fields and currently produces an average of 60,000 barrels per day, equivalent to 9,500 cubic meters, from five offshore fields in the country.

(viii)Independent & Indigenous Oil marketers

The indigenous independent marketers are local businesses or companies that operate within the petroleum industry in Nigeria without direct ownership or control by multinational corporations. These entities typically engage in activities such as wholesaling, distribution, marketing, and retailing of petroleum products within the domestic market. The Nigerian Petroleum Act of 2021 defines independent marketers as an oil marketer with a least N5.0 million Naira in retail sales of oil and gas product in a year or who does not produce less than 50,000 barrels of oil per day. The number of key independent oil marketers in Nigeria is currently 27. Out of these, the 10 major companies are AYM Shafa Limited, A.A. Rano Nigeria ltd, BOVAS Oil, NIPCO Plc, Rain-oil ltd, Con-oil limited, Prudent Oil, Oriental Oil, Swift Oil and Northwest Petroleum. Aside from the majors, other independent and indigenous oil companies also operate in Nigeria. They include Addax Petroleum, Yinka Oil, Dubri, Consolidated Oil limited and others. NNPC, Shell, ExxonMobil, Total and Elf are also key Nigerian-based petroleum product marketers with dual segments both in marketing and upstream exploration and production (E&P). Independent producers develop more than 80% of the country’s O&G. They account for about 3% of Nigeria’s GDP and they reinvest large sums back into the economy to discover and produce more oil. Overall, the independent oil marketers play crucial role in Nigeria's economy and energy security.

(ix) Host Communities (HCs)

In this context, a community that provides land for oil exploration on a large scale is termed a Host. It could be rural (local farmland), urban (city location) or sub-urban (mix of urban and rural) areas with residents within the petroleum prospecting or drilling areas, often impoverished because of oil exploration and/or production. In Nigeria, the host communities play a significant role as they are directly impacted by oil operations, both positively and negatively. They often expect benefits such as employment opportunities, infrastructure development, and social amenities from oil companies operating in their areas, while also advocating for environmental protection and fair compensation for land use and resources extracted. They are mostly within the Niger-Delta region and are regarded as the most vulnerable.

The oil-rich community in the Niger Delta has many ethnic militants that have been in conflict and violent campaigns against both the government and oil companies over the years. The concerns are often rooted in the history of institutional failures, lack of infrastructural development and environmental degradation and pollution which has resulted in the loss of sources of livelihood, lives as well as health. The lack of organized institutions that can resolve conflicts amicably resulted in the creation of the Oil & Gas Sector Reform Implementation Committee (OGIC) on April 24, 2004, which recommended the restructuring of the sector. Also, the 2008 report of the R. Lukeman-led foundation of what is now called the Petroleum Industry Act (PIA), with a framework of inclusion for the host community group was introduced. This helped to reduce the relational friction in the oil operating environment although not sufficiently satisfactory as the link between government and NIS still exist (Simmons et al., 2018). Ever since, there has been a few notable interventions in host communities ranging from OMPADEC, NDDC, Ministry of Niger-Delta Development Affairs, Amnesty Program and Ogoni cleanup but none seem to generate an efficient masterplan nor implement commitment enough to alleviate the challenges. However, the recent signing of the PIA in August 16, 2021 tends to provide rays of changes as captured in section 240(2) of the Petroleum Industry Act with the provision of 3% settlers benefits and 30% HCs Trust Fund for the frontier basin exploration, a development which tends to show government commitment towards addressing institutional reforms in a long-awaited framework that may provide a foundation upon which a better HCs can be built.

From inception of oil in the country, the Niger-Delta region has been facing numerous challenges associated with the oil industry. These challenges include environmental degradation due to oil spills and gas flaring, social unrest and conflict arising from disputes over resource control and distribution of oil revenue, inadequate infrastructure and social amenities in oil-producing communities, and the marginalization of local populations in the benefits derived from oil extraction. Additionally, there are governance issues such as corruption, lack of transparency, and weak regulatory oversight, which contribute to the inefficient operation of the oil industry in the region. Overall, addressing these challenges requires robust governance structures, effective policy frameworks, and sustainable development initiatives to ensure the equitable and responsible management of the oil resources in the Niger-Delta.

5.7.1. Engaging the Multinationals in Nigeria's Oil Industry

Following the examination of key stakeholders in Nigeria's oil sector, it is essential to understand the role and impact of multinational corporations (MNCs) in this industry. MNCs play a pivotal role in shaping the global oil market, influencing both local and international dynamics. This section will explore how MNCs engage with Nigeria's oil industry, their contributions to the sector, and the implications of their involvement for Nigeria's economic integration and strategic positioning within the global value chains.

Multinational corporations (MNCs) play a critical role in the global oil industry, and their involvement in Nigeria's oil sector is particularly significant. MNCs bring substantial investment, advanced technology, and global expertise, which can enhance the efficiency and scale of oil exploration, production, and refining. Their presence in Nigeria includes major players like ExxonMobil, Shell, and Total, among others. They bring substantial financial resources, which are crucial for the development of large-scale oil projects, including exploration, drilling, and refining. MNCs invest in cutting-edge technology that enhances operational efficiency, safety, and environmental management. Their expertise also contributes to the modernization of Nigeria's oil infrastructure, leading to increased production capacity and improved export quality. Additionally, MNCs facilitate Nigeria's integration into global oil markets by connecting local production with international refineries and consumers, thus positioning the country as a critical player in the global supply chain (Ezeoha et al., 2016).

Risks Associated with MNCs

Despite their significant contributions, MNCs also pose several risks to Nigeria's oil industry. MNCs often prefer Production Sharing Agreements (PSAs) as they guarantee rights to oil reserves, offer opportunities for substantial profits, and ensure predictable tax and regulation regimes. Conversely, the Nigerian government prefers Production Sharing Contracts (PSCs), which guarantee revenue even if oil extraction is not profitable for foreign companies. PSCs are deemed more favorable as they require the government to invest only where oil discovery is economically viable, thus shifting the exploration risk to MNCs. However, this arrangement sometimes leads to concerns about transparency, (Agbonifo, 2023) as many MNCs have faced criticism for a lack of transparency in their operations (Rui et al., 2018).

Nigeria's oil fields and offshore locations, such as the Akpo fields and Famfa OPL Block 216, are primarily operated by foreign companies. These fields, requiring skilled professionals and advanced technology, are often managed by companies like Chevron, Total, ExxonMobil, and Petrobras Oil. Transparency in these operations is frequently questioned (Adunbi, 2020). Securing access to state-controlled commodities like oil is challenging, and the NNPC's accounts have not been public since President Ibrahim Babangida's military rule. The lead operators, consistently profitable, are often complacent in addressing environmental issues. For instance, in Ogoni-Land, Port Harcourt, the Ogoni-Clean-Up Project remains pending after more than two decades (Uduji et al., 2021).

In Nigeria, the Niger-Delta residents and environmental groups have long demanded that companies like Shell, Chevron, ExxonMobil, and Total end their environmental and human rights abuses and improve compensation through adequate revenue distribution channels. The new Petroleum Industry Act (PIA) mandates a 3% payment to host communities for environmental damage, although implementation arrangements remain unclear (Petroleum PIA, 2021). In Corporate Social Responsibility (CSR), there is a lack of partnerships directly addressing host community problems, governance, and democracy issues, with voluntary projects often focusing on basic services with support from churches and NGO.

Despite these interventions, issues of compensation, corruption, and fraud persist among MNCs in Nigeria. Instead of setting up transparency institutions, multinationals often perpetuate rent-seeking and patronage systems. As Davies Ronald (2021) explains, that the violation of rights of oil-producing communities is overwhelming, with collective complacency in operations. Consequently, the benefits of MNCs are often overshadowed by the harm they cause, particularly by locking in economies, as evidenced in many developing countries (Otusanya, 2011).

Summing up, the presence of multinational oil companies in Nigeria poses several risks, including environmental degradation, social unrest, exploitation of local communities, and economic dependency on oil revenues. These issues lead to volatility and vulnerability to global market fluctuations. Additionally, MNCs' influence in shaping national policies and priorities potentially undermines local sovereignty and autonomy, highlighting the need for a more balanced and transparent approach to managing Nigeria's oil resources.

5.7.2. Environmental Risks of MNCs Operations in Nigeria

The operations of Multinational Oil Companies (MNCs) in Nigeria significantly impact the country's environment. With their advanced technological capabilities and substantial financial resources, MNCs tend to dominate the oil sector. This domination, while economically beneficial, has led to significant environmental degradation. Oil spills, gas flaring, and pollution are prevalent, particularly in regions like the Niger Delta, causing extensive harm to local ecosystems and communities.

Despite existing regulatory frameworks, enforcement remains weak, and MNCs often evade accountability for environmental damage from oil and gas operation e risks of environmental damage are present at every level of petroleum activities, including upstream, midstream, and downstream. This leads to issues such as oil spills, habitat destruction, air and water pollution, and deforestation, harming ecosystems, biodiversity, and local communities. One specific aspect is the daily air pollution from drilling, which disrupts wildlife, fuels climate change, and damages community lands. Despite the prevalence of such activities, they are poorly addressed by both the government and MNCs (Ortiz et al., 2022). Since oil discovery, Nigerians have faced significant health issues and fatalities, with the latest major incident occurring on February 3, 2022, when an oil vessel explosion killed seven out of ten crew members. Over the last six years, Nigeria has recorded about 4,919 incidences of oil spillage, as disclosed by Mohammad Abubakar, Nigeria’s current Minister of Environment (MOE Premium Times, July 6, 2021.

Gas flaring is another critical challenge in Nigeria’s oil industry, placing the country as the seventh largest gas flaring nation globally. According to the World Bank, approximately 2 million Nigerians live within four kilometers of flare stacks, facing severe health and environmental risks (Shapiro et al., 2018). This issue, combined with the economic impact of gas flaring, underscores the urgent need for diversified energy strategies.

Recent legal actions have brought attention to the practices of MNCs. For instance, four farmers successfully sued Shell Plc. for damages caused by oil spills in their Niger Delta communities. This landmark ruling by the Court of Appeal of the Hague in 2021 held Shell accountable, ordering compensation and extensive clean-up efforts. This case highlights the long-standing environmental degradation and human rights violations by MNCs in Nigeria.

However, MNCs often blame environmental problems on community sabotage, oil theft, and pipeline vandalism while evading liability for oil spills and operational inefficiencies. Addressing these issues requires robust environmental management practices, transparent reporting, and effective oversight mechanisms to ensure MNCs operate responsibly. Promoting mechanisms to hold MNCs accountable, such as anti-corruption laws and investigative media, can help strengthen industry regulation. But Nigeria's regulatory institutions are often weak, lacking the necessary professionals and skilled employees to enforce laws effectively (Siyanbola, 2016). Enhancing these institutions and promoting transparency in oil production and impacts can help mitigate environmental and social issues associated with MNC operations in Nigeria.

5.8. THE ROLE OF THE STATE IN THE NIGERIAN OIL INDUSTRY

While multinational corporations (MNCs) play a significant role in the development and operation of Nigeria’s oil industry, the state's role is equally crucial in shaping the sector's landscape. The state’s policies, regulations, and oversight mechanisms are essential in governing the interactions between MNCs and local communities, ensuring that the benefits of oil production are maximized while mitigating potential adverse effects.

As the owner of mineral rights, the state grants licenses for exploration and production, often through state-owned entities like the Nigerian National Petroleum Corporation (NNPC). It is also responsible for setting and enforcing policies, laws, and regulations that govern oil operations, including environmental protection, revenue management, and community relations. By implementing and overseeing these regulations, the state ensures that the benefits of oil production are maximized while mitigating potential adverse effects on local communities and the environment. This governance framework is crucial for balancing the interests of multinational corporations (MNCs) with national priorities, fostering sustainable economic development, and ensuring equitable resource management.

As a revenue generator, the state collects taxes, royalties, and other revenues from oil activities, which contribute significantly to government budgets and national development initiatives. However, challenges such as corruption, weak governance, and conflicts over resource control have complicated the state's role in effectively managing the oil sector and ensuring equitable benefits for all stakeholders. The citation from (Ogbuigwe, 2018) highlights the historical involvement of the Nigerian State in the petroleum sector as exemplified by the Nigerian National Petroleum Corporation (NNPC). This strong government presence underscores the significant role of state-owned entities in managing and regulating oil activities in Nigeria.

Linking the state with a brief history of the NNPC, underscores the significant role of government in the Nigerian petroleum sector through the establishment and operation of the Nigerian National Petroleum Corporation (NNPC). The NNPC was established in 1977 by a special Act, granting it autonomy as an oil corporation, after evolving from the Nigerian National Oil Company (NNOC) under Decree 18 of 1971. Initially a refining company, the NNPC operated with professionals predominantly from the private sector, overseen by a board appointed by the government, including professionals and a representative from the Ministry of Finance Incorporated (MOFI).

MOFI is the investment arm of the government and hence has an eye for profitability and efficiency. The Minister of Petroleum was the Chairman of the Board. Thus, the establishment was allowed autonomy to run its affairs, maintain assets and government investments to a large degree without political interference, except to obtain approvals as needed from time to time from the Minister of Petroleum. The Petroleum Act confers on the Minister the necessary authority to exercise these powers. Under this arrangement, capacity utilization by the Refineries is the same as existing elsewhere in the world, maintenance was carried out in a timely fashion, and all operating and maintenance costs and expenses (including staff salaries and benefits) were met without recourse to the Federation account. As a separate legal entity, the refineries had their own boundaries of rights, made profit, paid dividends and financially supported the government.

In terms of Economic Development functions, the state plays a crucial role in leveraging oil resources to drive economic development and diversification in Nigeria. It formulates policies and initiatives aimed at promoting local content development, industrialization, infrastructure development, and job creation within the oil and gas sector and other related industries. Its intervention in the oil sector started where it acquired a 33.33% stake from AGIP Oil Company and 35% from Shell Bp. Its responsibilities extended to participating in all aspects of petroleum upstream, midstream and downstream businesses. Thus, it became the country’s sole concessionaire, and the lead negotiator for every oil exploration and production license. The corporation also produces petroleum and has exploration and production capacity. It funds its share of production through oil-backed revenue from taxes, royalties and foreign direct investments (FDIs). It collects oil revenues and sells oil on behalf of the state and regulates the oil industry.

The State intervention became more dominant during Ibrahim Babangida’s Military regime (1985-1993) when the corporation was officially commercialized with accounts transferred to the Central Bank of Nigeria thus relinquishing its autonomy (Abasilim et al., 2018). It is currently the key channel designed to launder the country's image abroad. The corporation reported an after-tax profit of N764 billion in 2021. But its current structure and control of oil rents tends to provide avenues for potential mismanagement of state funds.

The NNPC controlled subsidiaries are currently 23 in number ranging from the Nigeria's Liquefied Gas Company (NLNG), National Petroleum Investment Services (NAPIM), Petroleum Product Marketing Company (PPMC), Nigeria Petroleum & Development Company, Integrated Data Services, NNPC Oilfield Services, NNPC Medical Service, NNPC Research & Development Unit, Properties and Pension funds among others with DPR and NNPC in legislation as regulatory bodies and NNPC Product &Distribution.Click or tap here to enter text.The major international oil exploration and production companies that are active in Nigeria are: Shell, ExxonMobil, Total Oil, Chevron, Section 17 of the PSC Acts holders of licenses or terms in production sharing contract agreements where NNPC has 40%, Shell 25%, ExxonMobil 15%, Chevron 10%, while Total oil has 10% market shares. Other operators include Eni, Addax, AGIP, Conoco-Philips, Con-Oil, etc. Ultra deep-water projects include Chevron (Agbani field), AGIP (Aboh field) and Total (Akpo and Usan Fields) which have commenced production recently in full capacities yet, about 80 others deep water oil blocs are yet to commence.

Rather than providing an encyclopedia listing of these different institutions and their impacts on the industry, we introduce them in our analysis in relation to their positions in the governance of Nigeria's petroleum chain.

In terms of understanding the context in which these institutions operate, it is perhaps useful to firstly understand the structure of the actors in the legal and regulatory framework which begins with the President of the Federal Republic of Nigeria in the following organogram.

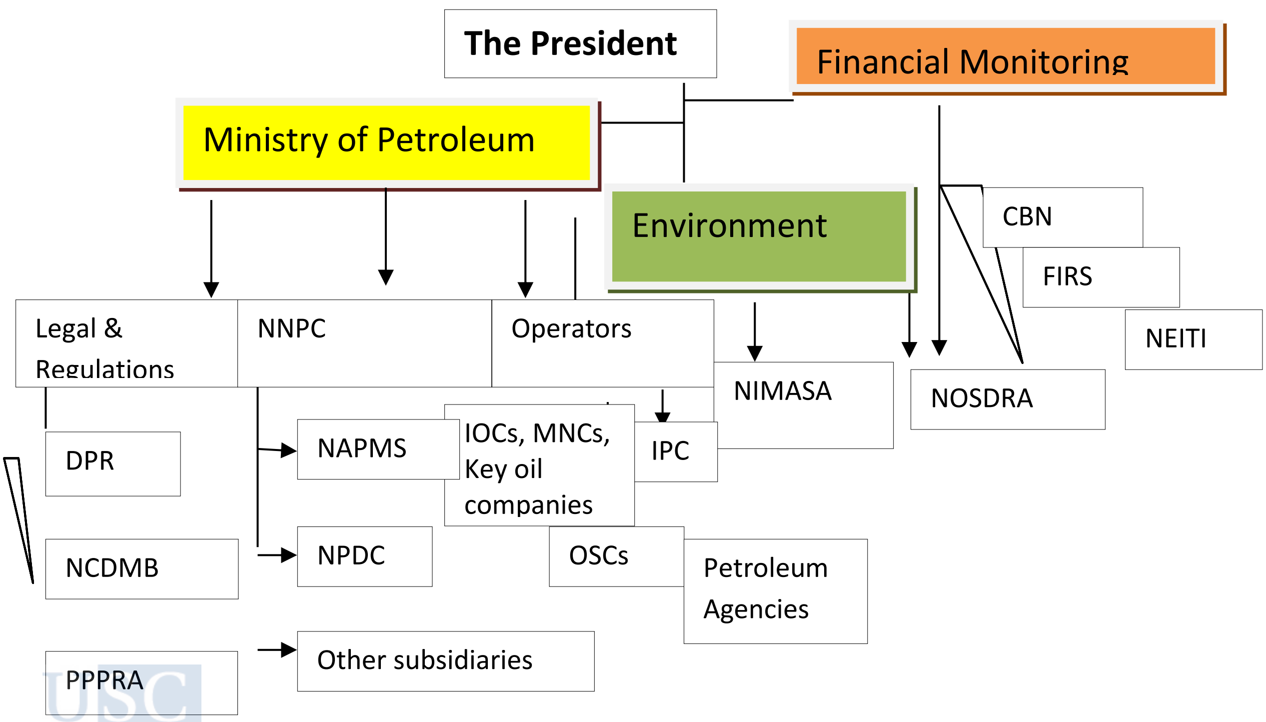

Figure 36: Actors in the framework of Nigeria's Oil Industry

Source: Own Elaboration from NNPC. (2020)

Figure 36 shows the actors in the regulatory framework of the Nigeria's Petroleum Industry (NPI), through which Nigeria's Federal government regulates and participates in the country's oil trade. The NNPC business operations are managed through Strategic Business and Corporate Service Units (SBCS) in many State's locations across the country with headquarters at Abuja, the Federal Capital Territory (FCT).

The Council of Ministers, which is chaired by the President of the Federal Republic of Nigeria, is the highest decision-making body. The Ministry of Petroleum resources and DPR are the agencies saddled with the responsibility of providing the primary oversight functions in the petroleum ministry (including monitoring and regulating oil & gas activities). It uses concession decrees to confer concessionaires' rights upon the Concessionaires (Shell Nigeria Petroleum Development Company, ExxonMobil, Total, Elf, AGIP, Chevron) through NNPC and determines the main tasks that come with it (e.g. oil prospects, seismic reports, punching, issuing and holding licensing rounds, monitoring contract proposals, remitting and marketing of royalty or profit oil etc. Although there is a direct link between the DPR, PPPRA and the NNPC, the Ministry of Petroleum has the major regulatory role in the industry, and its task includes formulation and enforcement of oil and gas (O&G) operations and taxation. Institutionally, oil taxes are directly channeled to the Ministry of Finance via the Central Bank of Nigeria (CBN). However, reviews on the sector's fiscal linkages indicate existence of institutional conflict regarding the role of oil tax collection between the petroleum ministry, the Ministry of Finance and the Central Bank (CBN) (Nwaoha & Wood, 2014).

- **Policies, Contracts and Agreements in the Nigerian oil sector**

Policies, contracts, and agreements are integral to shaping Nigeria's oil industry, influencing its operations, regulations, and overall trajectory. This section aims to provide insights into their significance, complexities, and implications for stakeholders by examining the intricate web of legal frameworks, regulatory measures, and international agreements.

In the oil sector, policies and laws encompass regulations established by governments to govern exploration, production, refining, and distribution of oil resources. These include licensing requirements, environmental regulations, taxation policies, and frameworks for revenue management and resource allocation. Additionally, international agreements often influence the legal framework, particularly in areas such as environmental protection and human rights. For example, Nigerian law designates all mineral rights to the state, with the Nigerian National Petroleum Corporation (NNPC) serving as the sole concessionaire for exploration and production activities. Therefore, oil companies, both foreign and domestic, must enter associations with the Ministry of Petroleum Resources through the NNPC, which can participate directly in oil blocks as an operator or partner.

Before the introduction of the Petroleum Industry Act (PIA) in 2021, Nigeria's oil sector was managed under four major laws: the Petroleum Act of 1969, the Petroleum Profits Tax Act, the Deep Offshore and Inland Basin Production Sharing Contract Act, and the Associated Gas

Reinjection Act. These laws, although essential at the time, were widely criticized as being outdated and unable to meet the evolving demands of industry and the economy. The PIA was introduced to modernize the regulatory framework and promote growth in the sector. One of its significant features is the adoption of Production Sharing Agreements (PSAs) before licensing rounds, allowing companies to participate in competitive public bidding for exploration and production rights.

The key contractual agreements used in Nigeria's oil industry include joint ventures and PSAs. In joint ventures, the government transfers ownership of oil to companies in exchange for royalty payments and income taxes. Conversely, PSAs involve the government retaining ownership of the oil, with companies serving as contractors to the Nigerian National Petroleum Corporation (NNPC). PSAs predominantly cover oil contracts, with risk-sharing arrangements for new Ultra-deep water and deep-sea oil blocks outlined in the PIA of 2021.
In the aspect of oil blocs, Nigeria currently owns 52% of the country’s 173 active oil blocks, with foreign companies owning the remaining 48% (NNPC, 2022). To operate an oil block, companies must obtain a Concession order from the Nigerian government, outlining operational terms after meeting standard guidelines from the oil ministry. Policy adjustments on price caps, subsidies, and taxation have been made in response to global market price hikes, with a renewed focus on local content laws (Iwuoha, 2021 and Nwaoha & Wood, 2014).

The increase in global oil prices in 2022 positively impacted Nigeria, leading to currency appreciation and mitigating the effects of rising international prices on imports and inflation. Additionally, it boosted public revenue and facilitated debt servicing, supported by measures like exchange rate stabilization and tighter monetary policies by President Muhammad Buhari’s government. Since the enactment of the Petroleum Industry Act (PIA) in 2021, Nigeria's oil industry has undergone significant restructuring, including the approval of a new hydrocarbon strategy for refinery rehabilitation and exploration plans from 2022 to 2025. These strategies emphasize expanding geological knowledge, implementing petroleum concession allocation under the PIA, and adjusting pricing policies and subsidies. The PIA also enables rights holders to use un-extracted petroleum products as security for financing and taxation purposes, aligning with frameworks like the local content Act of 2010 and the 1999 constitution of Nigeria (amended). These liberalization efforts aim to address challenges in the oil industry, including increasing production to meet domestic demands, developing a skilled workforce, and promoting research and development for future hydrocarbon sufficiency (Hammoudeh et al., 2023).

Overall, policies, contracts, and agreements are pivotal in shaping Nigeria's oil industry, particularly with the enactment of the Petroleum Industry Act (PIA) in 2021. This legislation replaced outdated regulations, providing a more streamlined framework for exploration, production, and revenue management. Key contractual arrangements like Joint Ventures (JVs) and Production Sharing Agreements (PSAs) govern operational responsibilities and ownership structures in the sector. Policy adjustments, such as subsidy reforms and focus on local content laws, reflect Nigeria's efforts to adapt to global market dynamics and promote sustainable growth. Looking ahead, strategic initiatives in the PIA will drive innovation, workforce development, and infrastructure enhancement in Nigeria's oil sector.

5.9. THE POSITIVE IMPACTS, RISKS AND BARRIERS OF THE OIL SECTOR IN NIGERIA

The Nigerian oil industry holds a pivotal position within the nation's economy, exerting significant impact both domestically and internationally. One of the main roles of the petroleum industry in Nigeria is in its involvement in the distribution and marketing of petroleum derivatives. It also takes care of the oil and gas field operations, refining and other refinery operations along with the following advantages:

- **The Benefits of Oil in the Nigerian Oil Sector**

- It serves as a major income and foreign exchange earner for the country.
- Generates huge revenue through crude oil exports, taxes and royalties, license fees, rents and petroleum profit tax among others.
- Contributes to economic growth and development through infrastructural building and major business investments aimed at providing revenue stream to support other sectors.
- The petrochemical industry within the industrial sector uses petroleum as a primary input to manufacture a variety of products, such as plastics, solvents, polyurethane, fertilizers, detergents, paints, and many other items that serve as both intermediate materials and finished goods.
- Serves as power and fuel sources for electricity and transportation both for homes and industries particularly in the provision of lower energy costs.
- Generates employment opportunities and ensures energy security.
- Acts as a major source of revenue/funding to the government.
- Attracts significant foreign direct investment (FDI) and accrues foreign exchange reserves.

- **The Risks Associated with The Nigerian Oil Sector**

The Oil and Gas industry is an important sector that contributes to the economic development of Nigeria and the well-being of the citizens. It could be a boon to the development of host communities, yet their environmental and social impacts sometimes tend to outweigh their benefits. Basically, the oil sector is known for the consumption of large amounts of energy and water, which during oil production generates huge quantity of waste waters that ends up releasing hazardous gases into the atmosphere. It also generates solid waste that are most often difficult both to treat and to dispose. This is aside from the challenges of air, noise and water pollution that are associated with the initial seismic and drilling operations. Other problems include:

- Gas flaring, carbon monoxide poisoning and the effect on biodiversity.
- Violent protests from competing host communities' claims.

- Repression of protest and government reactions resulting to human right violations.
- Oil spillage and wastes causes air pollution and fire incidents which damage the environment. Fire also has high impact on agricultural resource aside from causing death.
- Government inactions on oil theft, corrupt practices and increasing fuel importation are threats to the economy and national security. Basically, the impact of oil theft is always significantly larger than the value of theft.
- Government negligence on illegal refining contaminates both the ecosystem and marine environment thus leading to coastal erosion and significant losses.
- Environmental pollution (noise, air, sea and land). Wastes from oil and gas production contain heavy metals, radioactive materials; salt and toxic chemicals have the potentials to damage soil and directly affect vegetation cum other lives.

- **Barriers to Oil Refining & Oil Trade**

The Nigerian oil industry encounters several barriers that hinder its potential. The hindrances to oil trade in Nigeria include a range of factors such as regulatory hurdles, bureaucratic inefficiencies, infrastructure limitations, security challenges, political instability, corruption, and environmental concerns (Adeyanju et al., 2020). These barriers can impede the smooth flow of oil exports and imports, and lead to delays, increased costs, and disruptions in trade activities. Additionally, trade barriers also arise from international sanctions, trade disputes, or geopolitical tensions and poor infrastructure, which has further restricted market access and hindered the growth of oil trade (Xiaoqing, 2023). Many countries have successfully industrialized their downstream oil sub-sector through rehabilitation of the refineries, deregulating the industry thus attracting private sector investments. However, Nigeria, despite being one of the top ten in terms of reserves and deriving 90% of its income from the industry, the government effort towards the development of the downstream sector has yielded limited results (Ortiz et al., 2022). Currently, the four refineries in Nigeria are experiencing poor performance attributed to factors such as their age, inadequate maintenance, governance issues, pipeline vandalism and oil theft issues (Rui et al., 2018). The major challenge/s tends to particularly revolve around governance. Such issues include the fact that the petroleum downstream sector in the country is:

(i) Partially liberalized. This complicates the market regulations for fuel prices amongst other issues.

(ii) The Federal government also exerts control over the industry regulatory agencies, leading to an oligopolistic structure of the industry and market/s. The legal and economic concern is that it blocks the new entrants, slows innovation and causes frequent domestic fuel oil price hikes

(iii) In the aspect of entry barrier which the government argues that its purpose prevents unserious firms which cannot be relied upon from entering the market, the control by major petroleum dealers/cartels however leaves independent marketers struggling to meet consumers’ fuel demand due to stiff competition among the oil firms.

(iv) There is also the issue of government's inability to reinforce control of the core oil business along the value chain to integrate refining operations (Álvarez et al., 2018).

(v) The problem of low focus on investment regarding refinery conversion – Expansion of business activities to fit other players is required, (Olujobi, 2017).

(vi) Weak competition at a global and regional scale (Akanle & Shittu, 2022).

(vii) The quest and competitiveness from alternative energy products (Joshua Olujobi, 2017).

Nonetheless, there are also several trade barriers that the country faces in the process of importing petroleum derivatives. This includes tariffs on both imports and exports, non-tariff barriers such as import quotas, subsidies and licenses to import.

However, early evidence points to Free Trade Agreements (FTAs) being effective at lowering these barriers and the overall cost of trade, but recent cumulative petroleum import value detects excess even with the so-called free trade agreement. Currently, there are multi-level uncertainties even among the products from the European Union particularly after the pandemic with a less integrated market. In contrast, customs and shipping fees in countries like USA and Canada for petroleum derivatives make cost comparisons challenging. Conversely, there are import tax exemptions introduced by the government in the new Petroleum Industry Act of 2021 in the oil services, exploration and production sector which somewhat offsets some of the cost disadvantages for the US petrochemical products and in some specific industries.

Other challenges include bottlenecks in decision making, narrow access to decision makers, divestment by some IOCs, thus the need to encourage partnership among independent domestic oil firms and more active collaboration regionally and globally.

The Nigerian oil and gas sector is significantly threatened by regional instability and internal security issues, including terrorism, kidnapping, and banditry. These issues, initially concentrated in the Northern States, have spread to the Southern States, which host most of the country's oil and gas operations and reserves. Corruption and governance issues, including rent-seeking and patronage, undermine effective management and equitable resource distribution. The dominance of MNCs often limits opportunities for local firms, stifling domestic capacity building. This leads to a consistent increase in the value of imports for petroleum products, negatively affecting the downstream sub-sector's development. According to Ogbuigwe (2018) the mal functioning of the four oil refineries has led to massive production cuts, reduced employment, fuel scarcity &queues at the service stations, decreased domestic sales, and declining profitability for local independent oil companies. These barriers have not only affected operations but also deter investments in industry. Thus, the author recommends a high-capacity utilization of about 80% or more for the sector's sustainability, including the profitability, investments on research & development as well as workforce development.

The Federal government has undertaken some initiatives to address the barriers and enhance the Nigerian oil industry's capacity. These include the ongoing rehabilitation of the Port-Harcourt and Kaduna refineries, the initiation of modular oil refinery projects, and various private partnership projects such as the Dangote Refinery and Petro-chemical firm in Lagos, the Lekki Free Zone Project (LFZP), and the Bayelsa Azikel Refinery (BAR). These projects aim to increase indigenous crude oil refining capacity to meet domestic demands and reduce the volume of petroleum product imports, to potentially make the country a net exporter of refined oil. However, these steps have not yet achieved the desired results (Ogbuigwe, 2018).

5.10 SUMMARY

This chapter focuses on the Nigerian oil industry's position within Global Value Chains (GVCs). It provides a comprehensive analysis of its multifaceted processes and integration into global economic networks. Beginning with an introduction that underscores the industry's pivotal role in Nigeria's economy, the chapter explores its historical background and key drivers, highlighting the structural components shaping the trajectory of the oil sector.

The overview encompasses various dimensions, including historical formations of the industry, to unravel the underlying reasons behind Nigeria's unique position in the oil trade. It examines pivotal events from the industry's inception in the mid-20th century, such as the first oil discovery at Oloibiri, the establishment of the first oil refinery, Nigeria's accession to OPEC membership, and the creation of the Nigerian National Petroleum Corporation (NNPC) as a state-owned oil company. This provides context for understanding the strategic significance of Nigeria's oil production and its geographical origin.

The chapter also explores Nigeria's participation in global value chains (GVCs), emphasizing insights from Trade in Value-Added (TiVA) analysis. TiVA measures the value added by different countries in the production of internationally traded goods and services, offering a clearer picture of Nigeria's economic positioning. As part of this analysis, the chapter provides answers to Research Question 1, which examines Nigeria's status as a net importer of refined fuel despite being a major crude oil exporter. Findings from a 25-year review (1995–2020) indicate that Nigeria exhibits strong backward participation in GVCs, relying heavily on foreign inputs, technology, and expertise, particularly in oil extraction and refining. Conversely, forward participation remains weak, reflecting limited domestic value addition in refining, branding, and marketing activities. Despite peaking at 44% in both 2014 and 2020, Nigeria's total GVC participation remains below that of regions such as the EU and OECD, highlighting gaps in its integration into global production networks.

Beyond GVC participation, the chapter further examines the structural composition of Nigeria's oil industry, categorizing it into three distinct segments: the Upstream sector, responsible for exploration and production; the Midstream sector, tasked with crude oil transportation from wells to refineries; and the Downstream sub-sector, encompassing refining and marketing activities. This structural framework aims to streamline operations, allocate resources efficiently, and optimize overall performance and product quality within the industry. The Upstream sector, central to the supply side, engages in both on-shore and off-shore exploration and production, while the Downstream unit focuses on product processing, refining, marketing, and distribution. Meanwhile, core transportation responsibilities lie within the purview of the Midstream oil sector.

In addition, the chapter examines the myriad conditions under which the oil sector operates, including environmental concerns, market demand processes, competitiveness, and process.
improvement strategies. Environmental protection emerges as a crucial consideration, particularly with factors contributing to oil spillage including human error during oil extraction and transportation, as well as other levels of environmental degradation activities such as loss of biodiversity leading to soil erosion, violent conflicts, inequality in the distribution of gains, and other host community issues. Market demand intricacies, such as low-price elasticity and implications for consumption patterns, underscore the unique challenges faced by the industry. The discussion on process improvement emphasizes the importance of systematic actions to enhance operational excellence and create value within the sector.

The chapter also reviews the diverse stakeholders involved in the Nigerian oil industry, with a particular focus on the major six such as Shell, ExxonMobil, Chevron, Total Oil, Addax, and NNPC. It examines the role of the state and multinational corporations (MNCs), highlighting their contributions to exploration, production, refining, marketing, and distribution activities. Moreover, it delves into the resource and environmental issues associated with MNCs' operations, balancing the positive and negative impacts of the oil industry on Nigeria's socio-economic landscape. Additionally, the chapter elucidates the barriers to oil trade, shedding light on regulatory frameworks, contractual agreements, and policy interventions that shape the sector's functioning.

The economic dimension takes center stage in the chapter, highlighting the pivotal role of the oil industry in Nigeria's economy. The sector accounts for a substantial portion of government revenue, foreign exchange earnings, and GDP contribution, employing a significant portion of the population. Nigeria emerges as a major player in the global oil market, ranking among the top exporters globally and holding significant reserves of crude oil and natural gas. Additionally, its prominence in LNG production and role in supplying Europe further solidify its position as a key player in the global energy terrain.

In conclusion, the chapter emphasizes the importance of enhancing Nigeria's participation in GVCs through strategic improvements in the oil industry. This involves addressing environmental concerns, improving market demand processes, and fostering competitiveness and process improvement. By focusing on these areas, Nigeria can strengthen its position within GVCs, contributing to economic growth and development.

These insights pave the way for the subsequent chapter, which will delve deeper into the examination of the potential of Nigeria's National Innovation System (NIS) in the oil industry. Specifically, it will address the question of how the NIS can be strengthened to better support the oil industry and enhance its participation in Global Value Chains. By examining the practical implications and strategies for leveraging NIS, the next chapter aims to provide a roadmap for enhancing the competitiveness and sustainability of Nigeria's oil sector within the global economy.

Chapter 6.
The Nigerian National Innovation System (NNIS)

The concept of a National Innovation System (NIS) has gained increasing prominence in discussions surrounding economic development and technological advancement. According to the 2005 Oslo Manual by the Organization for Economic Cooperation and Development, NIS is crucial for promoting sustainable economic growth when it is positioned to foster networks that drive technological change and innovation within an economy. This symbiotic relationship between innovation and economic growth underscores the importance of NIS in shaping the trajectory of nations towards prosperity.

In the context of developing countries like Nigeria, the dynamics of NIS are particularly complex. Limited skills among the labor force and challenges in research and development contribute to the intricacies of NIS in such economies. As discussed earlier in chapter 4, NIS embodies the flow of technology and information among individuals, enterprises, and institutions, fostering innovation at the national level and propelling socio-economic development. Numerous literatures highlight that the Nigerian NIS appears complex. As the nation strives to navigate these complexities, understanding the intricacies of its NIS becomes paramount.

Against the backdrop of Nigeria's complex National Innovation System (NIS), this chapter aims to explore how determinants of successful NIS vary across countries, emphasizing the significant disparity between advanced economies and developing nations like Nigeria, particularly in technology, science, and innovation. It delves into the practice of NIS in Nigeria and its impact on the country's vital oil industry. Through a comparative analysis utilizing descriptive data from the Global Innovation Index (GII), this chapter seeks to characterize the level of development of Nigeria's innovation system. Furthermore, it examines the current landscape of science, technology, and innovation in Nigeria in comparison to other nations, while also exploring prospects for future development. The overarching goal is to assess the extent to which the Nigerian NIS can contribute to upgrading the oil sector.

By examining the NNIS within the broader light of National Innovation Systems' increasing consideration as a boast for economic growth, and transformation, it becomes evident that the NIS of Nigeria represents a comprehensive framework that integrates various actors, institutions, policies, and processes to drive innovation and technological advancement within the country (Leo, 2022) . This system plays a pivotal role in shaping Nigeria's economic development trajectory by facilitating the creation, diffusion, and utilization of knowledge and innovation across different sectors. At its core, Nigeria's NIS aims to harness the country's intellectual and technological capabilities to address socio-economic challenges, enhance competitiveness, and foster sustainable development, (Li et al., 2023).

The Nigerian NIS is in its nascent stage of providing the foundation for policy formulation, resource allocation, and collaborative initiatives aimed at promoting research and development, technology adoption, entrepreneurship, and knowledge transfer. It recognizes the importance of creating an enabling environment that encourages creativity, experimentation, and risk-taking while also safeguarding intellectual property rights and promoting ethical practices. In recent years, there has been a growing recognition of the critical role played by the NIS in driving economic growth and competitiveness in Nigeria (Shenkoya, 2019). Efforts have been made to strengthen the country's innovation infrastructure, improve the quality of education and research, and enhance collaboration between academia, industry, and government. Government initiatives aimed at fostering innovation span various sectors, including information and communication technology, with initiatives like incubators in universities inspiring entrepreneurial spirit among students - National Center for Technology Management.(NACETEM, 2020.)

Nigeria is also making strides in creating a vibrant ecosystem for start-ups through a network of institutions and policies aimed at fostering small and medium-scale business development. Initiatives like the Smart Business ICT Hub in Lagos and technology parks at universities such as the Lion Science Park at the University of Nigeria Nsukka and Abuja, along with smart factories, aim to create an attractive and creative environment for research, learning, and innovation (Shenkoya, 2019). Additionally, international cooperation in research and development, exemplified by agreements like the IDEON technology research agreement between the University of Sweden and the University of Nigeria-Nsukka, further enhances Nigeria's innovation terrain. Agencies like NACETEM, established under the Federal Ministry of Science and Technology, play a crucial role in training and developing manpower and conducting policy research in science, technology, and innovation to promote locally made goods and services (Siyanbola, 2016)

Indeed, the National Innovation System (NIS) of Nigeria represents a comprehensive framework that integrates various actors, institutions, policies, and processes to drive innovation and technological advancement within the country. This system helps in shaping the Nigeria's economic development trajectory by facilitating the creation, diffusion, and utilization of knowledge and innovation across different sectors. Efforts have been made to strengthen the country's innovation infrastructure, improve the quality of education and research, and enhance collaboration between academia, industry, and government.

However, despite these efforts, Nigeria's NIS faces significant challenges and criticisms, thus, hindering its effectiveness and impact on the economy. Indeed, the Nigerian NIS stands at a critical juncture, grappling with the imperative to bridge the substantial gap between its development status and that of advanced economies. Despite abundant human and natural resources, Nigeria faces significant hurdles in harnessing its assets to drive sustainable economic growth and competitiveness. These challenges which would be enumerated in the next section include limited funding for research and development, inadequate infrastructure, institutional bottlenecks, and weak policies for technology diffusion and commercialization. Thus, while advanced economies have robust innovation ecosystems with strong institutional support and significant investments in research and development, the Nigerian NIS is still in its nascent stages and lacks the necessary resources and infrastructure to compete on a global scale.

6.1. RECENT DEVELOPMENTS IN THE NIGERIAN NIS

In recent years, Nigeria's National Innovation System (NNIS) has grappled with formidable challenges that have impeded its ability to fully catalyze economic growth and development. These obstacles, ranging from insufficient funding to weak institutional arrangements, have underscored the urgent need for interventions to fortify the country's innovation ecosystem. Nonetheless, amidst these hurdles, concerted efforts have emerged to rectify deficiencies and propel Nigeria toward a more resilient innovation landscape. This section delves into the multifaceted challenges confronting NNIS, while also shedding light on recent initiatives aimed at surmounting these barriers to foster innovation and sustainable economic growth.

Furthermore, recent strides in the Nigerian innovation ecosystem, such as augmented budget allocations for vital infrastructural projects and the establishment of institutional frameworks and funds, signify a steadfast commitment to addressing these issues and cultivating an environment conducive to innovation and economic progress.

Moreover, significant developments within the oil sector have emanated from the NIS realm, notably regulatory reforms epitomized by the enactment of the Petroleum Industry Act of 2021. This legislative milestone underscores a cogent argument for regulatory enhancements, emphasizing the imperative of nurturing an environment conducive to innovation and investment in the oil industry, potentially alleviating some of the identified challenges.

However, despite two decades since its inception, efforts to establish a conducive environment for a successful NIS have fallen short (Isola, 2010). The educational and scientific policies have failed to facilitate the seamless flow of technology and information at the national level, resulting in ambiguity. Nigeria's struggle to commercialize inventions from its numerous government-owned research institutes and universities remains pronounced (Shenkoya, 2019). Despite early initiatives dating back to the establishment of the Nigerian Council for Scientific and Industrial Research in 1966, the country's research output has not kept pace with its investment in research and development (Ibeme, 2020).

Numerous authors characterize Nigeria's National Innovation System (NIS) as still in its early stages of development, with weak innovation systems hindering sustainable economic growth (NACETEM, 2021), particularly in sectors like oil. The weak NIS is attributed to challenges in technological diffusion, inadequate research support and facilities, limited human capital, and poor government policies (Iheukwumere et al., 2020). Government interventions in promoting the innovation system have not translated into significant improvements in research output or innovation (Adeoti, 2010). Nigeria's National Innovation System (NIS) is further hampered by poor financing for research and development, fragile institutional arrangements, and insufficient infrastructure (Casadella & Tahi, 2023).

As we transition to examining the performance of Nigeria's National Innovation System (NIS) from the Global Innovation Index (GII), it becomes evident that understanding the challenges and developments within the Nigerian innovation landscape is crucial for contextualizing its comparative performance. The insights gleaned from previous studies shed light on the complexities and shortcomings of Nigeria's innovation ecosystem, setting the stage for a comprehensive analysis of its innovation performance as evaluated by the GII.

6.2 NIGERIA'S INNOVATION PERFORMANCE - GLOBAL INNOVATION INDEX (GII)

Understanding a nation's innovation performance is pivotal for assessing its competitiveness and potential for economic growth on the global stage. One crucial metric in this regard is the Global Innovation Index (GII), which provides a comprehensive evaluation of a country's innovation ecosystem. For Nigeria, a closer examination of its GII ranking over the past decade offers valuable insights into the state of its National Innovation System (NIS), shedding light on areas of strength and opportunities for enhancement. This introductory exploration aims to show-case Nigeria's innovation terrain as reflected in its GII ranking from 2011 to 2020, elucidating key trends and implications for the country's trajectory in innovation-driven development. Figure 37 outlines the seven pillars of the Global Innovation Index (GII) innovation components, providing a framework for assessing the innovation performance.

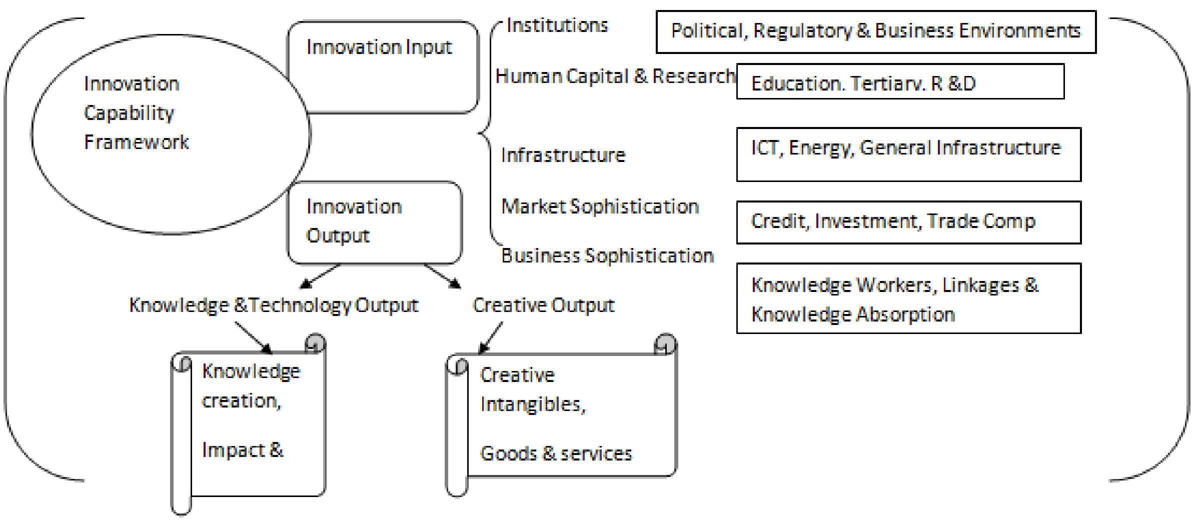

Figure 37: Structure of Innovation Capability Components

Source: Own elaboration based on data from GII & WIPO, (2020).

6.2.1. Integrated Assessment of NIS Pillars

This assessment provides a comprehensive analysis of Nigeria's National Innovation System (NIS) by examining various dimensions such as rankings, population demographics, geographical location, GDP, and more as seen in table 24a. This integrated assessment sheds light on both Nigeria's strengths and areas for improvement. By exploring these multifaceted aspects, we aim to gain a deeper understanding of Nigeria's innovation landscape and its implications for economic development and competitiveness.

Table 24a: Nigeria Integrated NIS trend 2011-2020

S/N	Item/s	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020 (m)
1	GII Rank	96	123	120	110	128	114	119	118	114	117
2	Income Level	Middle Income	Middle Income	Middle Income	Middle Income	Middle Income	Middle Income	Middle Income	Middle Income	Middle Income	Middle income
3	Region	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara Africa	Sub-Sahara
4	Population	158.3	160.3	167.3	168.8	178.5	182.2	187.0	190.9	195.9	201
5	GDP PPP$	2,203.3	2,589.0	2,734.6	2,831.5	2,997.0	5,008.4	6,108.4	5,929.2	6,027.2	5,286.1
6	GDP Per Capita PPP$	173.0	247.1	272.6	286.5	573.7	490.2	415.1	1118.4	1,169.1	1,216.8

Source: Own elaboration - GII. (2022)

Table 24a, titled "Nigeria Innovation Trend," provides a comprehensive assessment of various factors, including rank, income, region, population, and GDP, compiled between 2011 and 2020. The GII rankings reveal a fluctuating performance in Nigeria's National Innovation, ranging between the 96th and 128th position. Notably, the country's best performance was in 2011 (96th), while its lowest was recorded in 2015 (128th) out of 139 countries. Despite stable income levels across lower categories, GDP-PPP experienced fluctuations, peaking at $6,108.4 in 2017 and dropping to $2,203 in 2011. These fluctuations reflect challenges in advancing innovation capabilities, exacerbated by obstacles related to income levels, regional dynamics, population demographics, and GDP growth. Overall, Nigeria has faced difficulties in significantly improving its innovation ecosystem, underscoring the need for strategic interventions to enhance its innovation performance.

6.2.2. Human Resource, Research and Development Pillar

The Human Resource, Research & Development pillar of Nigeria within the GII measurement, typically involve the assessment of the capacity and investment in human capital, education and research activities. This pillar evaluates factors such as the quality of educational institutions, availability of skilled labor, expenditure on research and development (R&D), and collaboration between the academia and industry. It aims to measure the extent to which the country fosters an environment conducive to innovation through investments in education, training, and scientific research.

Table 24b: Nigerian Human Resource, Research & Development 2011-2020

Items	2011		2015		2018		2019		2020	
	S	R	S	R	S	R	S	R	S	R
Human Capital/productivity	17.1	109	24.9	96	11.3	119	11.2	121	11.9	121
Education	35.7	98	29.5	109	26.4	114	26.8	113	29.0	118
Tertiary Educ	8.2	114	7.8	110	7.5	114	6.9	120	6.6	120
Research (R&D)	1.3	100	1.3	103	2.0	96	2.4	94	2.8	90
Technology & adoption	12.5	102	13.8	101	11.8	107	11.2	106	11.2	106

Source: GII & WIPO. (2011-2020) Own elaboration

Table 24b illustrates the fluctuations in Nigeria's Human Resource ranking over the years, with the highest ranking observed in 2015 and the lowest in 2018 and 2019. Despite these variations, the rankings indicate a persistent challenge in terms of human capital development and productivity in Nigeria, showing limited improvement over the years.

On the other hand, the findings for R&D and technology reveal that Nigeria's National Innovation performance, as measured by the GII rankings from 2011 to 2020, fluctuated between the 96th and 128th positions. In 2011, the country ranked 100th in R&D and 102nd in Technology, indicating a moderate starting point. However, by 2015, there was a slight decline in R&D, with a movement from 100th to 103 out of 139 countries, but Technology remained relatively stable at 101. In 2018, there was an improvement in R&D moving from 103rd to 96th position while Technology rankings dropped to 107th from 102nd position respectively. This trend continued in 2019 and 2020, with R&D ranking further upgrading to 90th position out of 139 countries, while Technology remained stagnant at 106th position. While there are slight improvements in education and tertiary education indicators, R&D expenditure and adoption of technology show slow growth with relative fluctuations. These fluctuations underscore the challenges Nigeria faces in advancing its innovation system and emphasize the need for strategic interventions to foster sustained growth and development particularly in R&D and Technology sectors.

6.2.3. Pillar of Institutions

The institutional pillar is a fundamental component in assessing the Global Innovation Systems (GIS) ranking. It provides insight into the regulatory environment, political stability, and other institutional factors that influence the country's innovation system. As an essential determinant of the nation's innovation performance, the institutional pillar encompasses various aspects such as government effectiveness, rule of law, and regulatory quality. By examining the institutional framework, we can gain valuable insights into Nigeria's capacity to foster innovation, attract investment, and support sustainable economic growth.

Table 24c: Performance of Institutions in Nigeria by GII 2011-2020

Items	2011		2015		2018		2019		2020	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
Institutions	41.6	115	39.3	113	44.7	119	49.3	114	34.3	110
Political Environment	19.2	122	13.4	138	19.4	125	30.7	126	23.7	129
Pol Stability	13.6	125	12.7	122	18.6	125	8.2	128	8.2	127
Government Effectiveness	8.8	120	13.2	123	6.7	122	10.4	121	2.4	127
Regulatory Environment	43.0	101	54.1	104	58.9	81	60.4	81	60.6	78
Regulatory quality	20.8	114	25.5	117	23.5	121	28.9	122	26.0	122
Rule of Law	14.9	122	20.6	118	27.4	117	23.5	118	26.6	117
Cost of dismissals	7.3	1	8.0	1	8	1	8.0	1	8.0	1
Biz Environ	62.2	108	50.0	132	55.7	111	56.7	113	58.4	109
Biz Start-ups/Others	38.6	103	40.8	98	49.0	92	46.2	81	36.2	81
Resolving Insolvency	23.6	113	9.2	114	6.7	119	10.5	118	22.2	118

Source: Own elaboration - GII & WIPO. (2011-2020)

The data is analyzed across three key pillars: Institutions, Regulatory Environment, and Business Environment. The findings, which show a mixed performance, are detailed in table 24c.

(i)The "Institution" pillar assesses the quality of a country's institutions, including governance structures, regulatory frameworks, and the rule of law. This aspect highlights the leadership component of the innovation system, as robust institutions are crucial for creating a supportive environment where innovation can flourish.

The findings indicate fluctuations in Nigeria's rankings over the years, with notable improvements in 2019 and 2020. Nigeria achieved its highest ranking of 110th in 2020, reflecting moderate advancements in the quality of institutions, governance structures, and the rule of law. Despite these improvements, the country still faces challenges, as evidenced by rankings consistently above 100th place during the reviewed years. There remains significant potential for enhancing institutional leadership and governance, which are essential for fostering innovation and economic development. To create a more conducive environment for growth, reforms are needed to increase transparency, accountability, and efficiency within government institutions, as well as to strengthen the legal and regulatory framework.

(ii) The Regulatory Environment pillar assesses the ease of doing business, regulatory efficiency, and the effectiveness of regulatory frameworks in facilitating innovation and entrepreneurship. Nigeria's highest ranking in the regulatory pillar was 78th in 2020, suggesting some progress in regulatory quality. However, the country's ranking in 2011 was relatively lower at 101st place, indicating a decline over the years. Nevertheless, there were improvements between 2015 and 2019. Enhancing regulatory efficiency and effectiveness is essential for promoting business growth, investment, and innovation. This may require streamlining regulatory processes, reducing bureaucratic barriers, and improving compliance mechanisms to create a more conducive business environment with a stronger NIS in focus.

(iii)The Business Environment: This involves factors such as business sophistication, market competition, and infrastructure development conducive to innovation and entrepreneurship. Nigeria's rankings in this pillar have been relatively inconsistent, with fluctuations observed across different years.

The findings show the highest ranking in the business environment pillar as 109th in 2020, reflecting some improvements from previous years and particularly suggesting strength in factors such as ease of doing business and market competitiveness. However, the country's ranking was lower in 2015 at 132nd place, indicating that maintaining a favorable business environment has been a challenge in the country, thus, impacting its overall innovation performance. Addressing issues such as infrastructure deficits, access to finance, oil theft, refined fuel importation and market regulations is essential to foster a more vibrant and competitive business environment. Additionally, promoting entrepreneurship, innovation, and investment incentives can further enhance performance and promote economic competitiveness for global trade to thrive.

While Nigeria has made some progress in improving its institutional quality, regulatory efficiency, and business environment in 2020, there is still significant room for enhancement. Addressing the challenges and implementing reforms across these pillars will be critical in fostering innovation, economic growth, and sustainable development in the country.

6.2.4. Patents and Trademarks

Following the analysis of Nigeria's Institutions in the NIS, the next assessment focuses on patents and trademarks, two crucial components that contribute to innovation and knowledge creation. Patents, trademarks, designs and the dissemination of research findings through Intellectual Property protection are essential for fostering innovation, attracting investment, and driving economic growth. Therefore, understanding Nigeria's performance in these areas provides valuable insights into the country's NIS and its potential for future development.

Table 25: Nigeria IP Statistics (Residents abroad including regional) 2011-2020.

Year	Patent	Trademark (Claas count)	Industry design	GDP Constant $USD
2011	53	17,445	639	858.11
2012	64	20,987	1,045	915.36
2013	000	000	000	973.12
2014	000	000	000	998.98
2015	000	000	000	982.78
2016	98	000	674	990.70
2017	116	16,444	916	1,009.75
2018	415	11, 883	1,891	1,032.05
2019	452	14,723	2,017	1,013.53
2020	423	000	1,124	1,050.50

Source: Own elaboration - GII & WIPO. (2011-2020)

The intellectual property (IP) aspect encompasses various facets crucial to innovation, including the creation, protection, and commercialization of IP assets such as patents, trademarks, copyrights, and trade secrets. It also involves the legal frameworks, policies, and practices governing the ownership, licensing, and enforcement of these rights, aiming to incentivize innovation, creativity, and investment in research and development.

Table 25 offer insights into Nigeria's IP landscape, displaying the number of patents, trademarks, and industrial designs granted annually from 2011 to 2020, alongside the country's GDP in constant USD. Notably, there's an upward trend in the number of patents granted over the years, peaking at 452 patents in 2019 from 53 in 2011. Trademarks also exhibit growth, particularly from 2011 to 2012, albeit with fluctuations in subsequent years, notably in 2020 due to the global pandemic, which saw no filings. Industrial designs generally maintain an upward trajectory. Concurrently, the GDP reflects overall growth, indicating potential economic development and innovation within the country.

Despite these promising trends, Nigeria ranks 96th out of about 140 countries in the Global Innovation Index (GII) depicting its best performance and 128th position as least in 2015 in the overall trend, thus, signaling greater need for improvement. This suggests that while Nigeria demonstrates strengths in areas like tertiary education and intellectual property, significant challenges persist, particularly in human capital development, research and development, and IP enforcement. Issues surrounding the recognition and legislation of IP rights also pose recurrent challenges, impacting overall productivity and NIS status.

To address this short coming, it is imperative for Nigeria to comprehensively enhance its innovation system, bolster the oil industry, and drive sustainable economic growth. This requires concerted efforts to strengthen IP framework and improve human capital development to leverage its intellectual assets more effectively, thus, fostering innovation-led growth in order to give answers to research question two.

6.3. COMPARING NIGERIA WITH OTHER OIL-RICH ECONOMIES IN GII

This section undertakes a comparative analysis between Nigeria and other oil-rich economies, aiming to illuminate their respective National Innovation Systems (NIS) and innovation capacities. The analysis encompasses five countries—South Africa, Nigeria, Mauritius, Algeria, and Norway, spanning from 2013 to 2022. These nations, all oil producers, offer a varied panorama of innovation activities and economic growth. South Africa represents the African continent's economic powerhouse, while Nigeria stands as its largest economy and foremost oil producer. Mauritius is recognized for its economic diversification and favorable investment policies, while Algeria offers insights into North Africa's innovation dynamics. Norway serves as a benchmark for advanced innovation-driven economies.

This comparative analysis between Nigeria and other oil-rich economies, sheds light on their respective National Innovation Systems (NIS) and innovation capacity. The five countries are (South Africa, Nigeria, Mauritius, Algeria and Norway) oil producing nations' innovation activities from 2013-2022, to determine the current level of innovation performance & economic growth when compared with Nigeria. Comparing the GII innovation studies of these countries attempt to offer a diverse perspective on NIS performance across different regions and the economic contexts. South Africa represents the African continent's economic powerhouse, Nigeria signifies its largest economy and oil producing status, Mauritius is known for its economic diversification and investment-friendly policies, Algeria provides insights into innovation dynamics in North Africa, while Norway serves as a benchmark for advanced innovation-driven economies. This comparative analysis enables a comprehensive understanding of NIS strengths, weaknesses, and opportunities within and across these diverse countries, thus, facilitating cross-learning and policy exchange to foster innovation-driven growth and development among the oil producing economies.

The representatives of these 5 nations were considered given that they are oil-resource nations with similarities and differences in terms of their income groups, resource and geographies (Europe and Africa). Despite some limitations for country comparisons between 2013 and 2022, the Gross National Income per capita in current US Dollar was also used as a determinant as it defines the different thresholds by yearly economic classifications. We can see that 2013, 2015 and 2017 exhibited much higher values than the remaining years where the dispersion appears to be visibly skewed in the ranking. In comparing Nigeria with the rest of the four countries, the values of their scores and ranks between the periods 2013-2022 are presented in tables 26 and 27.

Table 26: Comparing 5 Oil producing economies' NIS 2013-2022

Year	Norway (High income)		South Africa (Upper middle income)		Nigeria (lower middle income)		Mauritius (Upper middle income)		Algeria (Upper middle income)	
Grades	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
2013	55.64	16th	37.60	58th	26.57	120th	38.00	53rd	23.11	138th
2015	53.80	21st	37.45	60th	23.72	128th	39.25	49th	24.38	126th
2017	53.14	19th	35.80	57th	21.92	118th	34.82	64th	24.34	108th
2019	51.87	19th	34.04	63rd	23.93	114th	30.61	82nd	23.98	113th
2022	48.8	22nd	29.8	61st	16.9	114th	34.4	45th	16.7	115th
Average scores	**52.65%**		**34.93%**		**23.21%**		**43.42%**		**22.50%**	

Source: Own elaboration - GII & WIPO. (2013-2022)

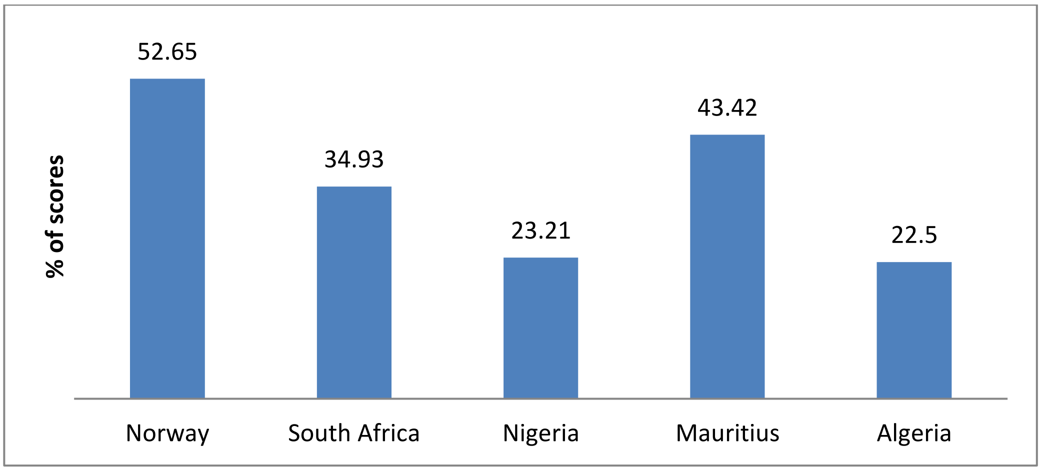

Figure 38: Comparing of Average GII Score for 5 petroleum nations.

Source: Own elaboration - GII & WIPO. (2013-2022)

Figure 38 presents the NIS scores and rankings of five petroleum resource countries, along with their combined annual performances from 2013-2022. The data shows Norway leading the group with scores ranging from 48% (lowest) to 55% (highest), and an overall average score of 52.65%. Mauritius follows closely with scores between 34% (lowest) and 38% (highest), averaging 43.42%. South Africa ranks third, with scores ranging from 29% (lowest) to 37% (highest) and an overall average of 34.93%. Nigeria is in the fourth position with an average score of 23.21%, while Algeria ranks fifth with an average score of 22.50%.

If sorted under economic dimension, records indicate that economies like South Africa, Mauritius, and Algeria which started with about 20% in World Bank classification of economies suddenly crossed the threshold to the upper middle-income range and with the 7 variables of knowledge and technology development have been able to catch-up, although the speed tends to vary with their income level and geographies. For instance, Mauritius tends to propel with faster speed since 2020 when it qualified for the Upper middle-income status than Algeria which assumed the status much earlier. South Africa and Mauritania can be classified under the second group but like the top-ranking countries in terms of their per capita GDP and basic innovation performance. The export share of natural resources and education score in terms of Nigeria and Algeria tends to show a falling tendency with less diversification over the years. Summarizing, the evaluation of the GII from the 5 countries, findings revealed that Norway topped the list with an average score of 52.65%, while Mauritius, South Africa, Nigeria and Algeria scored 43.42%, 34.93%, 23.21% and 22.50% thus positioning as 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} respectively.

In all, Norway ranks highest among the five selected oil-resource countries, consistently holding the top position and ranking between 16th and 22nd out of about 140 countries during the reviewed period (2013-2022). This performance underscores the significance of high-tech exports in Norway's economy, with a relatively low emphasis on primary crude oil production, linking its success to high value-added sectors. Mauritius ranks second, with an average score slightly ahead of South Africa. Both countries display similar patterns in their indicators, with medium to low values, but the key difference lies in education expenditures: Mauritius spends significantly more on education, with the sector's GDP at $11.4 billion compared to South Africa's $6.9 billion in 2022. Furthermore, Mauritius's small population (1.2 million) allows for a higher potential differentiation in product structure, favoring concentration in high value-added sectors and relegating South Africa, with its 61 million people, to the third position. Notably, Nigeria and Algeria occupy the fourth and fifth positions, respectively. This indicates that even among oil-resource states, Nigeria's NIS performance remains weak, with only two selected variables (regulatory policy and business environment) showing relative strength according to the GII report during the reviewed period.

In addition, the findings show that the output varieties of the five economies tend to decline over the years, possibly indicating a re-specialization in the current technology dispensation. However, Norway stands out with consistent and rapidly growing performance across almost all the variables. This highlights Norway's effective approach to adapting to technological changes and maintaining a robust innovation system, contrasting with the less dynamic performance seen in other economies under review.

In the case of Nigeria, two out of the seven pillars of "Institutions" and "Market Sophistication", were relatively significant. However, factors such as R&D expenditures, collaboration between universities and businesses, and high-tech imports did not enhance Nigeria’s position. This indicates that essential elements for coordinating funds, people, ideas, and cultural factors need to be addressed to increase innovation capability and productivity, thereby improving the country's economic development. A strategic approach is required, one that creates the right environment to integrate the existing strengths of each sector. Also, financial support from the government, particularly in the early stages of R&D collaborations with universities, would significantly improve the chances of performance (Siyanbola, 2016). Additionally, both theoretical and practical orientations of university researchers should be considered to ensure the effectiveness of these collaborations. Given the divergence within economic groups, businesses should take the initiative in proposing collaborative efforts. As economies develop different NIS categories with varying income levels, the innovation performance of their NIS will naturally differ, necessitating tailored strategies for each context.

Finally, the analysis between Nigeria, and the four oil-rich economies indicates that Nigeria may only improve its position by strengthening human capital development, infrastructure, business sophistication, and knowledge and technology output. Emulating Mauritius' accomplishments before aspiring to reach Norway's level may be a viable strategy for Nigeria's NIS enhancement.

In addition, the analysis highlights the pronounced and multifaceted disparities between the NNIS and those in advanced economies like Norway, as well as other developing nations. According to Isola (2010), these significant differences greatly impact the ability of countries to drive innovation and economic growth. The disparities in the ranking and scores are evident in areas such as Institutional Pillar, Human Resource, Research and Development pillars, funding collaboration networks, the overall scores and ranking from 2011 to 2020, among others. Understanding these gaps is crucial for identifying the challenges faced by developing nations like Nigeria in building effective NIS and devising strategies to bridge these divides. This examination helps to identify the specific aspects where these disparities are most evident, shedding light on the complexities and hurdles that countries like Nigeria must navigate to enhance its innovation capabilities particularly in the oil sector as well as, achieve sustainable development.

6.4. NNIS Agents and Interactions/Links

NIS plays a vital role in fostering innovation and driving economic development by facilitating interactions and linkages between various actors in the innovation ecosystem. These systems encompass a wide range of stakeholders, including government agencies, research institutions, universities, businesses, and other organizations, collaborating to generate and commercialize knowledge, technologies, and ideas.

In Nigeria, the interactions within NIS involve knowledge exchange, technology transfer, collaborative research and development (R&D), and the commercialization of innovations with each of the agent, playing a unique role in the innovation ecosystem. This section will explore the linkages within the Nigerian National Innovation System (NNIS) to demonstrate their contributions to enhancing the nation's competitiveness and innovation capabilities or identifying weaknesses. Ultimately, these efforts aim to drive sustainable growth and facilitate the upgrading of the oil industry in Nigeria. As a key agent within this framework, we commence our exploration with the government.

Government agencies are key actors in Nigeria's NIS, responsible for formulating policies, providing funding, and creating enabling environment for innovation. They interact with other stakeholders to coordinate innovation initiatives, allocate resources, and regulate the National innovation system. In the oil sector, government linkages are crucial for overseeing operations, regulating activities, and ensuring sustainable development. One prominent example of government linkages in the oil sector is the collaboration between the Nigerian

National Petroleum Corporation (NNPC) and the Department of Petroleum Resources (DPR). Aside, its central role in the exploration, production, refining, and distribution of petroleum products in Nigeria. It operates in partnership with international oil companies and oversees the country's oil and gas assets.

Additionally, government linkage extends to other agencies such as those in revenue management, environmental protection, and community engagement within the oil sector. These include the Federal Inland Revenue Service (FIRS), the Ministry of Environment, and the Niger Delta Development Commission (NDDC), among others.

The collaboration between the National Agency for Science and Engineering Infrastructure (NASENI) and the Federal Ministry of Science and Technology (FMST) is also crucial in promoting the development, acquisition, and adaptation of manufacturing technologies necessary for sustainable economic development. It collaborates closely with the FMST, which formulates policies and coordinates activities related to science, technology, and innovation in Nigeria.

In terms sectoral links, the execution of innovation policies, knowledge-generating institutions such as Federal and State Universities, research institutes, and private firms play crucial roles in generating, diffusing, and creating new knowledge and technological innovations. These institutions collaborate to ensure the achievement of NIS objectives through R&D activities. However, challenges such as limited funding for R&D, inadequate research facilities, and dependence on government funding hinder the effectiveness of these collaborations. Despite efforts to promote innovation through science parks and incubation centers, in some Enugu, Ibadan, Ife and Lagos State Universities, constraints such as capital maintenance and infrastructural limitations persist, hindering the full realization of Nigeria's innovation potentials (Siyanbola, 2016).

Specifically on R&D, Nigeria currently has 69 public research and scientific development institutes (see The World of Learning, 1998), 170 universities, of these, 79 are private, 43 are federal and 48 are State owned. The NASENI and FMST collaborate with other government agencies, and schools such as the National Information Technology Development Agency (NITDA) and the National Office for Technology Acquisition and Promotion (NOTAP), to leverage resources, share expertise, and address various challenges facing the innovation ecosystem. The country also has 45 polytechnics and colleges of technologies. Research efforts at these institutions are expected to provide useful technological information that can improve the technical performance of industrial firms. However, linkages between these institutions, oil industry and manufacturing firms or Agriculture are generally poor (Casimiro Zavale et al., 2018).

In terms of global linkage, the Global Innovation System (GIS), consisting of international institutions such as the World Bank, United Nations, UNESCO, UNIDO, multinational firms, and organizations like the Organization of the Petroleum Exporting Countries (OPEC), plays a pivotal role in Nigeria's National Innovation System (NIS). These entities serve as hubs for generating knowledge and technological innovations that are exchanged between Nigeria and global partners, fostering interrelationships, national development, and peace. Collaborative efforts and knowledge sharing with entities like OPEC enable Nigeria to enhance its innovation capabilities, address socio-economic challenges, and drive sustainable growth especially across the oil sector.

Overall, the framework of Nigeria's NIS, allows various national institutions to interact with each other and connect with regulatory bodies to formulate and implement innovation policies. This involves coordination among government agencies such as the Presidency, National Assembly, and Judiciary, as well as Federal Ministries, Departments, and Agencies (MDAs), and funding institutions like the Central Bank of Nigeria (CBN), Bank of Industry (BoI), and National Research and Innovation Fund (NRIF). However, the Nigerian NIS is confronted with various constraints, including capital and infrastructural limitations, inadequate skills, and international competition from high-tech firms. Overcoming these challenges necessitates strategic cooperation between government and firms, focusing on bolstering linkages between universities and industries to facilitate knowledge transfer and skills development. Unfortunately, collaboration between educational institutions, research organizations, and industry stakeholders is often weak, hindering the effective diffusion of technology and commercialization of research outcomes, as noted by the National Center for Technology Management NACETEM (2021). Establishing a dense network of interactions among these stakeholders is crucial for fostering innovation, improving production efficiency, and driving economic development in Nigeria.

6.5. The University System as Agents of Nigeria' NIS

The University System play a pivotal role as agents of the National Innovation System (NIS) in Nigeria, serving as hubs for knowledge creation, dissemination, and application. These institutions act as key drivers of research and development (R&D), fostering innovation through their academic programs, research activities, and partnerships with industries and government agencies. Moreover, universities contribute to human capital development by providing specialized training and education in various fields, equipping individuals with the skills and knowledge needed to drive technological advancements and entrepreneurship.

As of 2023, Nigeria boasts a total of 170 universities, with 79 being private, 43 federal, and 48 state-owned institutions. These universities serve as integral components of the National Innovation System (NIS), contributing significantly to research, knowledge creation, and human capital development. Through their research endeavors spanning various fields, universities generate new ideas, technologies, and innovations crucial for driving economic growth and development.

Rafiei & Davari (2015) underscores the importance of universities in fostering human skills essential for generating and assimilating knowledge, emphasizing the increasing role of science in innovation for developing countries. Several literatures also emphasize the potential for collaboration among university actors across arts, science, and professional schools, highlighting the university-industry technology inclusion (Kiseleva et al., 2022). Such coordinated efforts can yield substantial contributions to research and development, particularly in basic research, within Nigeria.

The evolving role of Nigerian universities is evident in their transformation from primarily teaching institutions to potent drivers of innovation and economic development. With private participation approved in 1999 and federal support for enhancing state universities in the 2000s, universities have expanded their impact beyond traditional educational roles. The establishment of quality assurance units, particularly within the National Universities Commission (NUC), underscores efforts to promote accreditation processes, especially in science and technology fields, further enhancing the administrative structures and autonomy of Nigerian universities.

According to Siyanbola (2016), the development trajectory of Nigerian universities aligns with specific historical periods, reflecting shifts in educational policies and societal needs. This nuanced understanding of the evolution of universities provides valuable context for their role within the NIS, shedding light on their dynamic contributions to research, innovation, and socio-economic development in Nigeria.

Table 27: Development of Universities in Nigeria

Years	Periodic generations	Purpose
1948	Premier University	Policy based on recommendation of the Asquith & Elliot Commission on higher Education in British colonies
1962-1970	1st Generation Universities	Basic manpower needs of a newly independent country
1971-1985	2nd Generation Universities	Increased demand for higher education especially after the civil war.
1986-1992	3rd Generation Universities	Needs for Agric and technology development to support food sufficiency in line with Sustainable development goal (SDG)
2001 – 2008	4th Generation Universities	Population increases and higher demand for access to higher education
2009 –Present	5th Generation Universities	A degree of autonomy to support transition to a free market economy, the alignment of STI & the diversification of R&D funding (policy of change in teaching programs).

Source: Siyanbola (2016) and Isola (2010)

Table 27 outlines the establishment of universities in Nigeria, tracing back to the mid-19th century when Western education was introduced by European missionaries. This introduction led to the establishment of the University College Ibadan in 1948, followed by subsequent institutions such as the University of Nigeria, Nsukka, University of Lagos, and Obafemi Awolowo University, Ile-Ife. These universities have played pivotal roles in shaping Nigeria's educational landscape and contributing to the National Innovation System (NIS).

Nigeria's higher education model follows the Sub-Saharan Africa post-independence structure, typically patterned after the colonial master's higher education system. The establishment of universities in Nigeria dates to the mid-19th century when Western education was introduced by European missionaries. This led to the founding of institutions like

University College Ibadan in 1948, and subsequent universities such as the University of Nigeria, Nsukka, University of Lagos, and Obafemi Awolowo University, Ile-Ife.

In response to the increasing demand for higher education across African countries, including Nigeria, over the last three decades (1990s-2020s), due to population pressure, “qualification inflation,” globalization, and the rise of the knowledge economy, private universities have emerged. Additionally, to meet the need for advanced technical education and scientific studies, universities of Science and Technology and polytechnics were established in the 1980s. Private participation in the university sector began in 1999 with the establishment of Igbinedion Private University as the pioneer.

The scientific activity in Nigeria has seen rapid growth, reflected in the significant increase in scientific publications from 1,059 in 2001 to 7,900 in 2020, though still lagging neighboring countries like South Africa and Egypt (Muhammad, 2022). Nigeria boasts about 70 public research and scientific development institutes, 170 universities (comprising 79 private, 43 Federal, and 48 State Government universities), and 1,145 polytechnics and colleges of technology. Despite this extensive network, Nigeria's National Innovation System (NIS) remains weak, as the infrastructure and institutions fail to fully translate into significant advancements in research output and innovation.

6.5.1. The University Commission and Structure:

The structure of universities in Nigeria is governed by the National Universities Commission (NUC), established in 1962 as an advisory agency before transitioning into a statutory body for higher education regulation. This regulatory body plays a pivotal role in coordinating the establishment, accreditation, and evaluation of academic programs across Nigerian universities, ensuring quality and adherence to standards.

Headquartered in Abuja, the Federal Capital Territory, the NUC operates through 12 directorates and 6 regional centers across the country. As the apex regulatory body for Nigerian universities, its multifaceted functions include the approval and coordination of higher educational institutions, research and advisory services on matters pertaining to higher education development, accreditation and evaluation of academic programs to ensure quality assurance, and financial oversight to address the fiscal needs of universities. Additionally, the NUC serves as a conduit for external support, allocating and disbursing federal grants and external aids to universities. It operates as a parastatal of the government-owned corporation and is governed by a dedicated Governing Board. Comprising Ex-Officio Members, including the Vice Chancellor, Deputy Vice Chancellor, and a senior representative from the Ministry of Education, the University Governing Council ensures strategic coordination and governance across the higher education sector.

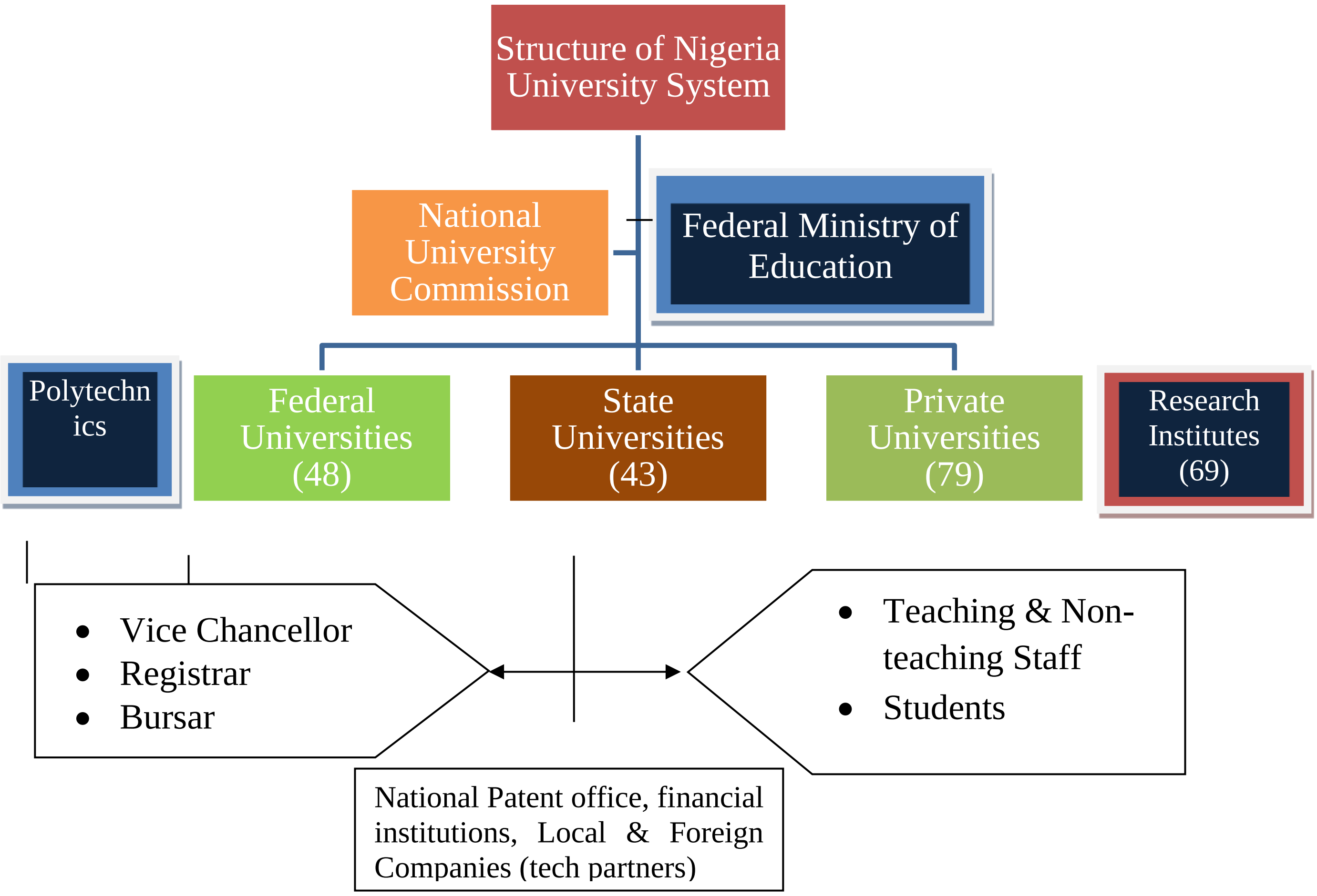

Figure 39: Structure of Nigeria University System

Source: Own Elaboration

The organizational structure of universities in Nigeria is depicted in figure 39 illustrating the hierarchical arrangement of administrative units and their functions within the university system. This organizational hierarchy of Nigeria's also has the higher education system, universities, and polytechnics providing O' and A' level education, and university research centers which collectively contribute to the advancement of knowledge and education. This structure is instrumental in facilitating the coordination and management of various academic and administrative activities, contributing to the overall functioning of the NNIS by fostering research, knowledge creation, and human capital development through educational programs and research endeavors.

6.5.2. The Contribution of Nigerian University Research to NIS

The realm of innovation and economic development, universities play a pivotal role as key actors within the National Innovation System (NIS). This section delves into the significant contribution of Nigerian university research within the broader context of the NIS, particularly examining how research activities conducted within Nigerian universities intersect with and influence both Global Value Chains (GVCs) and vital industries, including the oil sector. Through this examination, we aim to shed light on the crucial role that academic institutions play in driving innovation and economic progress within Nigeria. The petroleum sector offers substantial opportunities for students through scholarships and various trust funds, which have been instrumental in training the next generation of oil and gas engineers, physicists, and geoscientists both locally and internationally.

The research and innovation landscape in Nigeria is significantly influenced by its universities, including prominent institutions such as the University of Ibadan, University of Nigeria, Nsukka, University of Lagos, and Obafemi Awolowo University. These universities play a crucial role in the NIS by nurturing human capital and fostering knowledge creation. Through research across diverse fields, they generate ideas, technologies, and innovations essential for driving economic growth. The substantial increase in the volume of publications from Nigerian universities, from 1,059 to 7,900 between 2001 and 2020, underscores the vibrant scholarly community and commitment to advancing knowledge. This scholarly output enriches the overall knowledge base and innovation landscape, establishing Nigerian universities as pivotal entities within the country's innovation ecosystem and beyond.

However, universities in Nigeria face several challenges that hinder their ability to significantly contribute to the success of the NIS and the oil sector. Key issues include inadequate funding, leading to poor infrastructure, outdated research facilities, and insufficient resources for both students and faculty. This financial constraint limits the ability to conduct cutting-edge research and innovation critical for the NIS and the oil industry. Additionally, there is a significant gap between academic research and industry needs, with universities often not aligned with the practical demands of the oil sector. Frequent strikes and instability within the educational system disrupt academic calendars, reducing the effectiveness of educational programs and research initiatives. Furthermore, the brain drains, where highly skilled academics and researchers leave the country for better opportunities abroad, depletes the universities of talent crucial for advancing technological and industrial growth in the oil sector. Addressing these challenges is essential for Nigerian universities to play a pivotal role in supporting the NIS and enhancing the oil industry's development.

6.5.3. National Literacy Level

Nigeria's literacy level is a critical measure of its educational progress and societal development. It is measured by the ability to understand short and simple statements in life. As of recent data, the overall literacy rate in Nigeria stands at approximately 62%, with significant disparities between urban and rural areas. Gender differences are also pronounced, with male literacy rates notably higher than those of females. Contributing factors to literacy challenges include inadequate educational infrastructure, socioeconomic barriers, and regional conflicts. Despite these obstacles, ongoing government and non-governmental efforts aim to improve literacy rates across the country. Figure 40, sheds light on Nigeria’s literacy level between the periods 2000-2019 by compilation from World Bank data.

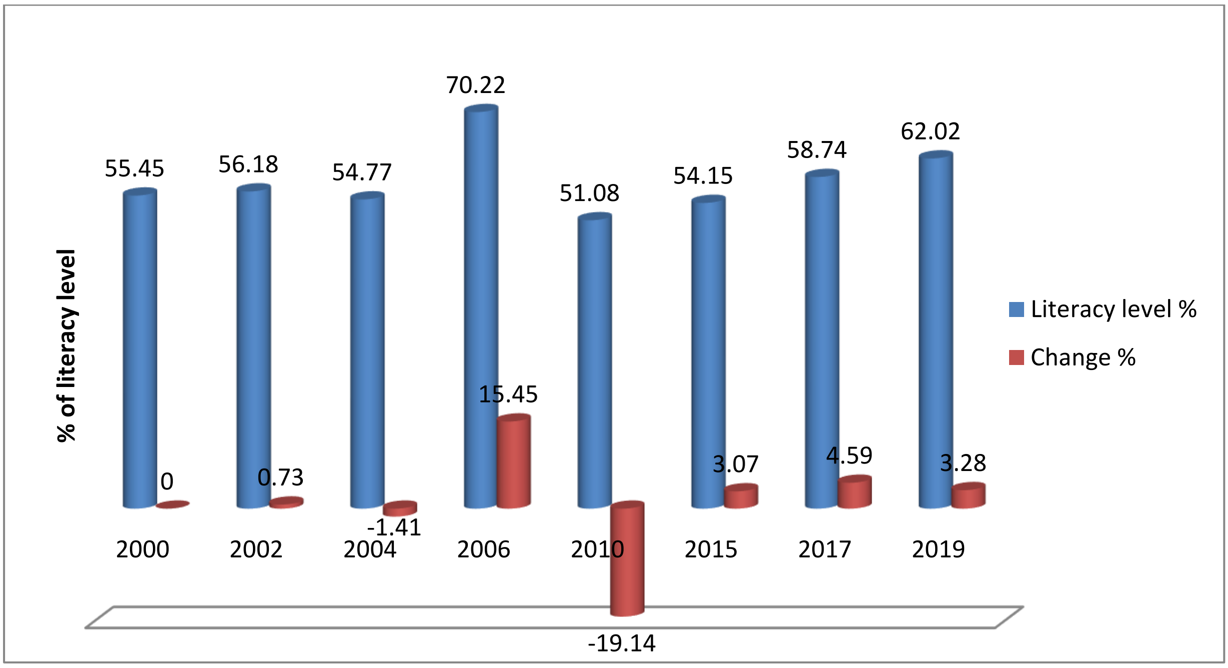

Figure 40: Nigeria's Literacy Level 2000-2019

Source: World Economic Forum (2022)

Table 42 presents data on the literacy and adult education rates in Nigeria from 2000 to 2019, revealing notable fluctuations over the years. Literacy levels peaked in 2006 at 70.22%, then saw a significant decline to 51.08% in 2010, a decrease of 19.14% from the previous year. This drop is largely attributed to environmental challenges like drought and desertification in northern states such as Borno, Kebbi, Sokoto, Zamfara, Katsina, Yobe, and Jigawa, which disrupted schooling and caused mass migration to southern regions. Federal government interventions brought about marginal improvements between 2015 and 2019, with literacy rates gradually increasing. By 2021, the literacy rate had risen to 77.62%, marking a significant 13.9% increase from 2010 to 2021. However, it has recently dropped to 62% in 2023, seemingly due to non-payment of teachers' salary and frequent strike actions. Furthermore, a UNESCO report in 2019 highlighted a gender gap, with male literacy rates at 89% compared to 78.85% for females. Basically, the data indicates a positive trend in literacy levels in Nigeria, reflecting a somewhat higher school participation from 2000 to 2019.

Overall, while Nigeria has made progress in improving literacy rates, significant challenges remain, particularly in addressing the gender and regional disparities that affect access to education and literacy outcome.

6.5.4. University Resource - Student in Higher Institutions

The University Resource in the National Innovation System (NIS) plays a pivotal role in shaping Nigeria's educational landscape and fostering innovation and development. Universities serve as key agents within the NIS, contributing to research, knowledge creation, and human capital development. It involves the multifaceted role of universities within the NIS framework earlier explained, student and academic staff etc., and, exploring their impact on research, innovation, and socioeconomic progress in Nigeria.

Table 28: Student Enrollments in Nigerian Universities 2019

Characteristics	Male	Female	Total	Total %
Federal	712,026 (59%)	494,799 (41%)	1,206,825	100
State	338,950 (62.2%)	205,986 (37.8%)	544,936	100
Private	34,850 (34%)	67,650 (66%)	102,500	100
Total	**1,085,826 (59%)**	**768,435 (41%)**	**1,854,261**	**100**

Source: World Bank (2018)

Table 28 shows that in 2019, Nigerian universities enrolled over 1.85 million students, with a gender distribution skewed towards males. Federal universities had the largest number of enrollments, followed by State and Private universities, where females were the majority. The predominance of male students across various disciplines highlights concerns about gender balance. Additionally, there are challenges such as imbalances in student-to-teacher ratios, particularly in social sciences, and issues related to infrastructure and teacher training. The number of graduates from Nigerian universities has been steadily increasing, reflecting a rising demand for higher education. This growth in both enrollment and graduation rates emphasize the need to address quality, infrastructure, and teacher training issues to better meet student needs and labor market demands.

Table 29: Academic Staff Complements in Nigerian Universities 2019

Titles	Federal	State	Private	Total
Professors	**7125**	**3033**	**1719**	**11,877**
Readers	**3377**	**1808**	**851**	**6,036**
Senior Lecturers	**7368**	**4283**	**2863**	**14,514**
Lecturer 1 & below	**21914**	**12450**	**6653**	**41,017**
Total	**39,784**	**21,574**	**12,086**	**73,444**

Source: Oladele et al. (2019)

The academic staff composition in Nigerian universities in 2019 reflected a predominance of federal university staff, comprising 54.16% of the total academic workforce, followed by state universities with 29.37%, and private universities with 16.45%. Notably, many teaching staff held PhD qualifications, indicating a significant improvement from previous decades, as highlighted by Professor Suleiman Bagoro, the Executive Secretary of

TETFUND. Despite progress in staff qualifications, challenges persist, including limited research output due to inadequate infrastructure, financial constraints, and policy instability. Nigeria's economic development has also been hindered by a lack of significant research breakthroughs and globally recognized products or companies. Despite a vast educational infrastructure, including numerous universities, polytechnics, and research institutes, Nigeria's technological capacity remains weak, contributing to high poverty rates and youth unemployment. Additionally, collaboration and skills transfer within higher education institutions and between countries in Africa are hampered by a lack of conducive environments for educational advancement.

6.5.5. Educational Spending & NNIS

Educational spending stands as a critical component of national investment, shaping the trajectory of human capital development and innovation within Nigeria. This allocation of resources encompasses various sectors, including primary, secondary, and tertiary education, reflecting the government's commitment to fostering a knowledgeable workforce and advancing societal progress. In Nigeria, the budgetary allocation is recognized but the distribution of educational funding seems not prioritized in curriculum development, infrastructure enhancement, and research initiatives, to reflect broader goals of economic growth and social development. Thus, the allocation and utilization of educational resources tends to rather slow innovation, and students and researchers with the skills necessary to navigate a rapidly evolving global innovation landscape (Isola, 2010).

Basically, the bulk of funding for higher education and public research, excluding private universities, is shouldered by the government through federal and/or state subsidies. However, this responsibility, with the government providing over 90% of the funding for higher education and nearly 100% for primary education, is perceived as burdensome, especially given the consistent rise in the student population over the years.

While the number and size of universities in Nigeria have been increasing annually, there have been challenges, such as fee hikes in State Universities and the promotion of industrialization under an import substitution strategy (Ibeme, 2020). However, the oil economy, which initially supported both educational development and industrialization, faced a downturn in the late 1990s because of declining crude oil prices. This downturn subsequently resulted in reduced financing and revealed vulnerabilities in the university system, the National Policy on Education, and the Import Substitution Industrialization (ISI) strategy. Since then, the situation has persisted. Figure 43 delineates the breakdown of educational expenditure spanning from 2011 to 2021 in the country.

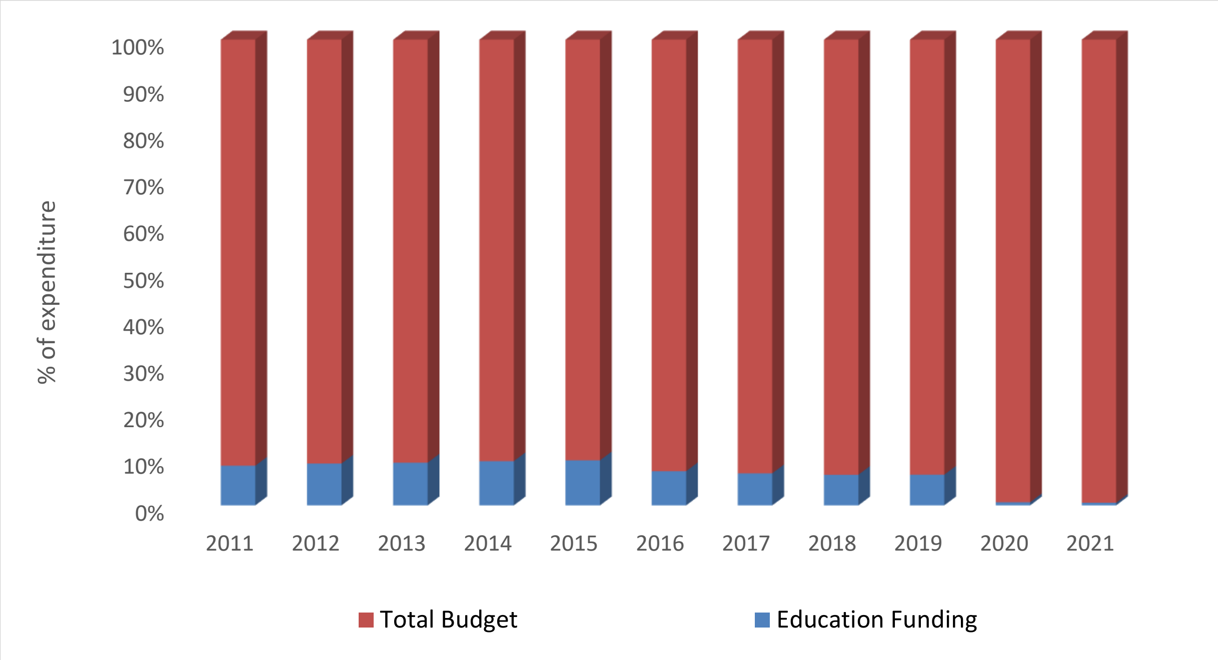

Figure 41: Education spending as a share of National Budget 2011-2021

Source: NBS (2022)

Figure 41 depicts the National Budget and its allocation for the educational sector in Nigeria. The analysis reveals variations in the total budget over the years, with fluctuations likely influenced by economic conditions, government policies, and external factors. There is a significant increase in the total budget from 2016 to 2020, followed by a notable decrease in 2021. These fluctuations can affect various sectors and services reliant on government funding, including education, infrastructure, and social welfare programs.

Specifically, findings indicate that the allocation for education as a percentage of the total budget has been consistently low, ranging from 5.6% in 2021 to a peak of 10.7% in 2015. The declining trend from 2015 onwards is concerning, showing a decrease in the prioritization of education within the national budget. Despite occasional fluctuations, the overall trend points to insufficient investment in education compared to other sectors. Inadequate funding can lead to a decline in the quality of education, affecting facilities, resources, and teacher salaries, which has implications for the National Innovation System (NIS). Countries that invest more in education often have a competitive edge in the global market (Intarakumnerd et al., 2012). Nigeria's low education funding may hinder its ability to compete internationally in various sectors (Ibeme, 2020).

Moreover, comparing Nigeria with other African nations provides valuable insight into regional trends and disparities. However, comparing Nigeria with other African nations provides valuable insight into regional trends and disparities. While Nigeria struggles with low allocations for education, it is essential to examine how its funding levels compare with those of neighboring countries. Figure 42 illustrates this comparison.

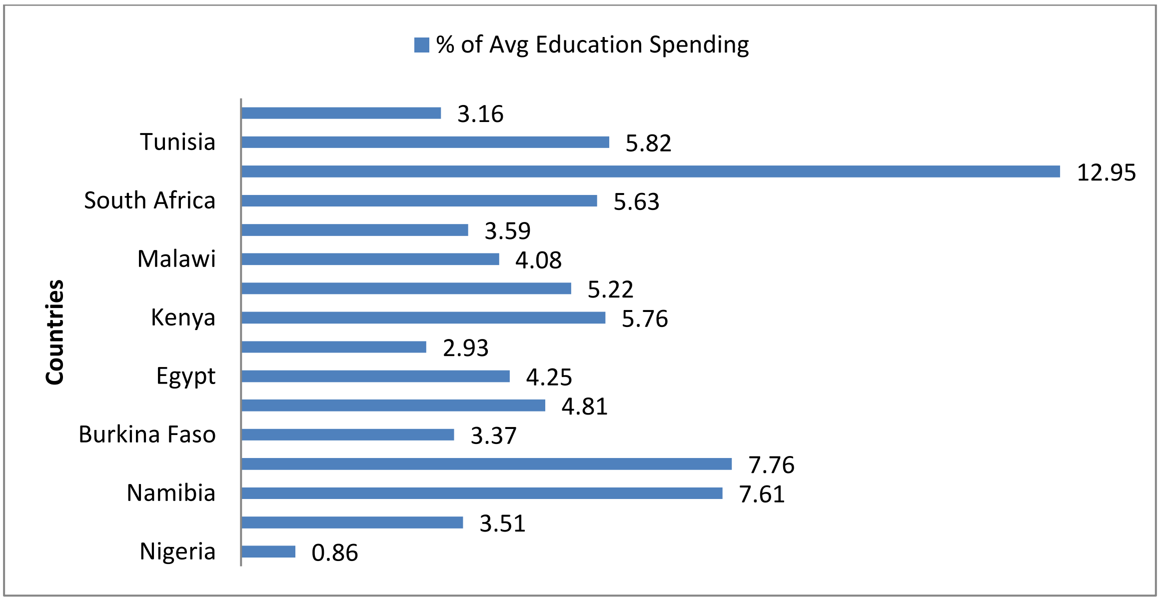

Figure 42: Average Education Spending of Selected African Countries 1990-2020

Source: Adegbite (2022)

Analyzing education budgets across Africa allows us to assess Nigeria's position in the region and identify areas for improvement in education and the entire Science, technology and innovation stands.

Figure 42 shows Nigeria being compared with 15 other African countries in their average education spending between 1990 and 2020. The result of findings reveals Nigeria’s education expenditure, at a mere 0.86%, which is notably lower than that of 15 other African countries, with Mauritius leading the pack at 12.95%. This glaring difference underscores the urgent need to address educational challenges through increased funding, particularly for innovation-related initiatives. Oketch (2016) assert that insufficient funding remains a persistent obstacle across various educational sectors in Nigeria, including universities and public research and development institutions. This funding shortfall hampers Nigeria's ability to effectively compete in knowledge-based activities, a handicap not observed in institutions abroad.

Furthermore, Sayed & Ahmed (2015) highlights the critical role of university performance, emphasizing the importance of teacher quality and curriculum relevance. Nigeria's innovation terrain also suffers from a lack of collaborative partnerships, as noted in successive literature on innovation in the country. These barriers collectively contribute to stagnation in labor productivity and technological advancement, highlighting the pressing need for strategic interventions to address these challenges and foster sustainable progress in Nigeria's education and NIS.

6.6. Science and Technology in NNIS

Science and technology play a pivotal role in Nigeria's National Innovation System (NIS), serving as catalysts for economic growth, societal development, and global competitiveness. With a growing emphasis on innovation-driven initiatives, the integration of science and technology within the NIS framework is more crucial than ever. This introduction delves into the dynamic terrain of science and technology within Nigeria's NIS, exploring its impact, challenges, and opportunities for advancement.

Since gaining independence, Nigeria has achieved notable technological strides, particularly in industries such as steel and petrochemicals. However, the nation still grapples with a significant shortage of skilled labor and remains heavily reliant on foreign technologies to meet its developmental needs. Scientific education and training primarily occur at prestigious institutions like the University of Ibadan, University of Ife, University of Nsukka, University of Lagos, and several major federal universities specializing in sciences and technology.

From 2000 to 2015, approximately 42% of college and university enrollments were in science and engineering fields, highlighting a substantial interest and investment in these disciplines. To bolster scientific research and innovation, the Federal Ministry of Science, Technology, and Innovation oversees 69 research centers, with a focus on various fields including science, technology, engineering, mathematics, biology, and anthropology. Additionally, the establishment of two universities of petroleum in Warri and Kaduna underscores Nigeria's commitment to advancing its capabilities in crucial sectors of the economy. Despite these efforts, challenges persist, necessitating continued investment, collaboration, and strategic planning to propel Nigeria's science and technology landscape forward.

Ahmed et al. (2015) and Osuagwu et al. (2018), aptly described Nigeria's technological terrain as characterized by a significant power vacuum, awaiting proactive efforts from any geo-political zone willing to mobilize its populace through dedicated and selfless innovation services. This observation underscores the critical need for strategic initiatives and collaborative endeavors to harness Nigeria's vast potential in science and technology for the nation's sustainable development.

Furthermore, science and technology (S&T) play a pivotal role in national development. As Ibrahim et al. (2014) emphasize, citing Metcalfe, any nation that neglects the advancement of S&T does so at its own peril. The interplay between knowledge creation and exploitation forms the bedrock of science and technology, with new knowledge continually unlocking fresh opportunities. Recent authors such as Johnson & Rickard (2022) articulate this dynamic, expanding on Steedman & Metcalfe (2013) description of innovation and/or economic development as a "self-exciting" process driven by the division of labor and market interactions within societies. However, in Nigeria, the trajectory of this process and its outcomes are often unpredictable, thus pose challenges in leveraging S&T for NIS development. Despite this, advancements in science offer avenues for generating practical solutions to societal challenges through technology, driven by the quest to understand natural principles are still awaiting necessary outcomes in the country.

In terms of research, Nigeria's research and development (R&D) capabilities, as indicated by the number of researchers and R&D personnel per million inhabitants, are described in many literatures as still evolving from the foundational stage. Siyanbola (2016), in comparing Nigeria with South Africa, noted that Nigeria's achievements fall significantly behind. Specifically, Nigeria has 119 researchers and 222 R&D personnel per million inhabitants, whereas South Africa boasts 815 researchers and 1,207 R&D personnel, approximately seven and six times more than Nigeria, respectively. This highlights the substantial gap in R&D capacity between the two countries. Investing in building capacity in science, technology, and innovation (STI) is crucial for Nigeria's development, as evidenced by South Africa's prioritization of STI indicators to enhance their national innovation systems.

terms of human capital, Egbetokun et al. (2017) assert that many companies in Nigeria lack the requisite human skills and experience to actively engage in research, science, and technology knowledge for production and innovation. Particularly in the fields of engineering and technology, human resources tend to be primarily focused on daily operational tasks rather than on research and innovation endeavors. More recent research by Adegbite (2021) assessing the capacities of African countries across dimensions of internet use, human resources, and R&D efforts found that public authorities, government, and companies in Nigeria exhibit weak performances, particularly in technology infrastructure, business performance, and innovation policies. This deficiency adversely affects outputs such as patent enrollments and innovation results. The analysis categorized countries into groups based on their technology capabilities, with Nigeria falling into the low-technology capacity group. Within this group, Nigeria demonstrated significant shortcomings, particularly in technological efforts by government, public authorities, and companies, as well as in intellectual property protection and innovation results. Additionally, Nigeria was placed in an intermediate position in terms of available technological base. Overall, there appear to be deficiencies in the alignment between the available technological base, technological efforts, and innovation outputs in Nigeria, hindering the successful performance of the National Innovation System in the country.

Siyanbola (2016) highlighted significant limitations of the current Science, Technology, and Innovation (STI) framework, notably the oversight in measuring innovation within the informal sector. Despite its pivotal role especially in developing countries, within Sub-Saharan Africa, the informal sector is often marginalized in STI assessments. This sector serves as a crucial source of knowledge generation, technology diffusion, and innovation. The authors emphasized that existing STI indicators lack appropriate methodologies to capture the dynamic nature of this sector, as conventional survey methods may inadequately gather relevant information. This critical limitation underscores the urgent need for improved frameworks that effectively include and measure innovation in the informal sector.

Further limitations arise concerning the utilization of Science, Technology, and Innovation (STI) indicators in Nigeria, particularly regarding indigenous knowledge. Indigenous knowledge holds significant promise for sectors such as medicine, agriculture, and cultural preservation, yet its integration into policy frameworks is hindered by inadequate funding and a reliance on interviews and case studies. Abdu & Jibir (2018) cited that despite agriculture's substantial contribution to Nigeria's GDP and employment, there is a lack of standardized methodologies for measuring and utilizing innovation in the sector. Additionally, the timing of information gathering presents a challenge, as innovation surveys are conducted only once every three years, which contrasts with the need for frequent and dynamic policy decision-making. As a result, STI indicators often function separately from broader statistical strategies, hindering their effective integration into policy management processes (Elum et al., 2016).

Science and technology are significant components of Nigeria's National Innovation System (NIS), yet the country faces significant challenges in harnessing their full potential due to inadequate infrastructure, insufficient funding, and a lack of standardized methodologies for innovation measurement. Improving the integration of indigenous knowledge and enhancing the capabilities of research and development (R&D) are essential for driving economic growth and technological advancement in the country.

6.7. Government Effort in developing science, technology and innovation

Government involvement in Science, Technology, and Innovation (STI) plays a crucial role in shaping a nation's developmental trajectory. Since gaining independence, Nigeria has recognized the significance of STI in fostering economic growth, societal progress, and global competitiveness. This recognition has led to the establishment of governmental bodies and policies aimed at harnessing the potential of STI for national development. Through strategic initiatives and interventions, the government seeks to promote research and development, facilitate technology transfer, and cultivate an innovation-friendly ecosystem. This proactive engagement underscores Nigeria's commitment to leveraging STI as a catalyst for sustainable development and inclusive growth.

6.7.1. The Establishment of STI Policies in Nigeria

In 1980, the Federal Ministry of Science and Technology (FMST) was established to facilitate the development and deployment of scientific and technological resources to enhance Nigeria's socio-economic development. The Ministry aims to accelerate national progress through the production and use of appropriate technological activities. The FMST supports the formulation of policies in science and technology, research and development, and promotes activities in various basic S&T sectors such as agriculture, energy, construction, and medical science research.

Recognizing the critical role of Science and Technology (S&T) in all aspects of life and its importance in transforming Nigeria's economy from a primary resource base to a tertiary economy, the first policy on S&T was introduced in 1986. This policy has undergone several reviews in 1997, 2003, and 2005 to adapt to changing needs and advancements Mashi et al., 2014). A notable feature in the 2005 review was the emphasis on "innovation," a global tool designed to speed up economic development and growth. This approach promoted collective ownership of the policies by all stakeholders and marked the country's renewed commitment to ensuring that R&D engagements enhance new businesses, encourage employment, and generate wealth creation.

With ongoing technological developments, the S&T policy was reviewed again in 2012 to address challenges in local technology and innovation development. The policy was designed to align with the objectives and pillars of Vision 20:2020 and the Millennium Development Goals (MDGs), aiming to resolve the longstanding disconnect between economic planning and innovation. Its core mission was to build a more diversified, sustainable, and competitive economy with a better standard of living, thereby positioning Nigeria among the top 20 economies globally. This prompted the formulation of federal government guidelines for policy engagement, encompassing various strategic aspects to foster national development through STI, including:

- The formulation, monitoring and review of National Policy on S&T guidelines to support the attainment of the macro-economic & Social objective of Vision 20:20:20 in related fields.
- Promotion of wealth creation agenda through support to key industrial and manufacturing sectors.
- Increase energy reliance through sustainable research & development in nuclear, renewable and alternative energy sources
- To acquire and apply innovation contribution to increase agriculture and livestock production.
- Involved in the creation of technology infrastructure, acquisition and application of space technology as a key driver to economic development.
- Application of natural medicine resources and technologies for health sector development.
- Ensuring the impact of R&D results in the Nigerian economy through the promotion of indigenous research capacity to facilitate technology transfer.

Currently, the FMSTI has 17 Agencies under its supervision with specialization in biotechnology, R&D and other innovation activities in the following Agencies:

- The Board for Technology Incubation (NBTI)
- Energy Commission of Nigeria
- Institute of Trypanosomiasis and Onchocerciasis (NITR)
- Raw material research and development Council
- National Space research & development Agency
- National Agency for Science and Engineering Infrastructure (NASENI)
- Institute of Science and Laboratory Technology (NISL)
- National Office for technology acquisition and promotion
- Nigeria building and road research institute.
- National Institute of leather science & technology
- National center for technology and Management (NACETEM)

- National Research Institute for Chemical Technology
- Sheda Science & Technology Complex
- Project and science development institute
- National Biotechnology development Agency (NABDA)
- Nigeria natural medicine development Agency (NNMDA)
- Federal Institute of Industrial Research and Development

These agencies collectively contribute to advancing technology and innovation across various sectors in Nigeria. They also strive to align with their designated functions, but they face significant inefficiencies. This inefficiency is reflected in Nigeria's status as more of a consumer than a producer or innovator in technology. The primary reason for this gap is the failure to develop a solid technological foundation, which has led to a persistent dependence on imported industrial products (Akanle & Shittu, 2022). This issue was notably addressed in a speech by former President Dr. Goodluck Jonathan during the commissioning of Nigeria's first locally built warship, the "NNS ANDONI." The President expressed regret that the country had not advanced its Science, Technology, and Innovation (STI) base sufficiently, largely due to inadequate progress in technology development (Oladipo et al., 2012). Supporting this view, Adikwu et al. (2017) pointed out Nigeria's shortcomings in high-quality research and development (R&D). This lag has led to low levels of intellectual property creation and journal publications, which have hindered the nation's progress in science, technology, and innovation. The authors stressed the importance of creating and applying knowledge within the framework of the National Innovation System (NIS) to address these challenges effectively.

In addition, the African Union Agenda for critical technical Skills has repeatedly pointed out the challenges and weaknesses of Science and Technology in Africa and indeed Nigeria. Scores for this subject matter have often been given a poor rating even in other external rankings like GII. Records have shown that Nigeria has invested very little in Science, Technology, and Innovation (STI) in the past 3 decades. Currently, the country's Gross expenditure for research is between 0.13% and 0.2%, which is less than the half of the world's required global average of 0.4% (Ogar et al., 2019). Many smaller and emerging countries in Africa such as Seychelles, Kenya, and South Africa, have demonstrated superior R&D output compared to Nigeria. Hence, there is a pressing need for Nigeria to enhance its research and development initiatives to remain competitive and foster innovation.

6.7.2. Other Insights on the Performance of NIS in Nigeria

- **(i) Research & Development**

The significance of Research and Development (R&D) in driving economic progress is widely acknowledged by experts. Contemporary studies emphasize that Science, Technology, and Innovation (STI) are pivotal for fostering economic transformation. Remarkably, over 50% of the wealth generated by developed nations can be attributed to technologies rooted in research. This underscores the critical role of STI in driving innovation-led growth and ensuring sustainable economic development.

Like global trends, the significance of Research and Development (R&D) for economic progress has garnered recognition with NNIS. Recent studies underscore the pivotal role of STI in driving economic transformation, echoing the sentiment that over 50% of the wealth generated by developed nations stems from research-based technologies. This acknowledgment underscores the imperative for Nigeria to prioritize R&D activities within its innovation framework to foster sustainable economic growth and development. Figure 43 illustrates the trends in R&D expenditure in Nigeria over the past decade from 2010-2022. This visual representation showcases the fluctuations and patterns in R&D investment, offering insights into the prioritization of research activities and their contribution to innovation and economic development within the country.

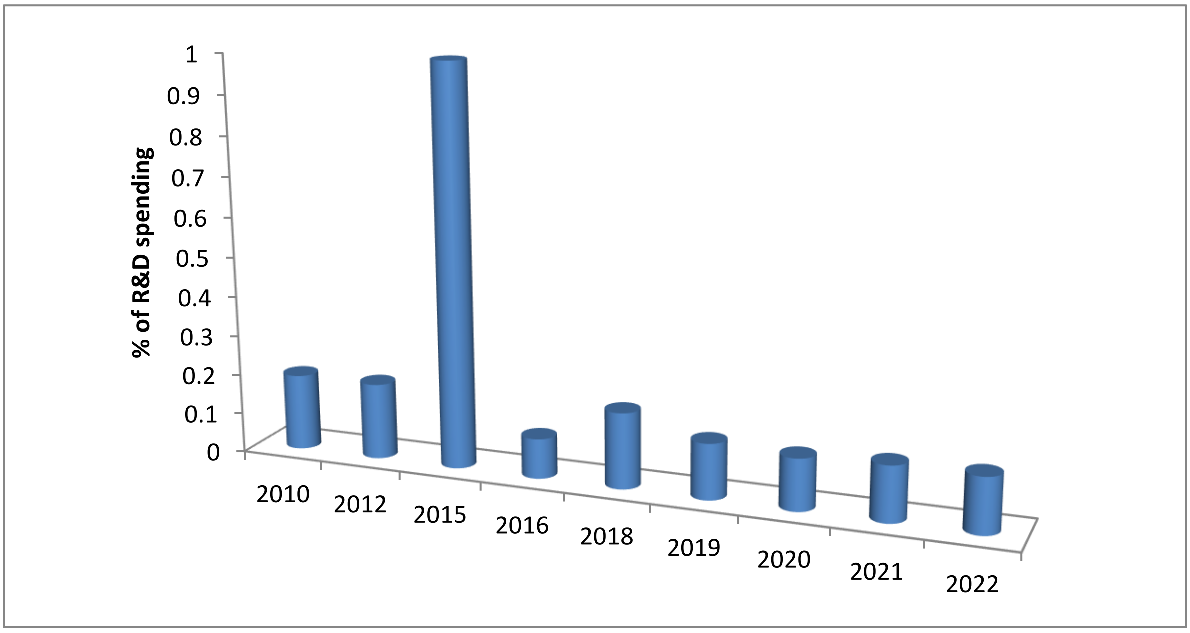

Figure 43: Share of R&D Expenditure 2010-2022

Source: Own Elaboration

The depicted figure 43 serves as a crucial indicator reflecting both state and private sector engagement in research activities. Highlighting the trends in research and development (R&D) expenditure over time, it offers valuable insights into the level of investment directed towards innovation within Nigeria's National Innovation System. Notably, the highest R&D expenditure observed was 1% in 2015, suggesting a potentially positive correlation between R&D investment and economic development. However, during the recession period in 2016, funding plummeted to 0.10%, indicating a significant decline in research investment. Subsequent years saw relatively modest allocations, ranging from 0.13% in 2020 to 0.19% in 2012 and 2019. This variability underscores the fluctuating commitment of the government for research and development activities during the periods under review.

- **(ii) Share of High-tech products in exports**

The production and utilization of high-tech products play a pivotal role in shaping the economic landscape of nations worldwide. Defined by their advanced technological features and innovative capabilities, these products encompass a diverse range of sectors, from electronics and telecommunications to biotechnology and aerospace. As catalysts for innovation and drivers of economic growth, high-tech products represent the forefront of industrial development and competitiveness in the global arena. In the context of NNIS, the exploration and integration of high-tech products hold significant implications for advancing technological capabilities, fostering industrialization, and enhancing the country's overall economic resilience. This introduction sets the stage for a deeper exploration of Nigeria's engagement with high-tech products within its innovation ecosystem.

Figure 44 illustrates Nigeria's technology and innovation capability through its high-tech exports, providing valuable insights into the country's production structure and focus on high-tech products. As a key indicator, high-tech exports shed light on Nigeria's engagement with advanced technologies and innovation within its economic landscape as analyzed in figure 44. By analyzing this trend in high-tech exports, it is believed that policymakers and stakeholders would gain a deeper understanding of Nigeria's strengths and opportunities in the high-tech sector, guiding strategies for enhancing technological capabilities and fostering innovation-driven growth.

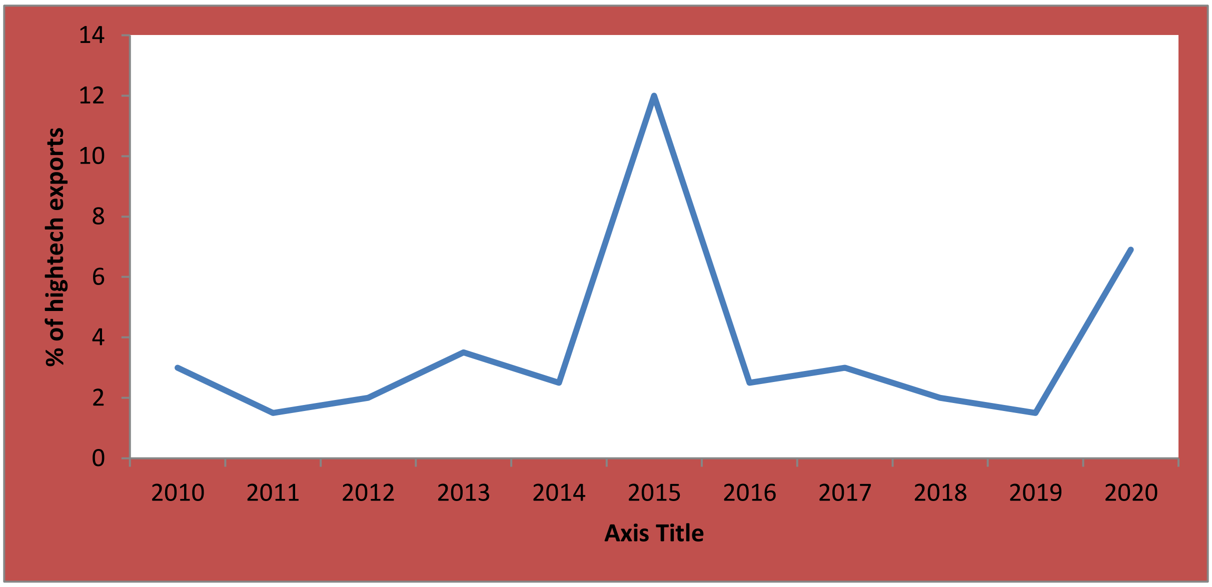

Figure 44: Nigeria High-tech Exports

Source: World Economic Forum (2022)

Figure 44 illustrates the trends in Nigeria's high-tech exports from 2010 to 2020, highlighting both fluctuations and limited growth in this sector. There was a significant increase of about 12% in 2015, but the following years saw only slight improvements or even declines, with the lowest point dropping to just 1%. By 2020, the exports gradually rose to 6.9%. These trends underscore the challenges and constraints facing Nigeria's high-tech industry, which is overshadowed by the dominance of natural resource exports, particularly in the oil sector. The country's heavy reliance on natural resources, coupled with fluctuations in global oil prices, has posed significant obstacles to diversifying its economy and fostering technological innovation. Moreover, despite a sizable population of students in higher education, Nigeria's investment in education and research as a percentage of GDP remains low, highlighting a disconnect between human capital development and technological advancement. This paradox, along with the phenomenon of Dutch disease and governance challenges, hampers Nigeria's ability to harness its vast natural resources for sustainable economic development, perpetuating a cycle of underdevelopment in key sectors like downstream oil production.

- **(iii) Number of Citations, Publications and H-index**

Research publications, citations, and H-index serve as vital indicators of academic and scientific advancement, reflecting the dissemination and impact of scholarly work within Nigeria. These metrics are pivotal for evaluating the quality and influence of research outputs, with higher numbers of publications and citations indicative of greater recognition and significance within the academic community. Moreover, research publications and citations play a crucial role in advancing knowledge across various fields, fostering collaboration among researchers, and guiding future research endeavors.
Table 30 is a comparative analysis of research publication and citation data across five countries: the USA, Algeria, Nigeria, Tunisia, and South Africa, based on Scimagoir 2020 records (Gema et al., 2020). Nigeria ranks 51st in Africa, with 12,435 documents and 11,812 citable documents, resulting in 161,756 citations. The country's H-index, a measure of productivity and citation impact, stands at 291, suggesting a moderate level of research output and influence within the academic sphere.

Table 30: Selected countries' Ranking Citations, Publications & H-index 2019

Country & Rank	Region	Documents	Citable Document	Citation	Self-Citation	Citation per doc	H-index
USA 1st	North America	724830	613526	9508307	3672746	13.12	280
Algeria 55th	Africa	8860	8417	69342	14473	7.83	235
Nigeria 51st	Africa	12,435	11,812	161,756	22,538	8.3	291
Tunisia 57th	Africa	8504	7931	68143	11792	8.01	257
S. Africa 27th	Africa	29898	26569	329126	62702	11.01	614

Source: Gema et al. (2020).

In continuing the analysis, the comparison of research publication and citation data reveals notable trends among the included countries. The United States emerges as the leader in research output and influence, boasting the highest H-index and ranking first across various metrics such as publications in all subjects, citable documents, self-citations, and other documents.

African nations exhibit a spectrum of research activities and influence levels. Nigeria, ranking 51st, demonstrates promising research output with 12,435 documents. However, its citation impact and self-citation rate suggest opportunities for enhancing research quality and visibility. In contrast, South Africa stands out with a higher citation count and H-index, indicative of a robust research culture and impact within the African continent. South Africa's position as the 27th out of 241 countries for combined indicators underscores its prominence in the global research landscape. Meanwhile, Algeria and Tunisia occupy the 55th and 57th positions, respectively, out of 241 countries, reflecting their substantial but relatively lower research influence compared to Nigeria and South Africa.

Also, records indicate that the financing landscape for innovation in Nigeria is inadequate, with innovation expenses falling below UNESCO-recommended benchmarks, as highlighted by the National Bureau of Statistics (NBS) in 2018. Industry data reveals that less than 1% of the national budget is allocated to scientific research, a disparity confirmed by the Global Innovation Index (GII) results. Malerba (2017)attributes this shortfall to poor research capabilities and ineffective technology transfer practices, while Siyanbola (2016) emphasizes the insufficient financial support for universities and research institutes as a primary factor. Authors like Egbetokun et al. (2017) emphasize the need to enhance the quality of researchers, while Akinwale (2016) advocate for increased focus on applied research and knowledge dissemination. Sweet and Eterovic (2019) echo these sentiments, suggesting a stronger emphasis on entrepreneurial activities to drive innovation in Nigeria.

Still other literatures attribute weaknesses in Nigeria's education system to longstanding issues such as poor funding and neglect of subjects like Mathematics, English, and Physics. Additionally, poor linkages between research institutions and industry exacerbate these challenges. Shenkoya (2019) argue that declining STEM education and frequent strikes by academic unions further contribute to these issues. The chronic underfunding of education and research activities has significant implications for the National Innovation System (NIS) and the oil industry. This lack of investment stifles human capital and technological development, thus hampering innovation in the oil sector and hindering its adaptability and competitiveness in the global market. The conclusions drawn by various authors highlight the weaknesses present in Nigeria's R&D programs. Omobhude and Chen (2019), Olofinyehun et al. (2022), Siyanbola (2016), Isola (2010), and Oyedepo (2012) all emphasize the shortcomings within the country's research and development initiatives with the key weaknesses including:
inadequate funding, insufficient infrastructure, and limited collaboration between academia, industry, and government.

In response to the identified shortcomings and the pressing need for research, science, technology, and innovation enhancement, the Nigerian government enacted legislation, including the National Center for Technology Management (NACETEM) and Research and Development Centers, under the Science, Technology & Innovation Act of 2012, amended in

2020. This legislative framework aims to reform institutions and rename the Ministry of Science and Technology to serve as a catalyst for innovation and economic growth. The focus on research and development is intended to strengthen coordination, promotion, and management within the system, reducing standalone research efforts without synergies. Notably, the appointment of Dr. Ogbonaya Onu, an experienced civil servant, as Executive Secretary of NACETEM, and Muhammad Abdullahi, an educationist with a passion for STEM fields, as Minister of Science, Research & Development, signifies a strategic move towards fostering R&D in Nigeria NACETEM, (2020). Additionally, the National Policy on Research, Science, and Technology Act addresses specific measures to promote R&D, laying the groundwork for advancement in these critical areas are:

- The establishment of a common ground in research and development, science and technology, thinking across the various relevant courses like Mathematics, Physics, Life science, social, human and economics.
- Promoting innovative and independent thinking with optimum development of intellectual capacity building especially in science, research and technology (exposing students to careers and opportunities that ignite passion for STEM education).
- Developing research, science, technology and innovation in the country.
- Encouraging collaborations between Nigeria and international institutions abroad on the development of research and STIs.
- Improving investment in education, research and STI

Despite these plans and frequent reviews, these challenges seem to extend beyond mere governance issues and encompass factors such as the translation of ideas into tangible outcomes and the provision of moral and financial incentives. Experts highlight the crucial role of governance in bridging the gap between policy formulation and practical implementation, shedding light on the complexities inherent in translating STI policies into reality. Furthermore, insights from Akanle & Shittu (2022) underscore the persistent challenges of moral and financial incentives, which continue to hinder the effectiveness of STI policies despite frequent reviews. Additionally, alternative perspectives may include discussions on the impact of high-tech industries, publication metrics, and the broader landscape of STI performance, providing a holistic understanding of the multifaceted dynamics shaping the NIS terrain. Addressing these deficiencies is crucial for enhancing Nigeria's innovation ecosystem and fostering sustainable. Additionally, examining interactions between key stakeholders - universities, industries, and government - is crucial for shaping effective STI policies and initiatives, facilitating the flow of knowledge, resources, and expertise within the innovation ecosystem. Our next section delves into these interactions within the University-Industry-Government framework.

6.8. INTERACTIONS WITH UNIVERSITY-INDUSTRY- GOVERNMENT (UIG)

The linking of universities, industries, and government in the National Innovation System (NIS) involves fostering collaborative relationships or partnerships to facilitate knowledge exchange, technology transfer, and innovation-led economic growth. This collaboration takes various forms such as: the joint research projects, technology commercialization initiatives, industry-academia partnerships, government funding programs for research and development, and policy frameworks that support innovation and entrepreneurship. Management experts explain that effective coordination and communication among the stakeholders are essential to leverage their respective strengths and resources for driving innovation and sustainable economic development.

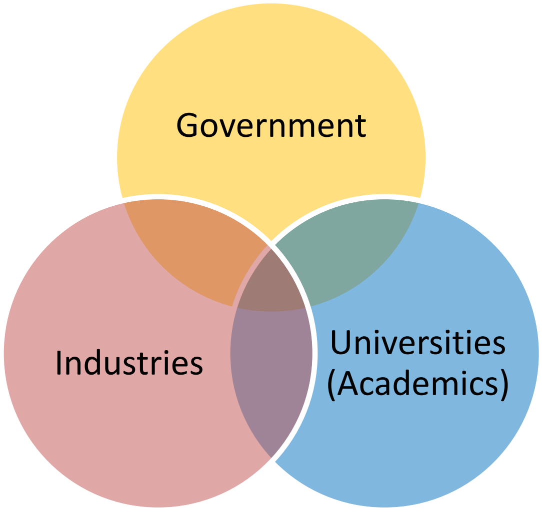

Figure 45: University-Industry-government interaction.

Source: Own Elaboration

6.8.1. Overview of UIG in Nigeria

University-industry-government relationship is one of the major sources of external knowledge and technologies for industries particularly in the context of the emerging markets and industry development (Cunningham et al., 2019). It is the framework that represents the collaboration and interactions between universities, industries, and government entities within the context of innovation and economic development. In Nigeria, universities serve as centers for research, knowledge creation, and talent development. Industries contribute resources, expertise, and market insights, while government entities provide funding, regulatory frameworks, and policy support to facilitate innovation and technology transfer. Together, these three stakeholders form a dynamic system aimed at driving innovation, fostering entrepreneurship, and enhancing the competitiveness of economies. Through effective collaboration and partnerships, the UIG framework can catalyze the translation of research into practical applications, stimulate economic growth, and address societal challenge Gereffi, (1996a; Zhan, 2021; Gereffi, 1994; Egbetokun et al., 2017).

Numerous studies advocate for the integration of the educational system and human resources into the National Innovation System (NIS) as crucial elements for evaluating its performance (Lundvall, 1999). However, contrasting viewpoints exist regarding this notion.

Egbetokun et al. (2017) highlight the significance of adequate training and learning policies in the innovation process. Lin & Schulz, (2023) delineates that the NIS revolves around two key variables: the effectiveness of learning and the capacity of industries to support learning and knowledge creation.
Finley (2021), suggests that synergies between industry, higher educational institutions and government in the productive sectors in Nigeria can play a critical role in securing and leveraging additional resources for the economy and where government, helps to promote innovation and technology transfer, or by ensuring that graduates have the skills and knowledge required to effectively contribute to the workforce. Supporting, Chete et al. (2014) and Etzkowitz & Zhou, (2017), explain that there must be a very strong networking between Government, University, and the industry, such as the "Triple Helix", the vital pivot which drives the economies of nations.

6.8.2. The Key Role of Learning in the UIG in Nigeria

Learning is the cornerstone of effective university-industry-government interactions, as it facilitates knowledge transfer, workforce development, R&D, policymaking, learning and the growth of innovation ecosystem. Learning in this context involves the exchange of knowledge and insights that help governments formulate and implement policies that support innovation, economic development, and societal well-being. It includes knowledge creation, human capital development, collaboration, technology transfer and policy advocacy.

(i)Knowledge Creation: Nigerian universities serve as critical hubs for knowledge creation and dissemination across various disciplines, contributing to global scholarship and innovation through learning. Also, academic research, scholarly publications, and intellectual exchange in universities generate new insights, theories, and discoveries that advance human understanding and address societal challenges. In the era of globalization, Nigerian universities have expanded their access to international academic journals, conferences, and collaborative networks, enabling them to contribute to global knowledge creation in STEM, and other fields. Moreover, universities foster a culture of inquiry, critical thinking, and creativity among students and faculty, empowering them to push the boundaries of knowledge and explore new frontiers of research. Despite facing constraints such as limited funding, inadequate research infrastructure, and institutional barriers, Nigerian universities continue to play a vital role in shaping the intellectual landscape and driving innovation both locally and internationally (Salau et al., 2018).

(ii)Human Capital Development: Nigerian universities play a crucial role in capacity building through academic programs, professional development initiatives, and research training opportunities. They equip students, faculty, and researchers with the knowledge, skills, and competencies needed to address complex challenges and contribute to sustainable development. They also foster entrepreneurship through learning. However, capacity building efforts are hampered by resource constraints, inadequate infrastructure, and gaps in curriculum design and delivery. Addressing these challenges requires sustained investment in education and research, along with strategic partnerships with international institutions and donors (Salau et al., 2018).

(iii)Collaboration: Nigerian universities engage in collaborative research projects, joint publications, and technology transfer initiatives with international partners, strengthening their research capabilities and global presence through learning. However, the capacity for collaboration has been hindered by challenges such as limited funding, inadequate research infrastructure, and institutional barriers. Despite these challenges, universities continue to seek partnerships with international institutions to leverage expertise, resources, and networks for mutual benefit, (Shenkoya, 2019).

(iv) Technology Transfer: Nigerian universities facilitate technology transfer and commercialization activities through research partnerships, licensing agreements, and entrepreneurship programs. They collaborate with industry stakeholders, startups, and investors to translate research findings into innovative products and services. However, technology transfer initiatives are often hindered by intellectual property issues, regulatory barriers, and limited access to financing. Enhancing technology transfer requires streamlined processes, supportive policies, and investment in innovation systems to nurture entrepreneurship and facilitate knowledge diffusion (Edeh et al., 2020).

(v) Policy advocacy: Nigerian universities advocate for policies that promote internationalization, research collaboration, and knowledge exchange to address global challenges and advance national development priorities. They engage with government agencies, international organizations, and industry stakeholders to influence policy decisions and foster innovation. However, the impact of policy advocacy is often limited by institutional constraints, bureaucratic hurdles, and political dynamics, necessitating greater coordination and collaboration among stakeholders (Onele et al., 2022).

6.8.3. The Constraints of UIG

Numerous literatures have explained that the Nigerian Innovation System (NIS) faces numerous constraints stemming from governmental challenges, which hinder its growth and effectiveness. One major issue is inconsistent and inadequate funding, which limits the resources available for research, development, and innovation initiatives. Policy instability and lack of clear, long-term strategic plans further exacerbate the situation, creating an unpredictable environment that discourages sustained investment and participation from both public and private sectors. Additionally, bureaucratic inefficiencies and corruption impede the smooth implementation of innovation policies and the effective allocation of resources. These constraints, coupled with insufficient support for collaboration between academia, industry, and government, significantly impede the NIS's ability to drive technological advancements and economic development in Nigeria. Other crucial constraints include the following:

(i) Government Initiatives and Policy Implementation: While the government may introduce policies and initiatives to promote university-industry collaboration, effective

implementation can be hindered by bureaucratic inefficiencies, lack of coordination between government agencies, and limited enforcement mechanisms (Olofinyehun et al., 2022).
(ii) Regulatory Barriers: Complex regulatory frameworks and bureaucratic procedures can create barriers to collaboration between universities and industries. Streamlining regulations and establishing clear guidelines for partnership agreements could help alleviate these barriers and facilitate smoother collaboration (Salau et al., 2018).
(iii) Funding Constraints: Adequate funding is essential to support government-led initiatives aimed at facilitating university-industry collaboration. However, budgetary constraints and competing priorities within government spending may limit the resources available for such initiatives, reducing their effectiveness (Ibeme, 2020).
(iv)Skills Mismatch: There are somewhat mismatches between the skills and expertise available within universities and the needs of the oil industry. Government initiatives to bridge this gap through skills development programs and training initiatives may face challenges in effectively addressing the diverse and evolving skill requirements of industries (Kayizzi-Mugerwa et al., 2021).
Addressing these challenges will require a multi-faceted approach, including policy reforms, targeted investments, capacity building initiatives, and stakeholder engagement efforts to create an enabling environment for university-industry collaboration and foster economic and NIS growth.

6.8.4. UIG and Engagement with Industries

In Nigeria, the critical interaction between universities, industry, and government, which is essential for driving innovation and economic development, is significantly underdeveloped. This lack of synergy has hindered the nation's ability to effectively leverage academic research for industrial growth and policy formulation. Understanding the underlying reasons for this weak collaboration is vital to addressing the gaps and fostering a more robust Nigerian NIS. The following discussion explores the primary factors contributing to the minimal linkages between these sectors, highlighting the challenges and potential pathways for improvement. One major reason is inadequate funding, which limits universities' ability to conduct meaningful research and engage with industry.

Additionally, there is a significant disconnect between academic curricula and industry needs, leading to a workforce that is often not aligned with market demands. Bureaucratic inefficiencies and corruption further hinder effective collaboration and resource allocation. Moreover, frequent strikes and instability within the educational system disrupt academic activities and diminish the potential for sustained partnerships between these sectors unlike advanced economies.

However, there are few instances where research plays a crucial role in the country's UIG interaction. Examples of such collaborations include research projects, providing technical expertise in soil experiments, spill management, and other extractive services. These partnerships enable the industries to leverage academic expertise and specialized knowledge to address industry-specific challenges, improve operational efficiency, and drive sustainable development. However, core challenges such as limited funding, bureaucratic processes, and institutional barriers often hinder the full realization of the potential benefits of university-industry engagement in the sectors. Despite these obstacles, ongoing efforts to strengthen these collaborations hold promise for advancing innovation, driving economic growth, and fostering sustainable development in the country, as noted by researchers like Dutse et al. (2021), Isola (2010), and Siyanbola (2016).

Table 31: Universities & Research Collaborations 2010-2015.

Type of Agency in Collaboration	Percentage of Collaboration
Universities Abroad	4.9
Nigerian Universities	6.8
Local Research Agency	32.8
International Research Agency	11.5
Industry	23.2
World Bank	2.3
Federal Government	9.2
Non-Governmental	2.3
Central Bank	1.9
Other Banks	0.8
Professionals	2.8
State Government	1.5

Source: (Isola 2010; Siyanbola, 2016)

6.8.5. Vertical collaboration between Oil Industry & Universities in Nigeria

In Nigeria, the collaboration between the oil industry and universities takes on various forms, including vertical collaboration. Vertical collaboration refers to partnerships that occur between entities operating at different levels of the supply chain or industry hierarchy. In the context of the oil industry and universities, vertical collaboration involves cooperation between upstream oil exploration and production companies and academic institutions.

These collaborations often focus on research and development (R&D) activities aimed at enhancing exploration and extraction techniques, optimizing production processes, and addressing environmental and sustainability challenges. For example, universities may conduct research projects funded by oil companies to develop new technologies for oil exploration in challenging terrains or to improve the efficiency of extraction methods. Furthermore, this type of collaboration sometimes extends to knowledge exchange programs, where the oil industry professionals share their practical insights and experiences with university researchers, and vice versa. This exchange of knowledge helps bridge the gap between theoretical understanding and practical application, enriching academic research and informing industry practices.

The universities of Ibadan, Lagos, Nsukka, Ile-Ife and the petroleum Institute in Warri are some of the direct examples of universities engaged in such tasks of providing specialized knowledge and education programs tailored to the needs of the oil industry workforce, equipping professionals with the skills and knowledge required for the sector's evolving demands. Akinwale YO, (2016), noted that Nigeria's, vertical collaboration between the oil industry and universities is relatively limited, despite its potential benefits. Several factors contribute to this scarcity of engagements. Ahmed et al. (2015), consistently highlight the weak relationship between universities and the oil industry, contributing to Nigeria's low ranking in the Global Innovation Index (GII) and in turn, the increase in refined oil import. This deficiency underscores the limited impact of knowledge exchange between academia and industry, hindering the oil sector's ability to drive economic growth effectively. Omoregie (2019) identifies several factors contributing to this lack of integration, including the academic nature of university training, issues of trust in research quality, and brain drain. Despite these obstacles, increased collaboration between universities, industry, and government is essential for advancing Nigeria's innovation system, as suggested by Akinwale YO (2016). Table 32 provide some examples of linkages between the oil industry and universities in Nigeria, highlighting the need for enhanced collaboration to foster innovation and economic development.

Table 32: Collaboration Activities of Oil Sector & Universities in Nigeria 2015-2020.

Jobs Completed by NNPC in-house research Department	On-going Research Projects	Partners	Other Collaborations with Academic/Research Institutions & Training
• Research into integrated Stratigraphy for quality upgrade in crude oil production. • Environmental Impact Assessment Studies of • Eleme Petrochemicals Company Limited.	Non-Conventional Upgrade of Whole Crude & Refined Products R&D on the Conversion of Nigerian Bentonite clay for use as drilling mud.	Shell Petroleum Development Company (SPDC), NAPIMS & PPMC ADDAX Petroleum Service, AFREN Energy Resource	NNPC Research & Training Center (NRTC). HYSYS training for chemical processing (in-house). Obafemi Awolowo University (Issues in Applied, Analytical and Image Science Research, 2013 & 2017)
Oil Spillage and Ground Water Pollution for PPMC in Baruwa, Ipaja, Alimisho and Lagos	• R&D and Conversion of Nigeria Portland Cement to G-cement for Oil Drilling	PPMC Research team, Oil and Gas Servicing Companies, Schlumberger, Halliburton and Hardy Oil Nigeria	Obafemi Awolowo University (Issues in Global Environment: Pollution and Waste Management, 2012)

Jobs Completed by NNPC in-house research Department	On-going Research Projects	Partners	Other Collaborations with Academic/Research Institutions & Training
• Nannopaleontology analysis for SPDC and • High resolution Biostratigraphy studies for Shell, SNEPCO oil project in Northwest field etc.	• Oil Ester based Drilling Fluid • & Deep-Water drilling evaluation	Chevron, Exxon Mobil, Ansett and DUBRI Oil	Covenant University (Oil Production, Demand and Refining output in 2020 & University of Ife (The Political Ecology of Oil and Gas Activities in Nigeria's Aquatic Environment, 2017)
• Delineation and Assessment of impacted sites at Ekerekana- Okirika and Ogale- Eleme	Restructuring of Port Harcourt R&D Facility laboratory	Equator Lab Exposition Nigeria	Rivers State University of Science &Technology, Port Harcourt (Refining and the modular refineries, 2015)
Integrated Studies of Anambra Basin and Benue Trough for National Petroleum Investment Management Services (NAPIMS)	Research on the demand for lubricants, chemicals, natural gas and ways for further reduction of sulfur/impurities and oil spillages	NAPIMS, Natore Chemicals, Total Nigeria and Northeast Petroleum	PPMC, Department of Petroleum Resource and University of Ibadan (World Catalogue of oil spillage, 2004)
• Evaluation of Natural Gas Company (NGC) Supply from Oben Metering Station to Geregu Power Plant & • NGC Gas Alaoji Pipeline Project	• Post Impact Assessment Studies • Ogbodo Oil Spill • Yorla South Oil well fire outbreak for NPDC	Federal Ministry of Science and Technology, NEXEN Petroleum and Amalgamated Oil	PTDF Graduate Overseas Training, Nigeria Research and Innovation Council (NRIC), & National Center for Technology & Development (NACETEM)
• Assessment of OML 65 & 111 for NPDC, Aroh 49 & Aroh North field • Benin, Kaduna and Yenegoa Mega fuel stations Launch • Upgrade of Petroleum Research Centre in Port Harcourt –River State	NNPC Research and Development Council	NNPC R&D, Petrobras, Shell, Conocco Philips, Exxon Mobil, Total Nigeria, Eni, AGIP Exploration Nigeria etc.	Federal University of Petroleum Resources, & Petroleum Training Institute (Warri, Kaduna and RST- Port Harcourt)

Source: Own Elaboration adapted from NNPC Petroleum Industry Act (2021)

Table 32 presents the external and collaborative relationships between Nigerian universities and the oil sector, framed within the context of SDG-led policies, emphasizing private sector emergence, entrepreneurship, and environmental development. Despite some attempts at collaboration, these relationships are limited, reflecting the constraints previously mentioned. Encouraging stronger and sustainable linkages between universities and industry, promoting worker mobility between both domains, and reviewing funding mechanisms for research are proposed strategies to enhance relevance and effectiveness (Hassani et al., 2017). Such interactions facilitate shared knowledge and create new opportunities to support innovation activities, aligning universities with their missions of contributing to national development and competitiveness (Kiseleva et al., 2022).

Despite efforts to develop UIG over the past two decades, numerous literatures suggest limited improvement in its organization and effectiveness, thus, creating a gap between NIS in advanced countries and those in developing countries like Nigeria. In addressing the performance of NIS, particularly its role in the Nigerian oil sector, the upcoming Customer Innovation Survey (CIS) will employ various analytic indicators to examine NIS processes comprehensively. This survey aims to analyze NIS influence on innovation activities in Nigeria's oil sector, identify gaps, and provide recommendations for improvement. Such measures are crucial for fostering an efficient NIS capable of driving technological progress and innovation, not only in the oil industry but also for broader national economic development, including regional expansion.

6.9. SUGGESTION - NNIS & TECHNOLOGY APPARATUS FOR ECONOMIC RECOVERY 2025

The National Innovation System (NIS) plays a crucial role in shaping Nigeria's technological advancement and economic development. The government's Economic Recovery & Growth Plan (ERGP) for 2017-2025 outlines a comprehensive strategy for economic revitalization, with a strong emphasis on technological advancement. Central to this plan is the goal of fostering sustained inclusive growth through increased investment in Nigerians and enhancing the efficiency of both public and private sectors. By prioritizing advancements in science, technology, and innovation, the plan aims to build a globally competitive economy. Key areas of focus include addressing environmental challenges, bolstering electricity power capacity, and supporting domestic oil refining to reduce reliance on petroleum imports. Additionally, the plan targets improvements in the criminal justice system and rule of law through the deployment of advanced detection technologies, such as videos, 3D imaging, and positioning systems.

Furthermore, the introduction of a rapid electronic ID system is envisioned to enhance security measures for oil theft as well as combat terrorism and violent extremism effectively. Advancements in technology, such as artificial intelligence, blockchain, and the Internet of Things (IoT), are expected to play a significant role in shaping the future of NNIS. These emerging technologies have the potential to revolutionize industries, improve efficiency, and create new opportunities for innovation and growth.

In the aspect of R&D, the capabilities within the NIS will be crucial for driving technological innovation and competitiveness in Nigeria. This investment is envisioned to support the development of new technologies, enhance knowledge creation, and foster collaboration between academia, industry, and government.

Overall, the outlook for NNIS and technology in 2025 is one of optimism and opportunity. By leveraging emerging technologies, fostering collaboration, and implementing supportive policy frameworks, Nigeria can position itself as a leader in technological innovation (NNIS) and drive economic growth with increased GPVC participation in the years to come.

6.10. SUMMARY

Chapter 6 serves as a pivotal exploration into the intricacies of Nigeria's National Innovation System (NIS), building upon the foundational understanding established in previous chapters. This chapter focuses specifically on the dynamics of innovation within Nigeria's socio-economic landscape, with a particular emphasis on the role and performance of the NIS. Through a detailed analysis, it provides insights into the mechanisms driving innovation and highlights the unique challenges and opportunities within Nigeria's innovation ecosystem.

The chapter begins by tracing the historical development of the Nigerian NIS, from the establishment of key institutions to the implementation of modern policies and initiatives aimed at fostering innovation. It underscores the significant influence of government interventions, research organizations, and industry partnerships in shaping the trajectory of Nigeria’s innovation landscape. This sets the stage for a more detailed examination of the NIS and its overall performance.

It then shifts focus to evaluating the Nigeria’s NIS performance using the Global Innovation Index (GII)**,** analyzing key indicators such as human capital development, research capacity, and economic outcomes from 2011 to 2020**.** The findings reveal that Nigeria consistently ranks lower than advanced and emerging economies**,** reflecting gaps in R&D investment, technological advancement, and knowledge diffusion**.** Compared to countries in the EU, Mauritius, South Africa, and rapidly developing Asian economies**,** Nigeria's innovation system struggles with weak institutional frameworks and limited private-sector participation**,** hindering its competitiveness in global markets. This analysis directly addresses Research Question 2**,** which examines Nigeria’s innovation capacity. Additionally, it provides answers to Objectives 3 and 4 by evaluating the potential of Nigeria’s National Innovation System (NIS) in upgrading the oil industry and its role within Global Value Chains (GVCs) while identifying strategic measures to enhance innovation-driven economic growth.

Despite the country’s fluctuating rankings, Nigeria's stable income levels within lower-income categories are acknowledged, thus positioning the country as an emerging player in the global innovation landscape. The chapter delves into specific challenges and opportunities facing innovation within Nigeria, examining factors such as research and development (R&D) investment, technology adoption, and knowledge diffusion. By utilizing case studies and empirical evidence, it highlights the mechanisms through which innovation occurs in the broader Nigerian economy.

Building on this foundation, the chapter addresses critical issues such as environmental sustainability, technology transfer, and intellectual property rights, emphasizing the need for targeted policy interventions to address these challenges effectively. It provides actionable recommendations for enhancing innovation outcomes, particularly within sectors that are integral to Nigeria's economy.

Furthermore, the chapter explores the broader implications of innovation on the Nigerian economy and society, including potential spillover effects on sectors such as education, infrastructure, and renewable energy. This analysis underscores the interconnectedness of Nigeria’s innovation ecosystem and the importance of adopting a holistic approach to innovation policy that maximizes the contribution of the Nigerian NIS to national development goals.

In conclusion, this chapter underscores the significant weaknesses within Nigeria’s NIS, particularly the need for stronger partnerships between industries, universities, and government entities. These collaborations are crucial for facilitating technology transfer, reducing dependency on fuel oil imports, and enhancing economic resilience. By fostering greater collaboration and implementing effective policies, Nigeria can strengthen its NIS and support sustainable economic development. Looking ahead, this chapter lays the groundwork for the proposed survey, which will be the focus of the next chapter. The upcoming analysis will delve deeper into the interaction between Nigeria's oil sector and its NIS, offering further insights into how these systems can be optimized.

Chapter 7.
The Nigerian Oil Industry in the Nigerian National Innovation System

In today's globalized economy, innovation is widely recognized as a key driver of economic growth, competitiveness, and sustainable development. At the heart of any nation's innovation ecosystem lies its National Innovation System (NIS), a complex network of institutions, policies, and actors that collaborate to foster innovation and technology development.

Nigeria, as a resource-rich economy with a significant presence in the global oil market, stands at a critical juncture where harnessing the power of innovation is paramount for achieving long-term economic prosperity and reducing dependence on crude oil exports. The country's National Innovation System holds immense potential as a catalyst for driving innovation across various sectors, including the oil industry, and promoting economic diversification.

This chapter focuses on the Nigerian oil sector within the context of the NNIS, aiming to address a critical paradox: why does Nigeria, a net oil-exporting country, import refined oil instead of refining it domestically? The oil sector is a core component of Nigeria's economy, significantly influencing its economic development and innovation capabilities. Understanding the dynamics of innovation within this sector is crucial for identifying pathways to enhance technological advancement and economic growth.

To explore this paradox, the chapter employs a questionnaire based on the Community Innovation Survey (CIS) methodology. The CIS provides a comprehensive framework for assessing innovative activities, capabilities, and outputs within the oil sector. The survey focuses on key aspects such as sources of knowledge, turnover, research activities, product innovation (new to the firm and new to the market), thus, enabling the analysis of innovation drivers and barriers, and assessing innovation outcome.

By analyzing responses from the questionnaire, this chapter aims to uncover key findings that align with the research objectives and questions. It also seeks to provide a comprehensive understanding of the innovation terrain within Nigeria's oil sector. This information is crucial for identifying the strengths and weaknesses of the current NIS and for developing strategies to enhance its effectiveness in promoting the upgrading of the Nigerian Petroleum Industry (NPI). The insights gained will be instrumental in guiding policy decisions, driving strategic investments, and fostering collaboration between industry stakeholders and NIS enablers, ultimately contributing to the sustainable development and competitiveness of Nigeria's oil sector.

This methodological approach ensures a thorough examination of how the Nigerian oil sector contributes to and is influenced by the broader NIS, offering insights into potential areas for policy intervention and strategic development. Through this analysis, the chapter seeks to shed light on the underlying factors that contribute to Nigeria's reliance on imported refined oil and to propose strategies for enhancing domestic refining capacity.

7.1. RESEARCH METHODOLOGY

In this research, a self-structured questionnaire based on the Community Innovation Survey (CIS) model was utilized to collect data on innovation activities within the target firms. The CIS is a well-established survey framework, widely used across various industries to assess the extent and nature of innovation in industries or regions. The questionnaire was structured into several sections to capture different aspects of the firm's operations and innovation activities. Section A introduces the geography and economic activities of the firm, thus providing a contextual background. Section B focuses on marketing and the provisions of the company, examining how the oil firms position and promote their products and services. Section C addresses knowledge acquisition, exploring both internal and external sources, including agents and other influential sources of knowledge that contribute to innovation. Section D delves into innovation types and significant improvements, covering product and process innovations, as well as organizational and marketing changes.

By using this questionnaire, the research ensures a standardized approach to evaluating innovation, enabling comparative analysis across different oil firms in Nigeria. This method offers a robust foundation for understanding the innovation dynamics within, thus allowing for a thorough analysis of the factors that drive or hinder innovation at the firm level.

- **Research Population**

The research population consists of 30 companies primarily engaged in the petroleum industry in Nigeria. These companies include indigenous Nigerian oil companies, National oil companies, and multinational oil companies such as Shell Petroleum Development Company, ExxonMobil, Chevron Oil, Total Oil Limited, and others. By capturing perspectives from this diverse group of stakeholders, the research aims to gather comprehensive insights into innovation processes, challenges, and opportunities within the sector.

The companies were selected based on several criteria, including their year of establishment, market capitalization (preferably above $10 million USD), involvement in a combination of upstream, midstream, and downstream activities, and their contribution to inclusive growth and social mobility within oil host communities. Due to the absence of a specific database for oil and gas companies in Nigeria, Google Earth maps and other geographical information systems were utilized to identify the companies. Out of the 30 companies identified, 25 responded to the survey questionnaire, representing approximately 85% of the total population. This response rate ensures a robust dataset that reflects the views and practices of key players within the Nigerian oil industry.

- **Research Design/Method**

The research design adopts a mixed-methods approach, specifically tailored to comprehensively investigate the Nigerian oil industry in the Nigerian Innovation System (NNIS). This multifaceted approach combines both qualitative and quantitative techniques, allowing for a robust exploration of the complex relationship between innovation and industry performance.

(i) Qualitative: This aspect of the study involves descriptive inquiry supported by an extensive review of relevant literature, documents, and industry reports. This review not only establishes the theoretical framework but also enriches the contextual understanding of the innovation dynamics within the Nigerian oil industry. The analysis of scholarly literature and industry reports provides crucial background information and deepens the qualitative findings, offering insights into the broader context of innovation in Nigeria.

(ii) Quantitative: This involves the primary data collection tool which is a questionnaire based on the Community Innovation Survey (CIS) model. This survey is important for gathering empirical data on innovation activities, capabilities, and challenges within the Nigerian oil sector. The questionnaire is administered to key stakeholders, including oil companies, research institutions, and regulatory agencies, with the aim of collecting firsthand information on innovation practices, investment patterns, and their impact on oil industry performance. The questionnaire does not only provide empirical evidence but also enhances the quantitative analysis by offering real-world insights that complement the qualitative finding.

The data collection in this research involved both primary and secondary sources. Primary data was gathered from a self-structured questionnaire based on CIS-based model/format to provide firsthand information on innovation practices and their impact on industry performance. Secondary data was sourced from industry reports, government publications, statistical databases, and academic journals, offering additional context and supporting empirical analysis.

The final stage of the research involved integrating qualitative and quantitative data, interpreting the findings in relation to the research objectives, and drawing conclusions based on the theoretical framework and empirical evidence. This comprehensive approach ensures that the research design and methodology work in tandem to provide a thorough analysis of innovation within the Nigerian oil sector. Additionally, the study’s findings contribute significantly to the understanding of the Nigerian National Innovation System (NIS), offering valuable insights into its capabilities and limitations. The research provides targeted recommendations aimed at enhancing innovation practices within the Nigerian oil sector and improving the overall performance of the NIS. Furthermore, the implications extend to policymakers, educational institutions, and stakeholders in other petroleum economies, informing broader discussions on innovation and development in the global context.

7.2 ANALYSIS OF THE QUESTIONNAIRE

The study examines oil and gas companies registered and operating in Nigeria under the indigenous Act of the Federal Government, categorizing them into two groups based on their year of establishment and incorporation. The first group, known as old generation companies, involve oil companies established between the 1950s and 1999. This period captures the early years of Nigeria's oil industry, which was dominated by multinational companies (MNCs). The industry's development during this time was characterized by significant foreign investment as well as the establishment of major infrastructure and exploration activities. MNCs played vital roles in shaping the industry's initial growth and setting up the foundational frameworks for oil extraction and processing.

The second group comprises the new generation indigenous oil companies that commenced business operations from the 2000s until 2022. The subsequent years reflect a period of significant changes and developments in the Nigerian oil industry. This era saw the entry of new firms, including indigenous companies, driven by policy changes, increased privatization, and local content initiatives. The period also witnessed advancements in technology, shifts in global oil markets, and evolving regulatory environments.

The choice of these periods effectively highlights the evolution of Nigeria's oil industry from its early foundations dominated by multinational companies to a more diversified sector with increased participation from new and indigenous firms. This historical segmentation allows for a detailed comparison of how different generations of companies approach turnover, personnel management, and other key factors in the oil industry in Nigeria. This chapter investigates the Nigerian oil industry in the Nigerian Innovation System (NIS).

7.2.1. Descriptive Analysis

This section provides an overview of key innovation indicators derived from the survey responses, offering insights into the structural composition and operational characteristics of firms within the Nigerian oil industry. The analysis begins by examining the size and ownership structure of participating firms, distinguishing between multinational corporations (MNCs), indigenous oil companies, and national oil companies. Additionally, firms are categorized based on their years of operation, classifying them into old-generation firms (established between the 1950s and 1999) and new-generation firms (established from 2000 onward). This classification helps in understanding the evolution of the industry, particularly in relation to innovation activities and technology adoption. Furthermore, turnover and revenue trends are analyzed to assess the financial performance of firms, while workforce composition is explored by evaluating the proportion of personnel employed for innovation activities. The study also investigates the level of investment in research and development (R&D), knowledge acquisition strategies, and the various types of innovation implemented within the sector, especially the product and process innovations. Additionally, the analysis identifies the major barriers to innovation, such as financial constraints, regulatory challenges, and infrastructure limitations. By presenting these descriptive findings, this section establishes a foundation for subsequent statistical analysis, particularly the Chi-Square tests, which examine the relationships between key variables such as the R&D as well as the Learning Process with observed and expected counts for both internal and external uses. Other graphical analysis also provides critical insights into the innovation dynamics of the Nigerian oil sector and serve as a benchmark for assessing its position within the broader National Innovation System (NIS), starting with the turnover and personnel data analysis.

(1) Turnover and personnel data

The sub-section provides an analysis of turnover figures and personnel data for both old and new generation oil firms with a focus on highlighting key performance metrics from 1950-2022. Table 33 shows the financial scale and human resource distribution across the surveyed companies for 3 years (2020-2022). These visuals will help illustrate deeper understanding of their innovation capabilities and operational efficiencies. Also, the study encompasses 30 oil companies, of which 25 responded to the questionnaire, representing about 85% of the sample population. The analysis includes 16 old-generation companies and 9 new-generation companies.

Old Generation: Among the old generation companies, which include MNCs, Chevron stood out with the highest turnover in 2020, reporting over $135.710 billion. However, there was a slight decline in 2021, with Chevron's turnover dropping to approximately $122.22 billion. In contrast, Basumoh Energy Limited, one of the smallest players, recorded the lowest turnover in 2020 at $84 thousand USD, and despite an increase in 2021, it remained the lowest with $175,730. By 2022, Shell Nigeria Plc emerged as the leader with a turnover of $171.450 billion, while Basumoh recorded a marginal increase to $190,675, maintaining its position as the company with the lowest turnover.

In terms of personnel, NNPC Limited consistently had the highest number of employees, with 7,388 personnel in 2020, slightly decreasing to 6,500 in 2021, and then slightly increasing to 6,621 in 2022. On the other hand, Basumoh Energy Limited had the smallest workforce, with just 60 personnel in 2020, increasing slightly to 75 in the subsequent years. The substantial difference in personnel numbers between NNPC Limited and companies like Basumoh Energy Limited suggests significant variations in the scale and scope of operations. However, having a large workforce without a corresponding output could indicate inefficiencies in resource allocation and utilization within the organization.

The turnover/personnel ratio provides further insight into the efficiency of these companies. Total Energy, established in 1956, consistently demonstrated the highest and most favourable turnover/personnel ratio across the three years, with returns of $157,097,242.38 in 2020, $165,820,689.66 in 2021, and $189,931,034.48 in 2022. In contrast, Accugas Oil and Gas exhibited the lowest turnover/personnel ratio, with $714.29 in 2020, followed by Frontier Energy with $888.89 and $818.18 in 2021 and 2022, respectively. A low turnover/personnel ratio implies that the company generates less revenue per employee, indicating potential inefficiencies in resource utilization and productivity. Such companies may struggle to cover operational costs, leading to financial strain and reduced competitiveness.

New Generation: For the new generation companies, Bell Energy consistently posted the highest turnover figures, starting with $1.9 billion in 2020, increasing to $2.2 billion in 2021, and further growing to $3 billion in 2022. Conversely, Frontier Oil and Gas Ltd recorded the lowest turnover across all three years, with figures of $120 thousand USD in 2020, dropping to $90 thousand USD in 2021, and remaining the same in 2022.

In terms of workforce, Quest Energy had the highest number of employees among the new generation firms, with 5,250 personnel in 2020, increasing to 6,500 in 2021 and maintaining the same number in 2022. Seven Energy, on the other hand, had the smallest workforce, with just 35 personnel in 2020 and slightly increasing to 50 in the following two years.

The turnover/personnel ratio analysis reveals that the newer companies generally have lower ratios compared to their older counterparts. For instance, Bell Energy, despite its high turnover, has a turnover/personnel ratio of $361,904.76 in 2020, $338,461.54 in 2021, and $461,538.46 in 2022. In contrast, Frontier Energy's ratios are significantly lower, highlighting inefficiencies that may impact its sustainability and competitiveness in the long term.

Comparison of the turnover between old and new generation

When comparing the two generations of companies, it is evident that the old generation MNCs dominate in terms of both turnover and personnel. This dominance can be attributed to their established market presence, extensive global networks, and access to resources that allow them to operate at a larger scale. The high turnover figures of these MNCs highlight their economic influence within the Nigerian oil sector.

Table 33: Turnover and Personnel of Oil and Gas Companies in Nigeria.

Old Generation Oil Companies (From Year 1950 to 1999)							
Company	**Year**	**2020**	**2021**	**2022**	**2020**	**2021**	**2022**
		Turnover ($)			**Personnel**		
Shell	1950	96,500,000,000	120,870,000,000	171,450,000,000	2700	2700	2952
ExxonMobil	1956	80,298,000,000	99,483,000,000	124,386,000,000	1860	1749	2000
Total	1956	108,240,000,000	120,220,000,000	137,700,000,000	689	725	725
Chevron	1963	135,710,000,000	122,605,000,000	155,798,000,000	5900	5874	6000
NNPC	1977	34,322,000,000	21,402,000,000	45,688,000,000	7388	6500	6621
ASCON	1984	67,000,000	56,450,000	48,000,000	500	485	350
Conoil	1984	1,300,000,000	6,220,000,000	8,560,000,000	125	140	151
Azimarine Ltd	1985	250,000	325,000	450,000	95	75	75
Coscharis	1987	500,240,000	680,220,000	750,780,000	520	595	595
Basumoh	1988	84,000	175,730	190,675	60	75	75
NLNG	1989	69,780,000,000	98,230,000,000	108,620,000,000	1572	1800	2263
Oriental Energy	1990	700,000	621,000	924,000	380	320	521
Atlas Pet	1991	1,100,000,000	1,586,000,000	2,100,000,000	500	538	538
Dredging Int	1991	737,200,000	1,300,000,000	2,100,000,000	70	95	109
Oilserv	1992	81,912,000,000	103,514,000,000	164,522,000,000	1602	1684	1684
AMNI Intl	1993	50,410,000	53,780,000	76,240,000	128	162	162
New Generation oil Companies (From Year 2000 - 2022)							
Company	**Year**	**2020**	**2021**	**2022**	**2020**	**2021**	**2022**
		Turnover ($)			**Personnel**		
Frontier	2001	76,000	80,000	90,000	102	90	110
Network Exploration	2001	250,000	201,000	314,000	37	55	55
Bell	2002	1,900,000,000	2,200,000,000	3,000,000,000	1500	1905	1905
Prudent Energy	2004	200,000	280,000	311,000	100	91	125
Petro Pride	2008	200,000	350,000	400,000	189	200	250
Quest	2010	422,870,000	470,560,000	620,150,000	5250	6500	6500
Accugas	2010	120,000	285,000	350,000	168	168	182
Seven Energy	2012	100,000	270,000	345,000	35	50	50
KARAKI	2014	500,000	500,000	400,000	100	120	200

Source: Data from Own Survey

In contrast, the new generation companies, while smaller in scale, show potential for growth. Bell Energy's increasing turnover is a testament to the growing capabilities of some domestic firms. However, the low turnover/personnel ratios observed in some new generation companies, like Frontier Oil and Gas, indicate potential inefficiencies in resource utilization, which could hinder their competitiveness and long-term sustainability.

The analysis of the average turnover over the three years further emphasizes the disparities between the two groups. Chevron, from the old generation, recorded the highest average turnover at $138.038 billion, while Basumoh had the lowest at $150,135. Among the new generation companies, Bell Energy boasted the highest average income at $2.37 billion, with Frontier Energy having the lowest at $82 thousand USD. These figures provide a comprehensive view of the financial standing of oil and gas enterprises, reflecting their innovation capabilities and business acumen.

Overall, the analysis underscores the significant challenges faced by domestic oil firms in scaling up operations to compete with the already established MNCs. The findings suggest a need for strategic interventions, including policy support, investments in innovation, and efforts to enhance the operational efficiency of domestic companies. Addressing these challenges is crucial for reducing the sector’s reliance on imports, promoting sustainable economic growth, and improving the overall competitiveness of Nigeria's oil industry.

(2) New Knowledge acquisition

This section explores how companies acquire new knowledge, categorizing it into internal and external sources, with graphical data to support each sub-section. New knowledge acquisition is vital for enhancing creative skills, innovation capabilities, and overall competitiveness in the oil and gas sector. We evaluated the significance of this knowledge acquisition for oil and gas companies in Nigeria and other countries, using a Likert scale that ranges from "very important" to "not important." For clarity, responses were grouped into categories: "highly important" (comprising ratings of "very important" and "quite important") and "disapproval" (covering ratings of "little important," "not used," or "not important

(3) New Knowledge Acquisition- Internal

The new knowledge Acquisition - Internal focuses on the processes and strategies that companies use to develop and enhance knowledge within their organization. This includes in-house research and development (R&D) activities and internal learning processes. Effective internal knowledge acquisition is essential for fostering innovation, improving operational efficiency, and maintaining a competitive edge in the oil and gas sector.

- **R & D Activities and Process of Internal Learning:**

We analysed the R&D activities and internal learning processes of companies in Nigeria comparing them with practices in other countries. This comparison is crucial for understanding how these companies gain insights, identify best practices, and benchmark their performance to enhance their competitiveness in the global innovation landscape. The analysis also highlights the need for targeted strategies to improve R&D engagement, foster collaboration between industry stakeholders and National Innovation System (NIS) enablers and drive sustainable economic growth in Nigeria's oil sector. Figure 46 illustrates the process of new knowledge acquisition internally, providing a visual representation of how companies are enhancing their R&D capabilities and internal learning.

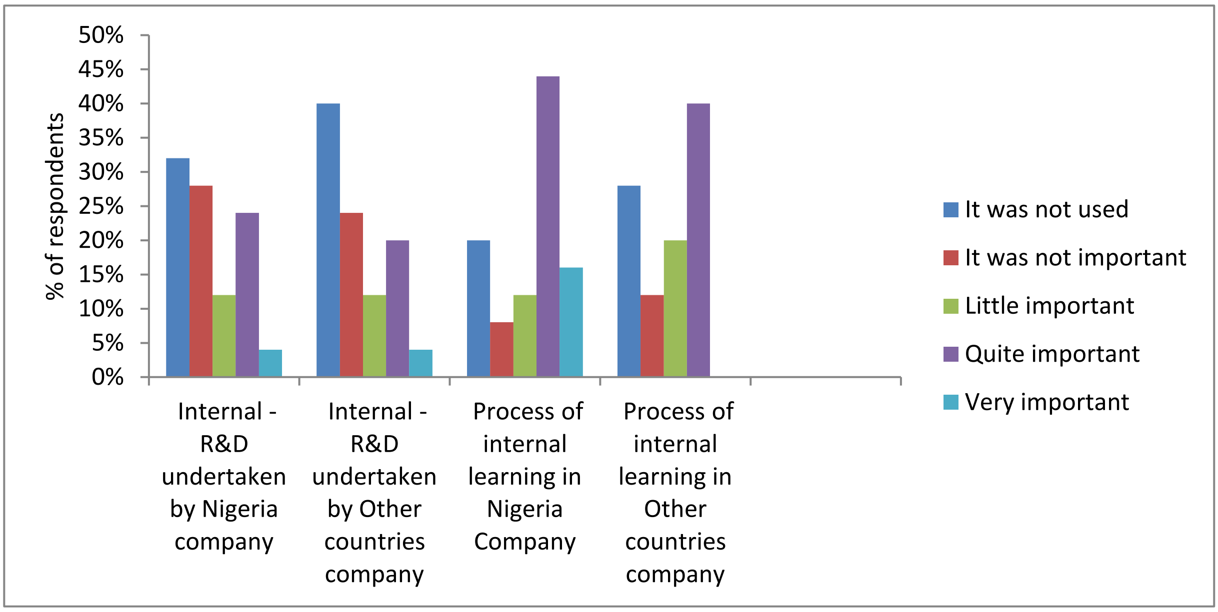

Figure 46: Knowledge Acquisition- Internal

Source: Data from own survey

Figure 46 presents the findings from the assessments of R&D activities and learning processes, both within and outside Nigeria, under the category of "new knowledge acquisition - internal." The analysis begins with an evaluation of R&D activities, followed by a review of the learning processes, leading to a comparative study between the two. The analysis includes:

(i) **R&D undertaken in Nigeria:**

- 32% of respondents reported that R&D was "not used," suggesting that a significant portion of the companies were not actively engaged in R&D activities within Nigeria.
- Additionally, 28% rated it as "not important" and 12% as "little important," reflecting a lack of emphasis or recognition of the value of R&D within the country.
- However, 24% considered it at least "quite important," and 4% rated it as "very important," suggesting that there is a somewhat recognition of the importance of R&D within Nigeria among a subset of respondents.

These results show that a significant portion of the respondents do not prioritize R&D, which can hinder innovation and technological advancement in the country's oil sector. This low level of R&D involvement suggests potential barriers to achieving higher productivity, competitiveness, and sustainable economic growth.

(ii)R&D undertaken in other countries:

- 40% of respondents indicated that it was "not used," suggesting a lack of engagement in R&D activities outside Nigeria.
- Additionally, 36% rated these activities as "not important" and/or "little important," indicating a similar lack of emphasis or recognition of the value of R&D activities conducted in other countries,
- 20% considered it at least "quite important," and 4% rated it as "very important," indicating some recognition of the importance of R&D activities conducted outside Nigeria among a subset of respondents.

When considering both aspects (R&D within and outside Nigeria), the finding reveals a general deficiency in R&D engagement among the surveyed companies both within Nigeria and abroad. Approximately 72% and 76% of the sampled companies showed low engagement in R&D activities within and outside Nigeria, respectively. On the other hand, a minority 28% within Nigeria and 24% outside Nigeria primarily multinational companies, demonstrate support for internal R&D initiatives. These results highlight a significant weakness in R&D practices within the Nigerian oil industry. There is a clear need for increased investment and engagement in R&D, both domestically and internationally, to foster innovation and secure competitive advantages in the sector.

- **Process of Internal Learning:**

This category typically examines the mechanisms or activities through which organizations acquire, internalize, and utilize new knowledge, skills, or technologies to drive innovation and improve their products, processes, or services. The data finding which start with companies within Nigeria suggests a relatively balanced perspective among respondents, with some notable disparities.

(i) Learning Process in Nigeria:

The analysis of internal learning processes within Nigerian companies reveals a mixed perspective on its importance:

- A sizable proportion of respondents (60%) considered internal learning to be at least "quite important" or "very important."
- Additionally, 12% of respondents rated it as "little important."
- However, 20% rated it as "not used," and 8% ranked it as "not important.

This data suggests that while most respondents recognize the value of internal learning processes, a notable proportion (28%) either do not utilize it or do not consider it important.

This discrepancy indicates potential barriers to fully leveraging internal learning opportunities. To address this, companies should enhance internal training by developing comprehensive training programs and workshops that emphasize the importance of continuous learning and skills development. Additionally, fostering of a corporate culture that values and rewards learning could help in overcoming these challenges.

(ii) Learning Process outside Nigeria:

The analysis of learning processes outside Nigeria shows a similar distribution of responses:

- 40% of respondents rated external learning as "quite important," and
- 20% rated it as "little important,"
- A significant proportion (40%) indicated that it was “not important” or "not use”.

This suggests a notable level of disagreement regarding the importance of external learning processes, with 60% either not utilizing or undervaluing it. Despite the recognition of the importance of both internal and external learning processes, there is significant room for improvement in how these opportunities are leverage. To better harness these learning processes for innovation and competitiveness, companies should consider enhancing internal training programs, fostering a learning-oriented corporate culture, invest in learning infrastructure, facilitating international collaboration and implementation of policies.

Moreover, a deeper assessment of the data reveals significant disparities between multinational corporations (MNCs) and indigenous oil companies. While all MNCs in this study reported engagement in R&D activities, figure 47 illustrate a lack of alignment among Nigerian companies, highlighting the need for a more cohesive approach to internal learning and R&D within the sector.

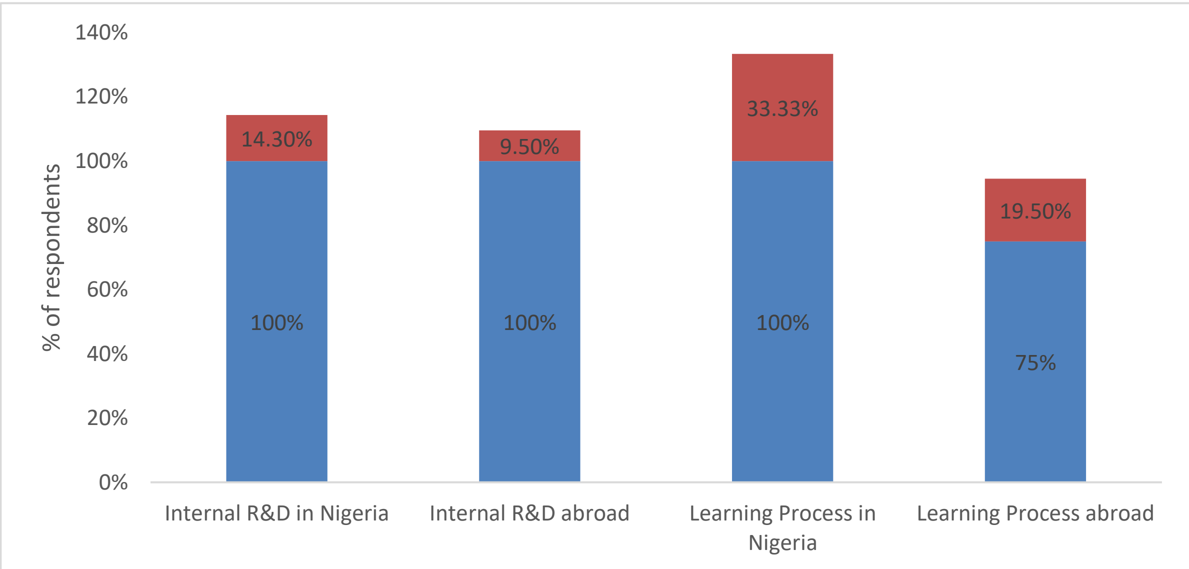

Figure 47: Comparing MNC and Indigenous Oil Firms.

Source: Data from own survey

Looking at figure 47, we compare the R&D and learning processes of MNCs and indigenous firms, while emphasizing the implications of these disparities. The results reveal a stark contrast in the approach to R&D activities between multinational companies (MNCs) and indigenous oil firms. Among the MNCs surveyed, 100% (4 out of 4) reported active engagement in R&D activities both within and outside Nigeria. In sharp contrast, only 14.3% (3 out of 21) of domestic firms supported R&D within Nigeria, and a mere 9.5% (2 out of 21) did so outside the country. This indicates a significant disparity in R&D prioritization, suggesting that many domestic firms either do not engage in R&D or consider it of low importance. This lack of focus on R&D could potentially hinder the innovation capabilities and strategies of indigenous firms, both domestically and internationally.

Similarly, there is a marked difference in the learning processes between MNCs and indigenous oil firms:

- Within Nigeria: All MNCs **(**100%**)** supported the learning process, whereas only 33.33% of indigenous oil firms did so. The majority (66.67%**)** of indigenous firms rated the learning process as "not used," "not important," or "little important".

- Outside Nigeria: 75% of MNCs supported the learning process, with 25% in other categories. Among indigenous firms, only 19.05% agreed, while 80.95% did not prioritize or utilize these processes.

These disparities highlight that MNCs are significantly more aligned with the learning process both within and outside Nigeria compared to indigenous firms. However, there is a slight improvement in the internal learning process among indigenous firms, both within and outside Nigeria. This is evidenced by a higher level of agreement in the "learning process" category, especially when compared to the low R&D scores from these firms outside the country. This trend suggests a preference for internal learning over R&D activities among indigenous firms, indicating that while R&D is undervalued, there is a growing recognition of the importance of internal learning processes.

The observed gaps between multinational corporations (MNCs) and indigenous oil companies regarding their engagement in R&D activities have significant implications for the competitiveness and innovation potential of Nigeria's oil sector. MNCs operating within Nigeria's oil industry prioritize R&D as a core element of their business strategies. This commitment to research and development enables them to stay at the forefront of technological advancements, enhance their innovation capabilities, improve operational efficiency, and maintain a competitive edge in the global market. Conversely, the lack of emphasis on R&D activities among indigenous oil companies highlights a potential gap in their approach to innovation and technology adoption. Without a strong focus on R&D, these companies may struggle to keep pace with evolving industry trends, limiting their capacity for innovation and risking a widening technological gap with their MNC counterparts. This gap could further exacerbate existing inequalities within the Nigerian oil sector, where MNCs, with their superior financial resources and access to advanced technologies, might consolidate their dominance, potentially marginalizing indigenous companies and hindering their growth.

However, the support for R&D activities among MNCs may stem from their need to navigate the complexities of modern, knowledge-based economies and the advantages they gain from their global headquarters. MNCs often possess the resources and capabilities to invest in R&D activities across borders, driving innovation and competitiveness. In contrast, the lower importance attributed to R&D activities among indigenous oil firms, particularly those conducted outside Nigeria, could be due to the financial challenges associated with moving intangible assets which is a costly and complex endeavour. Limited resources for international R&D efforts make it difficult for domestic oil companies to prioritize such activities. This challenge underscores broader weaknesses within the Nigerian Innovation System (NIS), where indigenous firms face significant barriers to engaging in R&D and innovation. Despite Nigeria's status as a net oil exporter, the reliance on imported refined oil illustrates the impact of these limitations. As MNCs lead in R&D investment and innovation, they further solidify their dominance in Nigeria's oil sector, deepening the country's dependency on foreign expertise and technologies. This situation underscores the urgent need for strategic interventions to strengthen the NIS, empower indigenous firms to engage in R&D and innovation, and reduce Nigeria's reliance on imported refined oil which is a critical step towards achieving economic self-sufficiency and sustainable development.

To address these issues, it is essential for domestic oil companies to recognize the importance of investing in R&D activities to enhance their competitiveness and drive sustainable growth. This can be achieved through partnerships with research institutions, leveraging government support for innovation initiatives, and fostering a culture of innovation within their organizations. By closing the gap in R&D engagement, indigenous oil companies can better position themselves to thrive in an increasingly competitive and dynamic industry terrain.

(4) New Knowledge Acquisition - External

The dynamic global oil and gas industry, external knowledge acquisition is vital for fostering innovation, enhancing competitiveness, and ensuring sustainable growth. External knowledge acquisition involves tapping into expertise, technologies, and practices from sources beyond the organization. This includes hiring qualified personnel, engaging in external training programs, collaborating with consultants in technology centres and universities, purchasing licenses for patents, and participating in joint innovation projects with academic institutions. For oil and gas companies in Nigeria, accessing external knowledge is particularly important given the complexity and fast-paced nature of the industry. It enables these companies to stay ahead in a competitive global market by integrating cutting-edge technologies and innovative practices. Moreover, collaboration with external entities, such as universities and research institutions, can help breach the gap between industry needs and academic research, leading to the development of innovative solutions tailored to the unique challenges of the Nigerian oil sectors.

This section delves into the extent to which Nigerian oil and gas companies engage in external knowledge acquisition, especially in comparison to same in other countries. The analysis evaluates the importance placed on external knowledge acquisition activities, using a Likert scale to gauge responses. The ratings, which range from "very important" to "not important," were grouped into "highly important" (including "very important" and "quite important") and "disapproval" (covering "little important," "not used," and "not important"). The subsequent analysis will explore the data on various aspects of external knowledge acquisition, such as hiring qualified personnel, external training hired by the companies, the specialized service from collaborating with technology consultants, acquiring patents, and participating in joint innovation projects, thus providing insights into how the Nigerian companies leverage these opportunities. The findings are supported by data in figure 48, illustrating the trends and highlighting the differences in external knowledge acquisition practices. This comprehensive understanding will shed light on the strategic choices Nigerian oil companies make in accessing external knowledge and the implications for their innovation capabilities and competitive positioning in the global market. Figure 48 on the next page provides a detailed visual representation of the findings.

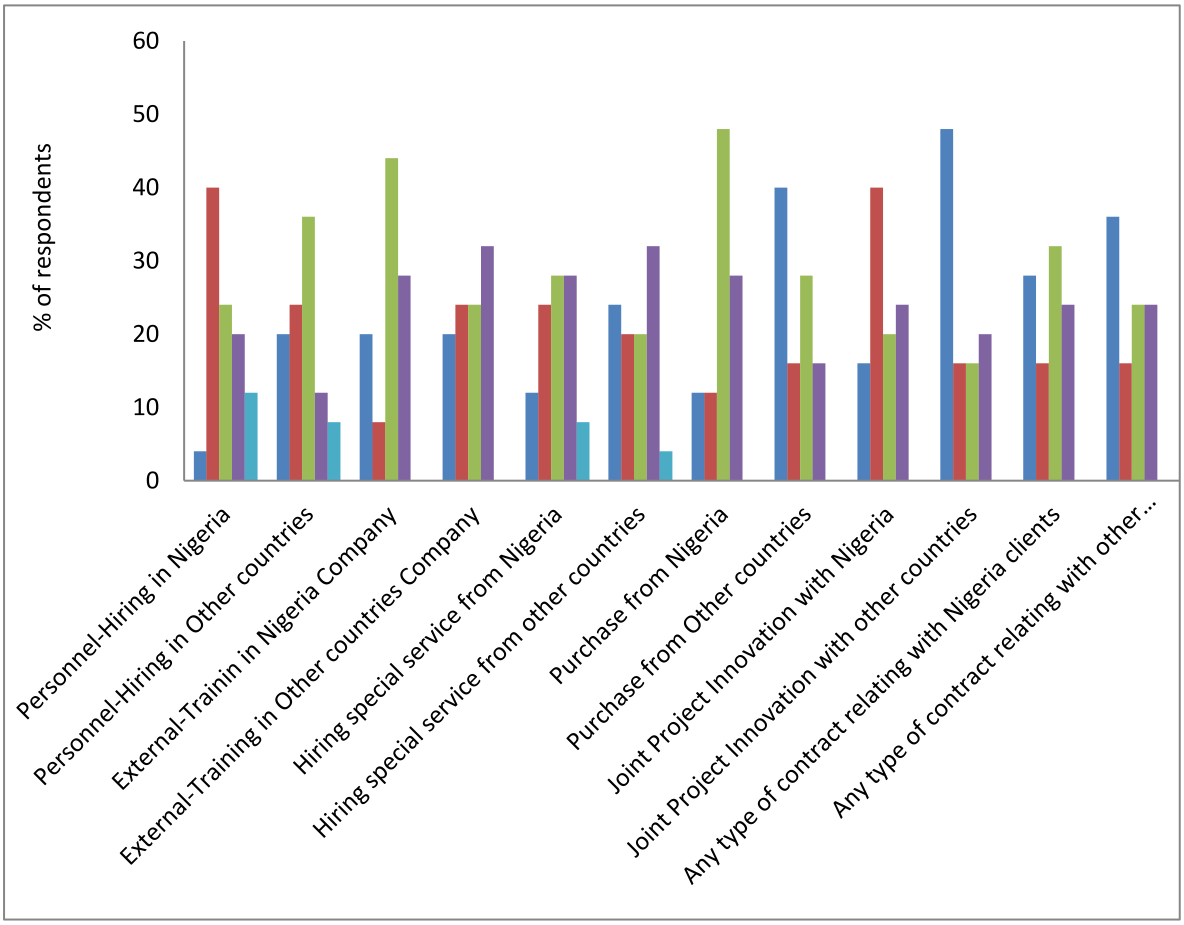

Figure 48. Knowledge Acquisition External.

Source: Data from own survey

Figure 48 illustrates the disparities in the approaches to external knowledge acquisition between activities conducted domestically in Nigeria and those conducted abroad, as outlined in the following:

(i) Personnel hiring within Nigeria:

- **Not used:** 4% of respondents indicated that personnel hiring for knowledge acquisition was "not used," implying that this approach may not be widespread among the surveyed companies.
- **Low importance:** A majority (64%) rated it as "not important" or "little important," indicating a lack of emphasis on this aspect for innovation purposes.
- **Recognition:** 32% considered it "quite important," suggesting that there exist some levels of recognition of its importance among the respondents.

(ii) Personnel hiring in other countries:

- **Not used:** 20% of respondents indicated that it was "not used," suggesting that actively engaging in personnel hiring for knowledge acquisition may not be prevalent among the surveyed oil firms.
- **Low importance:** 60% rated it as "not important" or "little important," indicating a lack of emphasis or recognition of the value of hiring personnel abroad for innovation purposes.
- **Recognition:** 12% considered it at least "quite important," and 8% rated it as "very important" suggesting that there is recognition of the importance of personnel hiring from outside the country among a portion of respondents. Overall, this segment signifies a potential lag in recognizing the value of hiring qualified personnel for knowledge acquisition outside the country by the firms.

(5) Training Hires (External)

The analysis of external training hired by oil companies, both within Nigeria and abroad, reveals the following insight:

(i) Within Nigeria

- **Not used:** Among respondents, 20% indicated that external training for knowledge acquisition was "not used," suggesting its limited prevalence among the surveyed companies.
- **Low importance:** A majority (52%) rated it as "not important" or "little important," indicating a lack of emphasis on utilizing external training as a strategic tool for fostering innovation and enhancing skills within the companies.

- **Recognition:** On the other hand, 28% considered it "quite important," while none rated it as "very important," suggesting that while there are recognitions of its significance, it is not regarded as a top priority by most of the Companies.

(ii) External training in other countries:

- **Not used:** 20% of respondents indicated that it was "not used," suggesting that actively engaging in external training initiatives may be prevalent among the surveyed firms.
- **Low importance:** 24% each rated it as "not important" or "little important" respectively, thus, indicating a lack of emphasis or recognition of the value of external training for fostering innovation.
- **Recognition:** 32% considered it at least "quite important," suggesting that there is recognition of the importance of external training abroad among some respondents, suggesting that there is recognition of the importance of external training abroad among some respondents.

(6) Specialised services

This refers to the use of external experts or consulting firms that provide specific knowledge, skills, or technologies tailored to a company's unique needs. These services are often sought to fill gaps in expertise, accelerate innovation, and improve processes or products. In this context, specialized services can play a critical role in helping oil companies stay competitive by offering insights and solutions that may not be available internally. The analysis of the service usage within and outside Nigeria reveals the following:

(i) Within Nigeria:

- **Not used:** 12% indicated that specialized services for knowledge acquisition were "not used," suggesting their limited prevalence among the surveyed companies.
- **Low importance:** A majority (52%) rated it as "not important" or "little important," indicating a significant gap and lack of emphasis or recognition of the value of specialized services for innovation purposes.
- **Recognition:** 28% considered it at least "quite important," with 8% rating it as "very important," suggesting some recognition of its importance among many respondents.

(ii) Specialized service in other countries

- **Not used:** 24% of respondents indicated that it was "not used," suggesting that actively engaging in specialized services for knowledge acquisition may be prevalent among the surveyed companies.

- **Low importance:** 20% rated it as "not important" and another 20% for "little important," indicating a significant gap and lack of emphasis or recognition of the value of specialized services for innovation purposes.
- **Recognition:** 36% respondents considered it at least "quite important, and very important" suggesting that there is a modest recognition of the importance of specialized services among the respondents.

(7) Use of patents

This involves the legal protections granted to inventors, allowing them to exclusively exploit their inventions for a certain period. In the oil and gas sector, patents play a crucial role in safeguarding innovative technologies, processes, and products. They not only encourage innovation by providing a competitive edge but also facilitate knowledge transfer through licensing agreements and partnerships. Patents are an important measure of a company's commitment to innovation and its ability to protect and capitalize on new knowledge. The analysis of findings includes:

(i)Within Nigeria:

- **Not used:** 12% of respondents indicated that it was "not used," suggesting a significant portion of companies may not be actively leveraging patented technologies through licensing agreement.
- **Low importance:** Additionally, 12% rated it as "not important" and 48% for "little important," indicating a significant lack of emphasis or recognition of the value of licensing patented technologies.
- **Recognition:** However, 28% considered it at least "quite important," and zero percent rated it as "very important," suggesting that there is superficial recognition of the importance of patent licensing among a subset of respondents.

(ii)Use of patents in other countries:

- **Not used:** 40% respondents indicated that licensing patented technologies was "not used," suggesting a significant portion of companies may not be actively leveraging patented technologies through licensing agreements.
- **Low importance:** 16% rated it as "not important" and 28% as "little important," indicating a lack of emphasis or recognition of the value of licensing patented technologies.
- **Recognition:** 16% considered it at least "quite important," with none rating it as "very important," suggesting that there is some recognition of the importance of patent licensing among a subset of respondents.

In this segment, majority, reported not being involved in the purchasing, use, or under license of patents or inventions not patented from other countries. The high percentage of "not used" tends to suggest the limited access to patented technology among Nigerian oil firms outside the country which may stem from financial constraints and concerns about intellectual property rights. Additionally, competing priorities and challenges in technology transfer may further restrict the adoption of patented technologies.

(8) Joint projects with universities

This refers to the collaboration between companies and academic institutions in conducting research and developing new technologies or processes. These partnerships are vital for bridging the gap between theoretical research and practical application, enabling companies to leverage academic expertise and resources to drive innovation. Joint projects with universities can also help companies stay at the forefront of technological advancements and foster a culture of continuous learning and development. The analysis in this context, is as follows:

(i) Within Nigeria:

- **Not used:** 16% of respondents indicated that joint projects with universities are "not used," reflecting limited engagement in such collaborations.
- **Low importance:** 60% rated these collaborations as "not important" or "little important," suggesting significant barriers to or disinterest in university partnerships.
- **Recognition:** 24% of respondents acknowledged the importance of joint projects, though this recognition remains limited.

(ii)Joint Project s with universities outside the country

- **Not used:** 48% of the respondents rated this segment within the “not used” category.
- **Low importance:** 32% rated it as "not important" and "little important," thus, suggesting that collaboration with universities for joint projects may not be a common practice among the surveyed companies, possibly due to a lack of established partnerships or perceived barriers to collaboration.
- **Recognition:** 20% considered it at least "quite important," while none rated it as "very important," indicating a limited recognition of the potential benefits of university collaboration for research and innovation.

(9) Contract Relations

This involves the formal agreements between companies and external entities, such as suppliers, consultants, or partners, that govern the exchange of goods, services, or knowledge. In the context of knowledge acquisition, contract relations are crucial for establishing clear terms for collaboration, knowledge transfer, and innovation development. Effective contract management ensures that all parties understand their roles and responsibilities, which can significantly enhance the efficiency and outcomes of collaborative effort. The analysis of its responses in this context indicates the following:

(i) Within Nigeria:

- **Not used:** 28was respondents indicated that contract relations for knowledge acquisition were "not used," suggesting limited engagement in this area among the surveyed companies.
- **Low importance:** 48% rated contract relations as "not important" or "little important," reflecting a significant lack of emphasis or recognition of the value of contracts with clients for partnership and innovation purposes.
- **Recognition:** 24% of respondents recognized the importance of knowledge incorporation and collaboration, indicating some acknowledgment of its value, albeit to a limited extent.

(ii) Contracts relations in other countries:

- **Not used:** 36% of respondents reported that contract relations were "not used," implying that this strategy may not be common among the surveyed oil firms.
- **Low importance:** 36% rated it as "not important" and 24% as "little important," highlighting a lack of awareness of the potential benefits of contract relations for cost efficiencies, technology transfer, and risk mitigation in international operations.
- **Recognition:** 4% considered contract relations “quite important,” while none rated it as “very important”, thus suggesting a minute recognition of its value in facilitating market expansion, enhancing competitiveness, and diversifying revenue streams, although none rated it as “very important”.

This analysis of external knowledge acquisition strategies in the oil and gas industry highlights a general trend of underutilization and low recognition of the importance of these strategies among the surveyed companies, both within Nigeria and abroad. The strategies examined include personnel hiring, external training, specialized services, joint projects with universities, and contract relations. Each of these methods play crucial roles in fostering innovation by bringing in new expertise, technologies, and collaborative opportunities, yet they remain largely underexplored. Figure 49 analyses the important and unimportant categories from respondents.

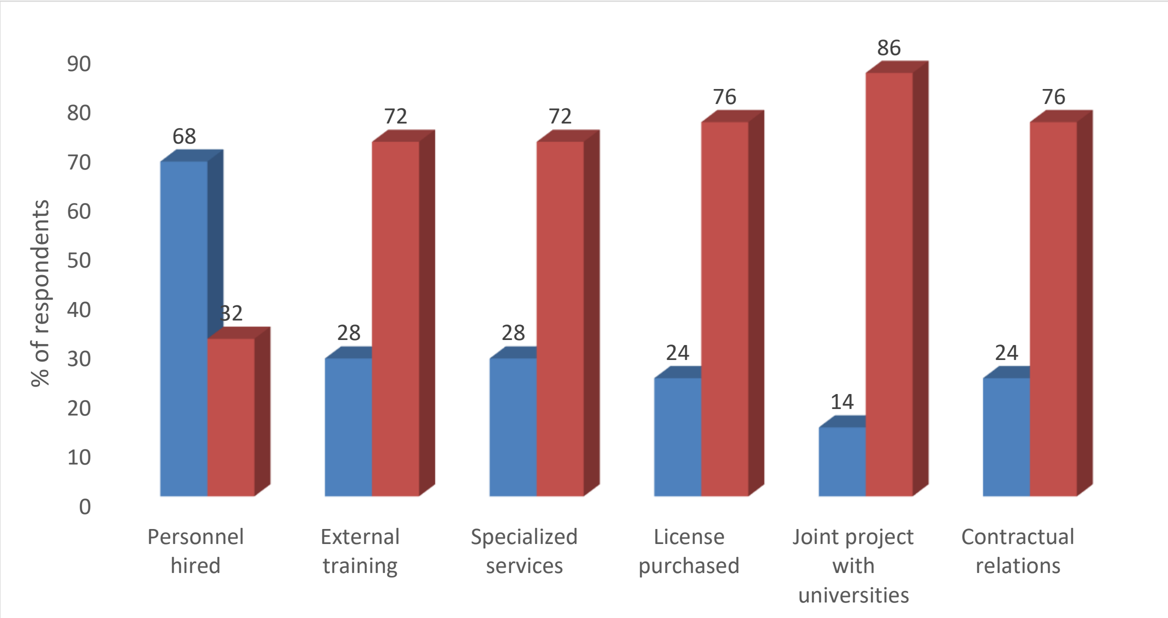

Figure 49. New Knowledge Acquisition - External (Innovation Capacity).

Source: Data from own survey

In assessing the 6 categories within the "New Knowledge Acquisition-external" figure 49 highlights a general trend of underutilization or limited recognition of the importance of the factors that enhance knowledge acquisition and innovation mostly within the Nigerian oil and gas industry. Similarly, each category indicates potential lags in different aspects of sourcing external knowledge, except in personnel hiring. These lags could be attributed to various factors such as limited awareness, perceived tariff, other trade barriers, or a lack of emphasis on certain strategies for fostering innovation and competitiveness. However, while there are huge gaps in actively engaging in activities such as using "patented technologies, collaborating with universities, and establishing contract relations", the importance of certain knowledge acquisition activities such as "personnel hiring, external training, and specialized services", were somewhat recognized by the firms.

On the other hand, the implications of the gaps have direct relevance to the main research question of why Nigeria is a net exporter of crude oil and still a net importer of refined petroleum products as it may hinder the ability of oil companies to effectively leverage external knowledge sources to foster innovation within the industry. Addressing these gaps will be crucial for enhancing the industry's capacity for innovation and sustainable growth thereby leading to value addition on petroleum production soon. This may involve increased awareness and emphasis on the potential benefits of activities such as patent licensing, university collaboration, and contract relations to foster innovation and competitiveness.

(10) Sources of Knowledge Acquisition - Agents

In the landscape of innovation, agents play a pivotal role as intermediaries in the knowledge acquisition process. Unlike internal sources, which draw from an organization's own capabilities, or external sources, which involve direct partnerships with outside entities, agents act as crucial facilitators who bridge the gap between these two realms. They encompass a range of actors, including consultants, government agencies, industry associations, and technology transfer organizations, who possess specialized expertise and extensive networks.

By examining the sources of knowledge acquisition from "agents" this section provides crucial understanding into how oil companies in Nigeria and abroad gather insights and innovations through intermediaries. This makes them instrumental in helping organizations navigate the complexities of acquiring and integrating new knowledge. By connecting internal resources with external opportunities, they not only enhance the flow of information but also tailor it to meet the specific needs such as client feedback, collaboration with providers, other personnel from other companies, competitive intelligence, engagement with consultants, and partnerships with universities, thus helping them to gain insights into the diverse strategies employed to enhance knowledge and drive innovation within the oil industry. Participants were asked to rank their significance as a source of knowledge using a 5-point scale, where ratings of 4 and 5 represent a high importance, while ratings of 1 to 3 suggest lower importance or insignificance as indicated in figure 50.

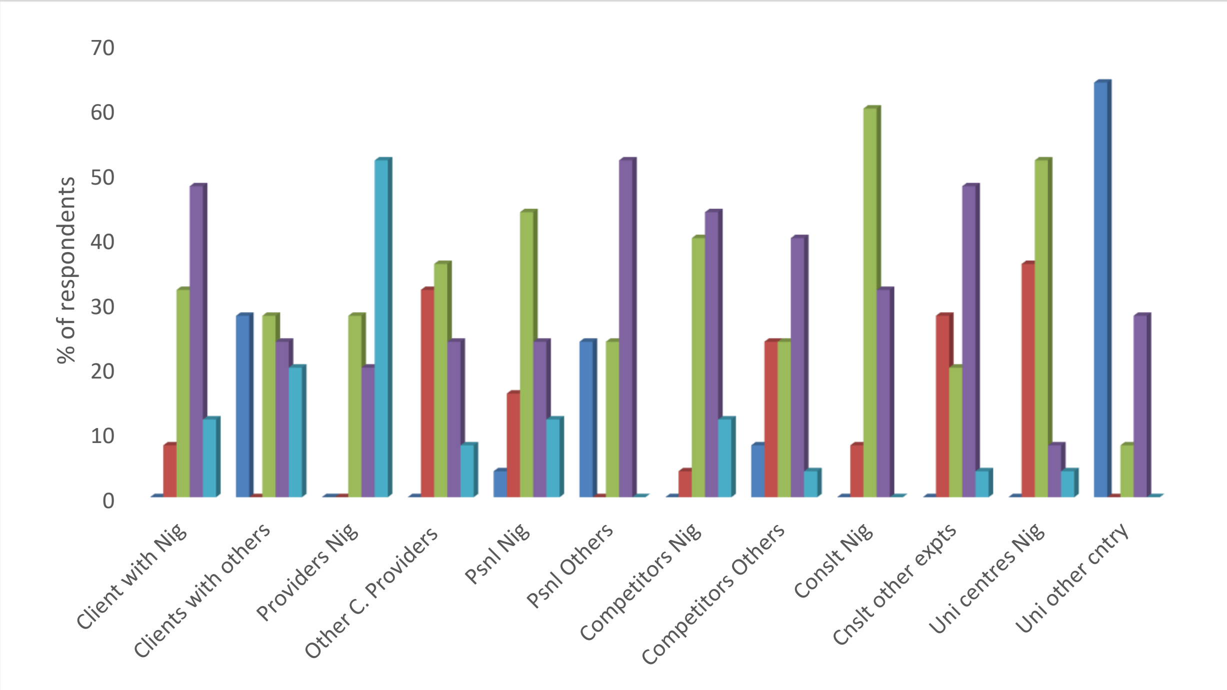

Figure 50. Sources of Knowledge - Agents

Source: Data from own survey

- **Clients**: The "clients" category in figure 50 shows that 48% of respondents in Nigeria and 24% outside Nigeria rated it as quite important, while 12% in Nigeria and 20% outside Nigeria rated it as very important. Additionally, 32% of respondents in Nigeria and 28% outside Nigeria found it to be of little importance, while 8% in Nigeria- and none outside Nigeria rated it as not important. Interestingly, none of the respondents in Nigeria indicated that clients were not used, while 28% outside Nigeria reported not using them as a knowledge source. This result suggests that clients are considered moderately important as a knowledge source by respondents, with a higher percentage rating them as quite important compared to very important. However, a significant portion still view them as of little importance. The fact that a portion of respondents, particularly outside Nigeria, reported not using clients as a knowledge source indicates potential missed opportunities for leveraging client insights for innovation and competitiveness.

- **Providers:** The data indicates that while 52% of respondents outside Nigeria viewed providers as very important, only 8% of respondents within Nigeria shared the same perspective. Similarly, 36% of respondents outside Nigeria and 28% within Nigeria rated providers as little important. This disparity suggests differing perceptions of the importance of providers as a knowledge source between the two regions, with a higher emphasis placed on providers outside Nigeria. This analysis reveals that providers are perceived as highly important knowledge sources, particularly outside Nigeria, where a majority rated them as quite important or very important. However, within Nigeria, a notable portion of respondents considered providers to be of little importance, suggesting a potential disparity in the perceived value of this knowledge source between the two contexts. The absence of respondents reporting providers as not used suggests that there is some level of engagement with providers across both regions.
- **Other companies' personnel:** This segment of the data is on the importance of other companies as a knowledge source. It reveals significant differences between Nigeria and outside Nigeria. While 60% of respondents outside Nigeria rated other companies as quite important, only 24% of respondents within Nigeria shared the same perspective. Additionally, 4% of respondents within Nigeria considered other companies as very important, compared to 12% of respondents outside Nigeria. These results suggest that companies outside Nigeria place a higher value on knowledge derived from other companies, indicating potential differences in collaboration practices or perceptions of the competitive landscape.
- **Competitors:** The analysis of the data on the importance of competitors as a knowledge source shows notable differences between Nigeria and outside Nigeria. While 40% of respondents outside Nigeria rated competitors as quite important, 44% of respondents within Nigeria shared the same perspective. Additionally, only 4% of respondents within Nigeria considered competitors as very important, compared to 12% of respondents outside Nigeria. This difference suggests that companies outside Nigeria attach greater significance to knowledge obtained from competing agents, potentially indicating a more competitive environment or a greater emphasis on benchmarking and industry analysis.
- **Experts and Consultants:** As a knowledge source, 32% of respondents in Nigeria and 48% outside Nigeria rated experts and consultants as quite important, while 0% in Nigeria and 4% outside Nigeria rated it as very important. Additionally, 60% of respondents in Nigeria and 20% outside Nigeria found it to be of little importance, while 8% in Nigeria and none outside Nigeria rated it as not important. Interestingly, none of the respondents in Nigeria indicated that experts and consultants were not used.

- **Universities and Investigation Centers:** As knowledge source, 8% of respondents in Nigeria and 28% outside Nigeria rated universities and research centers as quite important, while 4% in Nigeria and none outside Nigeria rated it as very important. Additionally, 52% of respondents in Nigeria and 8% outside Nigeria found it to be of little importance, while 36% in Nigeria and none outside Nigeria rated it as not important. Interestingly, none of the respondents outside Nigeria indicated that universities and research centers were not used, while 64% in Nigeria reported not using them as a knowledge source.

This performance rating suggests a significant disparity in the perception of the importance of universities and research centers as sources of knowledge between Nigeria and outside Nigeria. The low percentage of respondents in Nigeria indicating that these institutions and investigation centers were not used highlights a potential gap in leveraging academic research and expertise for innovation and industry advancement within the “agent” segment in the country. On the other hand, "universities and research centers" are largely underutilized in both segments, with the situation being worse in Nigeria than outside. Conversely, the lower importance attributed to universities and research centers by respondents outside Nigeria may indicate a different strategic approach to knowledge acquisition or a greater reliance on other sources of expertise and innovation. Overall, this disparity underscores the need for further exploration and potential re-evaluation of the role of academic institutions in driving innovation and industry development, both within Nigeria and internationally.

To further illustrate the effectiveness of various agents in providing valuable knowledge, figure 51 titled "Knowledge Utility from Agents" presents a comparative analysis of the utility each agent offers. It breaks down the knowledge utility into above-average and below-average percentages for clients, providers, other personnel, competitors, consultants/experts, and university centers. This allows us to clearly see which agents are most effective in delivering high-value knowledge and which are less reliable.

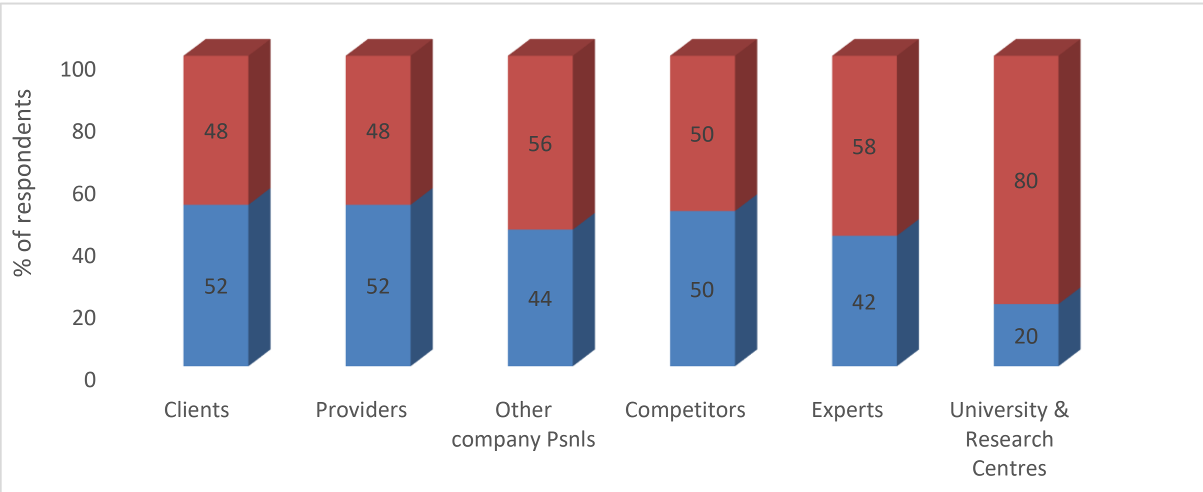

Figure 51. Comparing Knowledge Utility from Agents

Source: Data from own survey

The data reveals that "clients and providers" are among the most effective agents for knowledge utility, with 52% of the knowledge derived from these sources being above average, and 48% below average. This suggests that these agents are generally reliable and valuable for acquiring useful knowledge.

In contrast, "other personnel and consultants/experts" are less effective. For other company personnel, 44% of the knowledge utilized is above average, while 56% is below average, indicating that most of the knowledge from this group is of lesser value. Similarly, knowledge utility from "consultants and experts" is even lower, with only 42% being above average and 58% below average, showing a trend toward lower usefulness in the knowledge they provide.

When considering "competitors" as an agent, the knowledge utility is balanced, with an equal split of 50% above average and 50% below average. This balance suggests that competitors can provide both valuable and less useful knowledge in equal measures. Lastly, "university centers" show the lowest effectiveness as an agent, with just 20% of their knowledge utility being above average and a substantial 80% falling below average.

Overall, this indicates that university centers are the least effective contributors of high-value knowledge among the agents utilized by the oil firms analyzed. Examining deeply, we find that the universities and research centers" are largely underutilized in both segments, with the situation being worse in Nigeria than outside. The gap reveals potential weaknesses in Nigeria's NIS, especially in the areas of knowledge utilization within the oil sector. Strengthening the NIS could foster better collaboration between industry stakeholders, universities, and research institutions, enhancing the acquisition and application of new knowledge in the sector. By creating a more conducive environment for innovation and knowledge exchange, the NIS can support the advancement of the oil industry through increased research and development, technology transfer, and skill development among industry players.

(11) Research &Development (R&D) Activities 2021 - 2022:

This section delves into the research and development (R&D) activities undertaken by oil companies between 2021 and 2022, focusing on whether these companies have established R&D departments either in Nigeria or abroad. This segment is crucial as it provides insights into the extent of investment in innovation within and outside Nigeria, reflecting companies' commitment to advancing their technological capabilities and staying competitive.

(i) Analysis of R&D Departments

The respondents were asked whether their companies had R&D departments in Nigeria and abroad during the 2021-2022 period. The responses revealed that only 6 companies representing 24% confirmed having an R&D department in Nigeria, while 19 or 76% of the companies did not. On the other hand, 10 representing 40% of the companies reported having R&D departments abroad, compared to 15 or 60% that did not. The average response for companies with R&D departments, therefore, is 8 (for yes) and 17 (for no). This indicates a relatively low presence of R&D departments within Nigeria compared to abroad, suggesting that companies may prefer to invest in R&D activities outside the country, possibly due to better infrastructure, resources, or expertise available internationally. Figure 52 explains the organization of the workplace in terms of R&D departments in the oil firms surveyed.

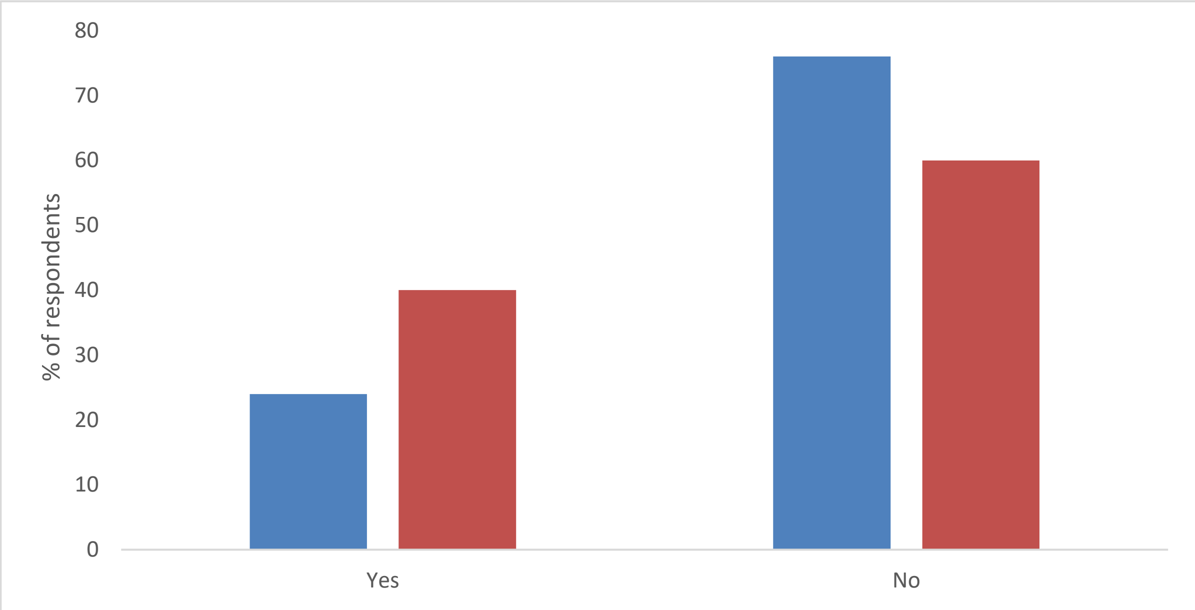

Figure 52: R&D Departments

Source: Data from own survey

Also, the wide disparity in the number of companies with R&D departments between Nigeria and outside the country tends to suggest differences in the level of investment and focus on innovation and technological advancement. This could impact Nigeria's position as a net exporter and net importer of petroleum products because robust R&D efforts can lead to enhanced efficiency, productivity, and competitiveness in the oil industry, potentially affecting the balance of trade in petroleum products. Therefore, the lack of significant R&D investment among the Nigerian oil companies compared to their counterparts abroad may contribute to Nigeria's reliance on importing certain petroleum products while exporting crude oil as it is currently.

(ii) Workforce in R&D Departments:

Analyzing the workforce in R&D departments offers valuable insights into the capacity for innovation within the oil industry. Comparing the size and growth of R&D teams between Nigerian oil companies and those abroad sheds light on the research and development capabilities driving competitiveness and technological advancement.

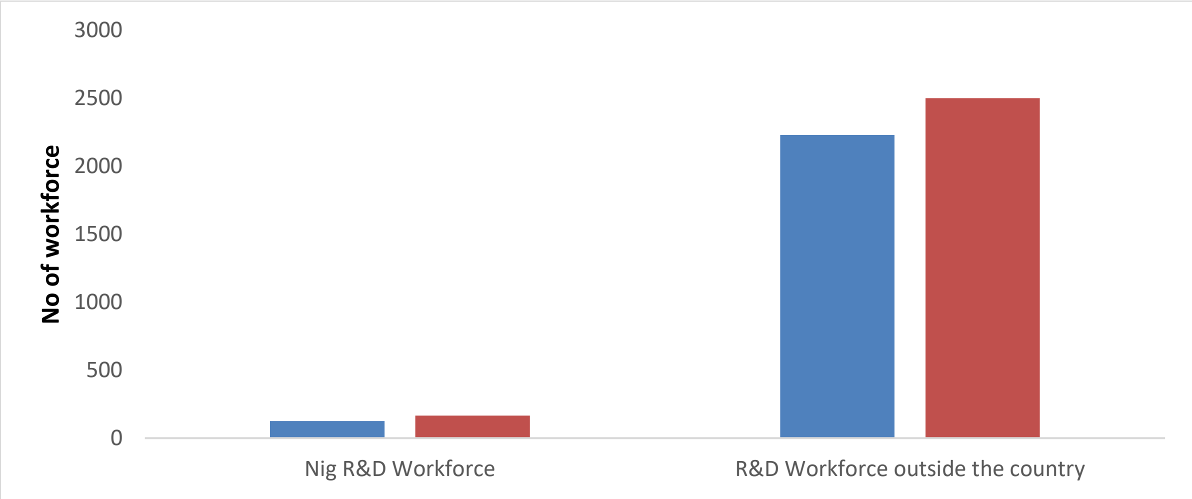

Figure 53: Workforce from R&D Department

Source: Data from own survey

Figure 53 shows that in 2021, the number of employees in R&D departments in Nigeria was 125, increasing to 166 in 2022. This growth reflects a positive trend in local R&D investment, albeit from a small base. Conversely, R&D departments abroad had a much larger workforce, with 2,230 employees in 2021, rising to 2,500 in 2022. The analysis indicates a significant difference in the workforce between R&D departments within Nigeria and those outside the country. In Nigeria, the R&D workforce saw a modest increase from 125 in 2021 to 166 in 2022, representing a growth of approximately 32%. On the other hand, R&D departments outside Nigeria experienced a more substantial workforce, with 2230 employees in 2021 and an additional 270 new staff in 2022, bringing the total to 2500 employees. The disparity in workforce numbers highlights the more substantial commitment to R&D in international locations compared to Nigeria.

The findings also highlight several key implications of significant gaps. One notable factor contributing to the larger R&D workforce abroad is the presence of major multinational oil corporations (MNCs). These companies typically have established, well-funded R&D centers in countries with advanced technological ecosystems. The large volume of workforce in these international locations likely reflects the scale and resources of these MNCs, which can afford to invest heavily in research and development.

Additionally, the challenges related to infrastructure, funding, and access to skilled talent in Nigeria likely deter MNCs from setting up significant R&D operations in the country, leading to a concentration of these activities in more developed regions. In contrast, the relatively small R&D presence in Nigeria suggests that local oil companies, particularly within the size of the small and medium-sized enterprises (SMEs), may lack the resources to establish or expand their R&D departments. In some case the number of employees in R&D department can indeed vary based on several other factors such as the size of the company, the financial resources allocated to research and development, the complexity of R&D projects, and the level of technological innovation required in the firms. This disparity implies that while global companies are driving innovation through substantial investments in R&D abroad, the Nigerian oil firms may miss out on the benefits of such activities, including technology transfer, job creation, and economic growth. To address this, it is crucial to create an environment (NIS) that encourages both local companies and MNCs to invest in R&D within Nigeria. This could involve improving the business climate, offering incentives for local R&D investment, and strengthening collaborations between industry, academia, and government.

(12) Innovation Strategies: Assessing knowledge enhancement in production and distribution

This segment delves into the strategic activities companies undertake to enhance their knowledge and expertise, particularly in the realms of production and distribution. The aim is to evaluate the extent to which companies engage in various activities aimed at enhancing their knowledge and expertise, particularly in the realm of expenditure, production and distribution. This includes investigating both internal research and development efforts as well as external knowledge acquisition, along with other innovation-related initiatives.

In the survey, respondents were presented with two options: "Yes" and "No". A "Yes" response signifies that the company frequently employs specific approaches to enhance knowledge and expertise in improving production processes, while a "No" response indicates either disagreement or lack of utilization of these methods. For those who responded affirmatively, further details were requested regarding the amount spent in dollars within the same category. However, not all respondents provided this financial data, leading the analysis to primarily focus on the initial yes or no response. This assessment encompasses seven key attributes, including internal research and development (R&D), external R&D acquisition, procurement of machinery/equipment or software, training initiatives, utilization of external knowledge, market innovation introductions, and other strategies for the advancement of new or improved production and distribution processes. To provide a more nuanced understanding, the section is divided into two segments: 'old' or '1st generation' and 'new' or '2nd generation' oil firms. This division allows for a comparative analysis of innovation strategies and activities between these two categories, highlighting the disparities or commonalities. The findings, as detailed in Table 34, offer valuable insights into how different generations of firms approach innovation to stay competitive and improve their operations.

Table 34: Comparing Innovation activities between 1st & 2nd generation companies.

Description/s		2nd generation oil companies (9)		1st generation Oil Companies (16)	
S/N	Innovation improvement channels	No of companies in agreement	Percent	No of companies in agreement	Percent
1	Internal R&D	1	11.11%	10	62.5%
2	Acquisition of R&D (external)	Nil	Nil	8	50%
3	Acquisition of machinery, equipment & software	8	88.89%	15	93.75%
4	Acquisition of another external knowledge	6	66.67%	7	43.75%
5	Training	7	77.78%	14	87.5%
6	Introduction of innovation in Markets	5	55.56%	12	75%
7	Other arrangements for production & distribution	6	66.67%	14	87.5%

Source: Data from own survey

- **1st generation companies:** The analysis of 1st generation companies reveals a strong commitment to internal research and development (R&D), with 10 out of 16 companies, representing 62.5%, actively engaging in strategies for developing new and improved products. Additionally, 50% of these companies (8 out of 16) collaborate externally within their corporate group to enhance R&D efforts. There is also a pronounced focus on acquiring technology and equipment, as evidenced by 15 out of 16 companies (93.75%) investing in machinery, equipment, or software. Employee training and skill development are prioritized by 87.5% of the companies (14 out of 16), who invest significantly in training initiatives. In terms of innovation commercialization, 12 out of 16 companies (75%) are moderately active in bringing new products or services to market. Furthermore, 87.5% (14 out of 16) are engaged in various other strategies aimed at developing new production and distribution processes, reflecting a comprehensive and multifaceted approach to innovation within this group of companies.

- **2nd generation companies:** In this aspect, internal R&D activities are notably limited, with only 11.1% (1 out of 9 companies) engaging in such efforts, indicating a minimal emphasis on internal research and development. External R&D collaboration is completely absent, receiving a score of 0%, suggesting that these companies do not prioritize external partnerships for R&D. In contrast, there is a strong focus on acquiring technology and equipment, as evidenced by 88.9% (8 out of 9 companies) investing in machinery, equipment, or software. Employee training and skill development are also emphasized, with 77.8% (7 out of 9 companies) investing in training initiatives. When it comes to introducing innovation to the market, 55.6% (5 out of 9 companies) are moderately active in launching new products or services. Additionally, 66.7% (6 out of 9 companies) are involved in other activities aimed at developing new production and distribution procedures, indicating a diverse approach to innovation within this group.

The comparison of innovation strategies between 1st and 2nd generation companies reveals significant differences, particularly influenced by the presence of multinational corporations (MNCs) and the weaknesses in the National Innovation System (NIS), especially in the areas of innovation commercialization and other related activities.

In the 1st generation companies, many of which are influenced by MNCs, place a strong emphasis on internal research and development, with 62.5% (10 out of 16) actively engaging in these activities. The presence of MNCs, which often have established and well-funded R&D departments, along with their extensive experience and long-standing presence in the industry, contributes to this higher level of engagement in internal R&D. In contrast, only 11.1% (1 out of 9) of 2nd generation companies prioritize internal R&D, indicating a significantly lower commitment to developing innovation internally among these newer companies, which may lack the resources and global reach of MNCs. In terms of investments in external R&D Collaboration, the impact of MNCs is also evident. While 50% (8 out of 16) of 1st generation companies collaborate externally within their corporate group, a reflection of the global networks and partnerships typical of MNCs, none of the 2nd generation companies (0%) indicated that they engage in external R&D collaboration/s. This suggests that 2nd generation companies, possibly due to their smaller size and limited resources, are less inclined or able to seek external partnerships for innovation, potentially limiting their access to external expertise and knowledge.

For technology acquisition, both groups show a strong focus on acquiring technology and equipment, but 1st generation companies, influenced by MNC standards, slightly lead in this area, with 93.75% (15 out of 16) investing in machinery, equipment, or software, compared to 88.9% (8 out of 9) of 2nd generation companies. This indicates that despite their lower engagement in R&D, 2nd generation companies still recognize the importance of technological investment to stay competitive, though they may not match the scale of MNCs' investments.

Furthermore, training initiatives are emphasized by both groups, with 87.5% (14 out of 16) of 1st generation companies and 77.8% (7 out of 9) of 2nd generation companies investing in employee training and skill development. The slightly higher commitment to upskilling among 1st generation companies may be attributed to the influence of MNCs, which often have extensive training programs as part of their global operations.

In the aspect of innovation commercialization or market, the 1st generation companies are more active, with 75% (12 out of 16) bringing new products or services to market. However, this figure also reflects a weakness in the NIS, where even among established companies, there is room for improvement in translating R&D efforts into marketable innovations. For 2nd generation companies, the situation is more pronounced, with only 55.6% (5 out of 9) actively commercializing innovations. This lower rate underscores the challenges these newer companies face in bridging the gap between innovation and market introduction, likely due to weaker support structures within the NIS, such as limited access to commercialization expertise, funding, and market networks. But in terms of investing in other innovation-related activities, such as developing new production and distribution procedures, both group of companies are largely involved. However, the 1st generation companies again lead, with 87.5% (14 out of 16) stands out while 66.7% (6 out of 9) participation rate is among 2nd generation companies thus, highlight another area where the NIS may be lacking. These companies may struggle to fully engage in broader innovation activities due to inadequate support, whether in the form of resources, expertise, or infrastructure, necessary for developing and implementing new processes.

Overall, the results in this segment indicate that the 1st generation companies, particularly those influenced by MNCs, demonstrate a more robust and comprehensive approach to innovation. They show higher engagement in both internal and external R&D, stronger investment in training, and a greater focus on bringing innovations to the marketplace. On the other hand, 2nd generation companies, while heavily investing in technology acquisition, show less emphasis on R&D and innovation commercialization. The influence of MNCs among 1st generation companies clearly enhance their innovation strategies, allowing them to leverage global resources and expertise, which newer companies may lack. This comparison highlights the varying strategies between the established, MNC-influenced companies and newer entrants, with the former leveraging a more integrated and globally informed approach to innovation.

(13) Types of Innovation and level of improvement:

This section, presents the analysis of innovation activities within the petroleum industry, focusing on two critical dimensions: product and process innovation. These innovation strategies were selected due to their prominence and relevance within the context of the study, as well as their implications for positioning within GVCs. Product innovation focuses on developing new or improved goods or services, which not only enhances a company's ability to meet market demands but also strengthens its role and competitiveness within GVCs. Process innovation, on the other hand, involves enhancing or creating more efficient methods of production or delivery, leading to operational efficiencies and potentially elevating a company’s standing within GVCs through the adoption of advanced technologies and participations. These two approaches are fundamental in assessing the overall innovation capabilities and strategies of the companies under study, offering valuable insights into their competitive strengths, areas for improvement, and their integration and performance within GVCs. By comparing the engagement levels of first and second-generation companies in these innovation types, we aim to gain a comprehensive understanding of their innovation levels, their potential implications for industry competitiveness, and their positioning within the global value chain terrain.

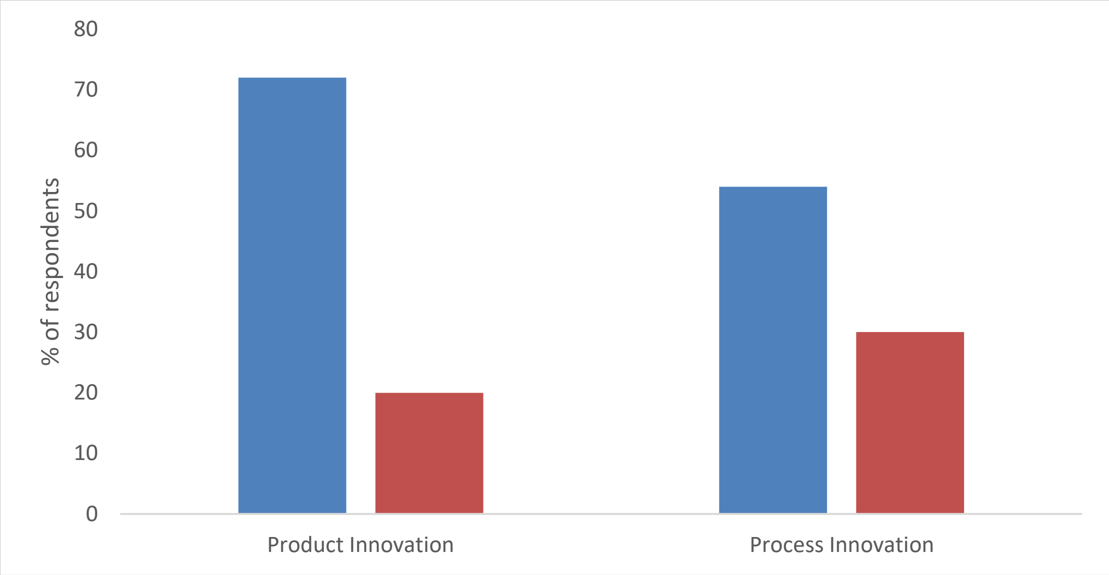

Figure 54: Product and Process Innovation

Source: Data from own survey

Figure 54 highlights a significant disparity in innovation activities between 1st and 2nd generation oil companies, with important implications for the industry. In terms of "Product innovation", the high overall rating at 92% suggests that the oil sector is generally active in introducing new or improved products. However, a closer look reveals that this innovation is heavily skewed towards 1st generation companies. While 72% of 1st generation companies reported implementing product innovations, only 20% of 2nd generation companies did the same. This stark contrast implies that 2nd generation companies may be struggling to keep pace with their more established counterparts in terms of product innovation. The reasons could range from limited resources and less mature R&D infrastructures to weaker market positions and less access to advanced technologies or skilled labour. This gap could potentially hinder the competitiveness and long-term viability of 2nd generation firms, as product innovation is often key to capturing market share and responding to changing industry demands.

The pattern is similar for "process innovations", with 84% of companies overall engaging in such activities. However, 1st generation companies again lead, contributing 54% of the "yes" responses, compared to just 30% from 2nd generation companies. This suggests that while process innovation is somewhat more evenly distributed across the two groups than product innovation, 2nd generation companies are still lagging. Process innovation is crucial for operational efficiency, cost reduction, and maintaining competitiveness, especially in a capital-intensive industry like oil. The lower engagement of 2nd generation companies in process innovation may reflect a reliance on older technologies and processes, which could result in higher operational costs, reduced productivity, and difficulty in meeting environmental and regulatory standards.

The implication of the disparities in product and process innovation between first and second-generation companies for Nigeria's petroleum industry is that the first-generation companies, with their higher levels of innovation, are better positioned to lead in GVCs by driving technological advancements and operational efficiencies. In contrast, second-generation companies, despite their lower innovation levels, still contribute to industry growth. However, their limited engagement in innovation activities may restrict their competitive edge and integration into GVCs. Strengthening the NIS and fostering greater collaboration and support for second-generation companies could enhance their innovation capabilities and improve their roles within GVCs.

Despite differing innovation levels, both first and second-generation companies play complementary roles in advancing the petroleum industry and enhancing Nigeria's participation in GVCs. First-generation companies drive high-tech advancements and efficiency, while second-generation companies contribute to market expansion and diversification. To maximize their collective impact, it is essential to address the innovation gaps by encouraging knowledge sharing, adopting best practices, and investing in technology. Recommendations include increased support for domestic firms and second-generation companies through targeted policies, incentives for innovation, and strategic partnerships to prioritize innovation and invest in upgrading their technological capabilities, thus leveraging the strengths of both groups for sustained industry growth and global competitiveness. However, to further analyse these disparities and their implications, a Chi-Square test is employed to assess the relationships between key variables influencing innovation and industry performance in the next section.

7.2.2 Chi-Square Analysis:

This section presents the statistical analysis of responses regarding the importance and utilization of R&D and Learning Processes (LP) by 25 out of 30 surveyed oil companies. The analysis was conducted to address Objective 4, which aims to evaluate the potential of the National Innovation System (NIS) in enhancing knowledge and innovation capabilities within the Nigerian Petroleum Industry (NPI).

A Chi-Square test was employed to analyze the responses, focusing on:

1. The relationship between internal and external R&D activities.
2. The relationship between internal and external Learning Processes.
3. The broader distinction between R&D and Learning Processes as key components of innovation.

These analyses were intended to identify areas of emphasis, evaluate the balance between internal and external mechanisms, and highlight potential weaknesses within the NIS. The response options were categorized into five levels of importance and usage**:** "Very Important," "Quite Important," "Not Important," "Little Important," and "Not Used."

Hypothesis Statement 1: Test of interdependence in R&D activities

- **Null Hypothesis (H_0):** There is no significant difference between the importance of internal and external R&D activities.
- **Alternative Hypothesis (H_1):** There is a significant difference between the importance of internal and external R&D activities.

Hypothesis Statement 2: Test of interdependence in Learning Process (LP)

- **Null Hypothesis (H_0):** There is no significant difference between the importance of internal and external learning processes in Nigerian oil companies.
- **Alternative Hypothesis (H_1):** There is a significant difference between the importance of internal and external learning processes in Nigerian oil companies.

Hypothesis Statement 3: Test of interdependence between R&D and LP

- **Null Hypothesis (H_0):** There is no significant difference between R&D activities and the Learning Process.

- **Alternative Hypothesis (H_1):** There is a significant difference between R&D activities and the Learning Process.

(a) Hypothesis Statement 1

(i) **Null Hypothesis (H_0):** There is no significant difference between the importance of internal and external R&D activities.

(ii) **Alternative Hypothesis (H_1):** There is a significant difference between the importance of internal and external R&D activities.

Analysis of R&D: The data on R&D was categorized based on the perceived importance of R&D and their internal and external activities. Table 35 summarizes R&D activities and the observed and expected counts for both internal and external uses with the statistical analysis below: Where Chi-square = $\chi 2=\sum E\underline{(O-E)2} \div E$

Table 35: Observed, expected counts & contributions for Internal and External R&D ($\chi 2$ test for R&D)

R&D Activities	Observed Internal (Within Nigeria)	Observed External (Outside Nigeria)	Expected Internal	Expected External	Contribution Internal	Contribution External
Very Important	2	4	3.0	3.0	0.3333	0.3333
Quite Important	10	5	7.5	7.5	0.8333	0.8333
Not Important	7	6	6.5	6.5	0.0385	0.0385
Little Important	5	4	4.5	4.5	0.0556	0.0556
Not Used	1	6	3.5	3.5	3.4036	3.4036

Source: Data from own survey

As indicated in table 35, the result of chi-square to establish if there is any significant difference between the responses for internal or external R&D activities are:

- Chi-Square Statistic ($\chi 2$): 6.093
- Degrees of Freedom (df): 4
- p-value: 0.192

Interpretation: The p-value (0.192) exceeds the significance level (0.05). This establishes that at a 5% significance level ($\alpha = 0.05$), the p-value of 0.192 indicates that the null hypothesis cannot be rejected. This suggests there is no statistically significant difference between internal and external R&D activities. While external R&D appears slightly more prominent in certain categories, the overall differences are not significant. This suggests that companies do not prioritize one over the other but highlights an overall underutilization of R&D, with many respondents rating it as "Not Important" or "Not Used.

(b) Hypothesis Statement 2

- **Null Hypothesis (H_0):** There is no significant difference between the importance of internal and external learning processes in Nigerian oil companies.
- **Alternative Hypothesis (H_1):** There is a significant difference between the importance of internal and external learning processes in Nigerian oil companies.

Analysis of Learning Processes: Similarly, the data on learning processes were analyzed to assess the importance of internal and external learning activities and thereafter, compare the responses of R&D with Learning Process. Table 36 presents the observed and expected counts.

Table 36: Chi-Square test for Learning Process

Learning Process	Observed (Internal)	Observed (External)	Expected (Internal)	Expected (External)	Contribution Internal	Contribution External
Very Important	11	13	12.0	12.0	0.0833	0.0833
Quite Important	6	0	3.0	3.0	3.0	3.0
Not Important	1	0	0.5	0.5	0.5	0.5
Little Important	5	6	5.5	5.5	0.0455	0.0455
Not Used	2	6	4.0	4.0	1.0	1.0

Source: Data from own survey

The result of Chi-Square test performed from the learning process (LP) data:

- Chi-Square Statistic ($\chi 2$): 9.258
- Degrees of Freedom (df): 4
- p-value: 0.055

Interpretation: The p-value (0.055) is close to the significance threshold (0.05), suggesting a trend toward a significant difference between internal and external learning processes. Companies demonstrate a stronger emphasis on internal learning, with many respondents rating it as "Very Important" or "Quite Important," compared to external learning, which was less recognized.

© Hypothesis 3: R&D Activities vs. Learning Processes

Hypothesis Statement

- **Null Hypothesis (H_0):** There is no significant difference between R&D activities and the Learning Process.
- **Alternative Hypothesis (H_1):** There is a significant difference between R&D activities and the Learning Process.

To evaluate the importance of internal and external R&D activities, as well as internal and external learning processes, a chi-square analysis was conducted. The goal was to determine whether there are significant differences in how these activities are perceived and utilized within the same survey. As earlier indicated, the responses were categorized as: "Very Important," "Quite Important," "Not Important," "Little Important," and "Not Used" and the results are:

Table 37: Relationship between R&D and Learning Process

Category	Chi-Square	Degree of Freedom (df)	P-Value
R&D Activities	6.093	4	0.192
Learning Process (LP)	9.258	4	0.055

Source: Data from own survey

1. **Chi-Square for R&D**: $\chi 2=6.093$, p=0.192p = 0.192p=0.192

   This indicates no significant difference between Internal and External R&D.

2. **Chi-Square for Learning**: $\chi 2=9.258$, p=0.055p = 0.055p=0.055

   This indicates a near-significant difference between Internal and External Learning, with a potential emphasis on Internal Learning.

Interpretation: The statistical analysis indicates no significant differences between internal and external R&D activities, reflecting that Nigerian oil companies do not exhibit a strong preference for one over the other. However, at a 5% significance level ($\alpha = 0.05$), the p-value of 0.055 results for learning processes reveal a near-significant trend suggesting that internal learning processes may hold greater importance. This aligns with broader observations in literature, where internal learning is often more directly tied to immediate organizational capacity-building and innovation activities.

Discussion: The results highlight systemic weaknesses within the NIS, particularly in the oil sector's approach to R&D and Learning Processes, thus, implying the following:

1. **R&D**: The lack of prioritization of both internal and external R&D activities indicates limited engagement with innovation-driven practices. This underutilization of R&D hampers the industry's capacity for technological advancement and global competitiveness.
2. **Learning Processes**: The emphasis on internal learning over external learning reflects a preference for in-house development. While internal learning is critical, the limited focus on external opportunities (e.g., collaborations, international exchanges) restricts the sector's exposure to global best practices.
3. **NIS Implications**: These findings point to systemic challenges in fostering a balanced and integrated innovation system. Addressing these gaps requires a concerted effort to promote both R&D and external learning as vital components of the NIS.

In conclusion, the statistical analysis demonstrates that while companies show some recognition of the importance of learning processes, R&D remains significantly underutilized. To strengthen the NIS and the oil sector's position in the global value chain, companies must prioritize innovation strategies that integrate R&D and learning processes. This includes fostering collaborations, increasing R&D investments, and leveraging external learning opportunities. Such efforts will not only address the current gaps but also position the sector for sustained growth and global competitiveness.

7.3 OTHER PERSPECTIVES IN THE DATA ANALYSIS

This section explores additional insights derived from the data analysis, providing a broader understanding of the Nigerian oil industry's dynamics. By examining the performance and strategies of various entities within the sector, we gain a more comprehensive perspective on the industry's landscape.

7.3.1. Comparing National Oil Company and other surveyed companies

One of the key aspects of this section is the comparison between Nigeria's National Oil Company (NNPC) and other surveyed companies within the industry. This comparison sheds light on the operational efficiencies, production capacities, and strategic approaches of these entities.

- **Operational Efficiency:** The NNPC and its counterparts vary significantly in terms of operational efficiencies. While multinational corporations often benefit from advanced technologies and streamlined processes, the NNPC faces challenges related to maintenance, infrastructure, and regulatory constraints.

- **Production Capacity:** The data reveals that NNPC's production capacity is frequently below that of international oil companies. Factors contributing to this disparity include outdated equipment, insufficient investment in infrastructure, and operational inefficiencies.
- **Strategic Approach:** The strategic priorities of the NNPC differ from those of private and international firms. The NNPC focuses on national interests, such as ensuring fuel availability and supporting local economic development, whereas multinational companies prioritize profitability and global market integration.

7.3.2. Local vs International Oil Companies

This section delves into the contrasts between local and international oil companies operating in Nigeria, focusing on their operational models: market strategies, and contributions to the national economy.

- **Market Strategies:** International companies often leverage global market strategies and advanced technologies, while local companies focus on meeting domestic demands and navigating the local regulatory environment.
- **Economic Contributions:** Both local and international companies contribute to Nigeria’s economy, but in different ways. International firms often bring in significant foreign investment and expertise, whereas local companies play a crucial role in job creation and supporting local industries.

7.3.3. Additional Comparisons

This section explores additional insights derived from the data analysis, providing a broader understanding of the Nigerian oil industry's dynamics. By examining the performance and strategies of various entities within the sector, we gain a more in-depth perspective on the industry’s terrain.

- **Ownership and Control:** The Nigerian National Petroleum Corporation (NNPC) operates uniquely as a government-owned entity, setting it apart from privately-owned corporations in Nigeria's oil and gas sector. This ownership structure gives NNPC distinctive strategic and regulatory roles, influencing its capacity constraints, export strategies, and downstream sector optimizations. In contrast, privately-owned oil firms typically focus on specific segments of the industry, navigating challenges according to their organizational structures, market positioning, and strategic priorities.
- **Industry Dominance and Regulatory duties:** NNPC holds significant influence and control over Nigeria's oil and gas resources, overseeing major

exploration, production, and distribution activities. This dominance contrasts with other oil firms that may lack the same level of overarching control or regulatory authority. NNPC's dual role as an operator and regulator can sometimes create conflicts of interest, potentially affecting transparency and accountability within the organization. Conversely, other oil firms adhere to external regulatory frameworks, influencing regulations through consultations rather than direct governance.

- **Revenue Generation and Vertical Integration:** As a major revenue generator for Nigeria, NNPC contributes substantially through taxes, royalties, and dividends. Its vertical integration across the oil and gas value chain for instance, from exploration and production to refining, transportation, and distribution further underscores its pivotal role in the country's economic terrain.
- **Research and Development Functions:** NNPC operates its dedicated Research and Development (R&D) division aligned with national priorities and policies. This department focuses on enhancing domestic refining capacity, optimizing production processes, and developing innovative technologies. In contrast, other oil firms, whether international or domestic, conduct R&D activities based on their industry focus and strategic imperatives, varying in scale and scope due to differing resources and global networks.

7.3.4. Challenges in the Perspectives of Collaborations within the oil sector

Collaboration between the Nigerian National Petroleum Corporation (NNPC) and other oil firms in Nigeria faces significant hurdles that impact effective partnerships and cooperation within the industry.

- Differing Priorities and Strategic goals: NNPC's role as the national oil corporation often diverges from the priorities of other oil firms operating in Nigeria. Variances in strategic objectives, investment preferences, and risk tolerances can hinder collaborative efforts and create tensions. Competing interests in market share, resource access, and exploration opportunities further complicate joint ventures and cooperation initiatives (Chukwuma-ekwueme, G. 2023).
- Regulatory Complexities: The intricate regulatory framework, licensing requirements, and contractual obligations in Nigeria's oil and gas sector present challenges for collaboration. Regulatory reforms like the 2010 Nigerian Oil and Gas Industry Content Development Act have introduced bureaucratic obstacles and administrative complexities, increasing red tape and project execution timelines. These factors can deter investments and discourage partnerships or joint ventures among MNCs.
- Trust and Transparency: Building trust and ensuring transparency between NNPC and other oil firms are crucial for successful collaboration. Historical governance issues, accountability lapses, and transparency deficits within

Nigeria's oil and gas sector have eroded trust among stakeholders. For instance, controversies such as the 2014 allegations against NNPC for failing to remit $20 billion in oil revenue highlighted governance deficiencies. Enhancing transparency and governance practices within NNPC is essential to rebuild trust and effectively manage Nigeria's oil revenue.

- Competition and Resource Constraint: Despite mutual interests in maximizing oil production and exploration, competition among oil firms in Nigeria can inhibit collaboration. Competition for market dominance, access to resources, and technological capabilities often discourage joint ventures or shared initiatives. Resource constraints, including financial limitations and technical expertise gaps within NNPC, further complicate collaborative efforts with IOCs.

Overall, the constrained perspectives in the collaboration between NNPC and other oil firms arise from differing strategic objectives, with NNPC focusing on national interests while private firms prioritize profit. These differences also affect investment preferences, risk tolerance, regulatory concerns, levels of trust, and competitiveness, as NNPC faces more political pressures and regulatory risks, while private firms navigate market-driven risks and global competition with more agility.

7.4. RECOMMENDATIONS & WAY FORWARD IN COMBINING OIL INDUSTRY AND NIS

In the light of our study on the role of the Nigerian oil industry within the Global Value Chains (GVCs) and the national innovation systems capabilities for upgrade, we have identified several key insights that provide a foundation for actionable recommendations. By synthesizing findings from various aspects such as R&D activities, knowledge acquisition, market dynamics, and the intersection of global value chains and national innovation systems, we aim to offer strategic guidance for enhancing innovation and competitiveness within the sector.

Nigeria is the largest crude oil exporter in Africa and the 10th largest globally. It holds a prominent position in the global oil market. However, the country faces significant challenges within its National Innovation System (NIS), thus hindering its ability to fully capitalize on its potential for innovation and technological advancement in the oil industry. This study sheds light on the gains, dysfunctions, and systemic failures within Nigeria's NIS, particularly as they relate to the oil sector.

To address these challenges and capitalize on the opportunities identified in our research, we recommend the following:

- **Strengthening NIS capacities:** This involves the allocation of resources, both financial and human, towards strengthening the institutions, policies, and infrastructures that facilitate innovation within the country. By enhancing the capabilities of the NIS and promoting greater integration with industry stakeholders, this recommendation aims to create a more conducive environment for domestic oil firms, including small and medium enterprises (SMEs), to compete with multinational corporations (MNCs). This can help level the playing field and reduce the dominance of MNCs in the oil sector and may potentially increase domestic production capacity. Additionally, addressing weaknesses such as inadequate funding of R&D initiatives, supporting education and training programs in science, technology, engineering, and mathematics (STEM), establishing collaborative networks between academia-industry-government, and implementing policies that promote entrepreneurship and technology transfer is crucial.

- **Fostering Industry-Academia Collaboration:** This involves closer collaboration between universities, research institutions, and oil companies within the NIS framework. This partnership with relevant stakeholders/actors can facilitate technology transfer, knowledge sharing, and innovation, enabling domestic oil firms to improve their competitiveness and productivity. The strategies for implementation include initiating contracts with the universities (research projects with universities on a case-by-case basis, allowing firms to leverage university expertise without forming long-term commitments. This approach enables flexibility in research collaboration and facilitates access to specialized knowledge and resources as needs), sponsoring research (providing financial support to research initiatives within universities allows oil companies to access knowledge without becoming involved in the academic institution's governance or decision-making processes. This sponsorship model enables targeted support for specific research programs or projects aligned with the company's interest), and Knowledge exchange (sharing of information and expertise through seminar, videos, networking etc., without creating a formal alliance. These agreements are flexible and can focus on specific areas of interest, enabling mutual learning and collaboration between industry and academia). This practice can also empower local companies to develop the capabilities needed to refine crude oil domestically, thereby upgrading the oil sector.
- **Technology Adoption:** Support initiatives aimed at accelerating the adoption of advanced technologies and best practices within the oil industry through the NIS can provide incentives for technology uptake, thus, facilitating access to research and development (R&D) infrastructure. This could promote technology diffusion programs and enable oil firms to leverage cutting-edge innovations for enhanced productivity. In addition, this recommendation/s aims to enhance the efficiency and competitiveness of domestic firms in the oil industry. This can enable them to improve their refining capabilities, increase local production, and reduce fuel imports.
- **Skills Development:** This refers to the strengthening of efforts to build skilled workforce equipped with the technical expertise and innovation capabilities needed to drive the modernization of Nigeria's oil industry. For instance, ICT-based training programs can enhance the effectiveness and accessibility of Science, Technology, Engineering, and Mathematics (STEM) education for all staff, thus, providing interactive learning experiences, access to online resources, and opportunities for skill development in emerging technologies. By harnessing digital platforms and

tools, oil firms can cultivate a culture of continuous learning, foster innovation, and equip their workforce with the technical expertise needed to drive technological advancements and remain competitive in today's rapidly evolving globe. Investing in skills development and entrepreneurship can empower local talents to innovate, drive productivity improvements, and seize opportunities in the sector. With this initiative, the country can develop a pool of talent capable of leading the nation towards self-sufficiency in fuel production with increased participation in GVCs. However, it would require huge investment in education and training programs, to cultivate talent pool/s, capable of driving industry transformation within the NIS landscape (Adewuyi et al., 2023).

- **Policy Coordination:** This involves the promotion of greater coordination and coherence in policymaking and implementation across relevant government agencies responsible for science, technology, innovation, and industry regulation. For instance, the streamlining of regulatory frameworks can provide a level of policy alignment and create an enabling environment for domestic oil firms to thrive and compete effectively with MNCs. This can also create a level playing field, provide support to local companies, encourage investment in domestic refining capacity and reduce their dependence on fuel imports.
- **Repair of the Refineries:** Nigeria’s four refineries are currently moribund, hence refurbishing them could involve implementing a phased approach to rehabilitation, prioritizing critical repairs and upgrades to improve operational efficiency and reliability. Additionally, ensuring ongoing maintenance and adopting best practices in asset management are some of the essentials to sustaining the refineries' performance over the long term, contributing to energy security and economic stability.
- **NNPC and Monopoly:** Aside from the research findings, various literature sources discuss the NNPC/government monopoly and its implications. Therefore, our recommendation includes promoting market liberalization and competition within the oil and gas sector, as well as enhancing transparency and accountability through measures such as privatization or partial privatization and strengthening regulatory oversight. Moreover, fostering institutional diversity through the encouragement of private or government-backed modular refineries could provide alternatives to the current NNPC-dominated landscape, and potentially enhance competition, innovation, and efficiency in the oil sector (Itaman & Wolf, 2021).

While these recommendations may not be exhaustive, they provide a framework for enhancing domestic initiatives, thus fostering NIS capabilities, and creating an enabling environment for local oil firms to compete more effectively in the oil industry. Over time, implementing these recommendations may contribute to reducing MNC dominance, increase domestic production of fuel, and facilitate petroleum product exports, thereby increasing participation in GVC. Implementing the proposed recommendations will drive positive changes, upgrade the oil sector and advance the objectives of the study.

Suggested policies and action steps

The following are suggested policies and action steps aimed at promoting interaction between the National Innovation System (NIS) and the oil sector. These steps are designed to foster collaboration, incentivize research and development (R&D), support technology transfer, promote skill development, rehabilitation of refineries, streamline regulatory processes, encourage institutional diversity, provide funding support, establish innovation hubs, and implement monitoring and evaluation mechanisms. By implementing these policies, Nigeria can create a conducive environment for innovation and technology development in the oil sector, driving economic growth, and ensuring long-term sustainability. This involves:

(i) Promoting Innovation and Technology

- **R&D Department:** Establishing dedicated research and development units within both public and private institutions to drive innovation and technological advancement in the oil sector. Increasing funding for research and development (R&D) in the oil and gas sector can encourage innovation in exploration, production, and refining technologies to improve efficiency and reduce environmental impact.

- **Digital Transformation:** Adopting digital technologies and advanced analytics to optimize oil field operations can enhance supply chain management and improve decision-making processes. Implementing digital oil fields technologies can increase productivity and reduce costs. Moreover, leveraging Information and Communication Technology (ICT) facilitates skill enhancement among workers, thus empowering them to adapt to technological advancements and contribute to industry's innovation and sustainability effort.

(ii) Strengthening Regulatory Frameworks

- **Regulatory Reforms:** Streamlining and simplifying regulatory frameworks to reduce bureaucratic hurdles and encourage investments. Implement transparent and consistent policies that provide a clear path for new and existing oil companies,

- **Enhancing Transparency and Accountability:** Establishing independent oversight bodies to monitor NNPC's operations and financial transactions. Increase transparency in revenue reporting and allocation to rebuild stakeholder trust, synergy and ensure proper management of oil revenue.

(iii) Enhancing Collaboration and Partnership

- **Public-Private Partnership:** Fostering public-private partnerships to leverage private sector expertise and capital is crucial. This can encourage joint ventures between NNPC and international oil companies (IOCs) to enhance technical capacity and resource management.

- **Capacity Building:** Investing in training and capacity-building programs for NNPC staff to enhance technical and managerial skills can support innovation. This can be through promoting knowledge transfer through collaborations with leading global oil firms and research institutions. Also, innovation initiatives within the oil industry, including incentivizing investment in research can foster collaboration between academia and industry, and support technology and capacity building.

(iv) Improving Domestic Refinery Capacity

- **Upgrading Refineries:** To prioritize the rehabilitation and modernization of existing refineries to improve efficiency and capacity utilization. Implementing regular maintenance schedules and allocating sufficient funds to ensure operational reliability is crucial for increasing local refining capacity and reducing dependency on fuel imports.
- **Supporting new Refinery:** This facilitates the establishment of new refineries, such as the Dangote refinery, by providing incentives and reducing bureaucratic bottlenecks. Encouraging investment in modular refineries can increase domestic refining capacity and reduce dependency on imports. Also, MNCs can be encouraged to set up refineries in Nigeria to align with the broader goal of enhancing domestic refining capacity. By allowing MNCs to establish refineries under joint venture or production sharing agreements, it can stimulate investment and improve the efficiency of the downstream oil industry. This initiative aligns with the broader goal of reducing reliance on fuel imports and enhancing domestic refining capacity.

(v) Diversifying the Economy

- **Local Content Development: St**rengthening local content policies to ensure greater involvement of Nigerian firms in the oil and gas value chain can provide support for local enterprises to enhance their capacity and competitiveness.
- **Institutional diversification:** This requires encouraging institutional diversity through the promotion of modular refining schemes, which offer opportunities for smaller, more flexible refining operators to enter the market and contribute to overall industry resilience and competitiveness. Also, by developing policies that promote economic diversification away from oil dependency. Investing in other sectors such as agriculture, manufacturing, and services can create a more resilient economy.

(vi) Environmental and Social Governance

- Sustainable Practices: Implementing stringent environmental regulations to mitigate the ecological impacts of oil exploration and production. Promote sustainable practices and invest in cleaner technologies.
- Community Engagements: To enhance engagement with local communities to address their concerns and ensure that they benefit from oil-related activities. Implementing social investment programs to improve the living standards of communities in oil-producing regions may be crucial.

Way Forward

The future of Nigeria's oil sector hinges on strategic reforms and proactive measures to address existing challenges and harness opportunities. By strengthening regulatory frameworks, enhancing collaboration, improving domestic refining capacity, promoting innovation, diversifying the economy, and prioritizing environmental and social governance, Nigeria can achieve a more sustainable and resilient oil industry. These steps will not only enhance the sector's contribution to national development but also position Nigeria's competitively in the global oil market.

Figure 55: Suggested recommendations to promote the Oil industry in the Nigerian NIS

Source: Own Elaboration

7.5. SUMMARY

The oil sector remains a fundamental pillar of Nigeria's economy, significantly influencing industrial development and innovation capabilities. This chapter examines the role of the Nigerian National Innovation System (NNIS) in shaping the innovation approaches of oil companies, utilizing a structured questionnaire based on the Community Innovation Survey (CIS) methodology. The research population consists of 30 companies primarily engaged in the Nigerian petroleum industry, including indigenous Nigerian oil companies, national oil companies, and multinational corporations such as Shell, ExxonMobil, Chevron, and Total Oil Limited, among others. Twenty-five of these companies (representing approximately 85% of the total sample) responded to the survey, offering a comprehensive dataset for analyzing the innovation processes, challenges, and opportunities within the sector. The findings highlight considerable disparities in innovation performance between first-generation multinational oil companies (MNCs) and second-generation domestic firms, revealing systemic weaknesses that hinder Nigeria's ability to compete globally.

One of the critical findings relates to business turnover, where first-generation MNCs report significantly higher revenues and growth rates compared to domestic firms. This disparity suggests that advanced technological capabilities, greater access to financial resources, and established global networks contribute to the superior performance of MNCs. In contrast, second-generation companies struggle with lower turnover, primarily due to limited innovation capacity and weaker integration into global value chains (GVCs). These challenges highlight the pressing need for policies that support indigenous firms in scaling up their technological and market competitiveness.

The study also explores knowledge acquisition patterns, revealing that while companies value learning processes, R&D remains underprioritized. The graphical analysis of questionnaire responses shows that MNCs strongly support both internal and external R&D, with 100% engagement in both areas. However, domestic oil firms exhibit significantly lower support, with only 14.3% involvement in internal R&D, 9.5% in external R&D, 33.3% in internal learning processes, and 19.5% in external learning processes. This trend reflects a fundamental gap in knowledge acquisition and innovation practices, reinforcing the argument that the NNIS is not effectively fostering knowledge spillovers or collaboration between MNCs and local firms.

The chi-square statistical analysis provides further insights into the sector's innovation landscape. The test on R&D activities yielded a chi-square value of 6.093 and a p-value of 0.192, indicating no significant difference between internal and external R&D activities. This suggests that while external R&D appears slightly more prominent, overall R&D engagement remains low, particularly among domestic firms. Meanwhile, the chi-square test for learning processes resulted in a value of 9.258 and a p-value of 0.055, signaling a near-significant difference. This suggests a stronger emphasis on internal learning over external learning, with MNCs leading in both categories while domestic firms struggle to adopt external learning mechanisms effectively.

Additionally, the study finds that investment in machinery and technology remains substantial across both generations of companies. However, new-generation firms display a higher dependence on external knowledge sources, further emphasizing the need for improved linkages with global innovation ecosystems. Data on product and process innovation further confirms this divide: 92% of oil firms engage in product innovations, but MNCs dominate with 72% participation, while only 20% of domestic firms engage in similar activities. A similar trend is observed in process innovation, where 54% of first-generation companies participate compared to just 30% of second-generation firms. These findings illustrate the persistent innovation gap between multinational and domestic firms, with the latter struggling to develop and sustain competitive advantages in the oil sector. Also, the statistical and graphical analyses reinforce the findings of Research Questions 1 and 2 while directly supporting Objective 4, which evaluates the NNIS's role in enhancing innovation capabilities within the Nigerian oil industry. The weak innovation system, characterized by inadequate R&D prioritization, limited external knowledge acquisition, and insufficient policy support, has created structural barriers that prevent domestic firms from competing effectively.

Addressing these weaknesses requires a multi-faceted approach. Nigeria must significantly increase investment in R&D, create stronger linkages between academia and industry, and encourage external learning through international collaborations. Policies that provide tax incentives for R&D investment, grants for technology acquisition, and innovation capacity-building programs for domestic firms should be prioritized. Additionally, fostering a culture of knowledge-sharing between MNCs and local companies can help bridge the innovation gap and accelerate technological diffusion.

In conclusion, while learning processes are somewhat recognized within the industry, R&D remains significantly underutilized, especially among domestic firms. The findings highlight a weak innovation system where MNCs lead in both R&D and learning, while indigenous companies lag in innovation capabilities. To strengthen the NNIS and enhance the oil sector’s global competitiveness, both first- and second-generation firms must integrate R&D, external learning, and technology adoption into their strategic priorities. Addressing these challenges will not only close the existing innovation gap but also position the sector for sustainable growth, technological advancement, and stronger participation in global innovation networks.

PART 4.
CONCLUSIONS

Chapter 8.
Conclusions

This final chapter consolidates key insights from the study, which examines Nigeria's oil industry within Global Value Chains (GVCs) and evaluates the role of its innovation system in facilitating industrial upgrading. By analyzing these dynamics across multiple chapters, the study provides a comprehensive perspective on Nigeria's position in the global economy and the constraints limiting its innovation-driven transformation.

Each chapter offers distinct insights into the interplay between global trade structures and domestic innovation capabilities, shaping the study's policy and strategic recommendations. This chapter also reflects on how the research objectives and questions have been addressed throughout Chapters 1 to 7. It provides a structured summary of each chapter, highlighting their contributions to the overall study. Furthermore, it discusses the broader implications of the findings, acknowledges the study's limitations, and identifies directions for future research.

8.1. SUMMARY OF PREVIOUS CHAPTERS

To provide a clear overview of the study, the following section presents a summary of each chapter, highlighting their contributions to overall research and how they collectively address the study's objectives and research questions.

Chapter 1 introduced the foundational elements of the thesis, providing background, rationale, research questions, and objectives. It framed the central paradox of Nigeria's oil industry: despite being one of the world's largest crude oil exporters, the country remained heavily reliant on imported refined petroleum products due to limited domestic refining capacity and weak industrial upgrading. The chapter introduced the National Innovation System (NIS) framework as the central analytical tool for evaluating Nigeria's oil sector. It highlighted the significance of innovation, industrial policy, and value chain dynamics in shaping the country's global competitiveness. Additionally, a brief overview of the methodology was provided, outlining the study's empirical approach and the data sources employed.

Chapter 2 provided a comprehensive review of existing literature, focusing on global value chains (GVCs) and industrial development in resource-rich economies. It examined the theoretical foundations of GVCs and their role, particularly in developing countries. The chapter also analyzed the global oil industry within the context of GVCs, tracing the evolution of value chains in the petroleum sector and examining how countries and firms integrated into and moved up the value chains. It explored the governance structures that influenced the distribution of value across global oil markets, with a particular focus on the impact of multinational corporations (MNCs) in refining, trading, and the application of advanced technologies. A key focus was placed on the strategies countries adopted to upgrade within the petroleum value chain, from basic resource extraction to higher-value activities such as refining, petrochemicals, and energy services.

A significant component of the chapter was its examination of Trade in Value Added (TiVA) as a measurement framework for assessing countries' capabilities to add value to their production and services. The discussion highlighted how different economies, particularly developing countries, participated in GVCs, focusing on their degree of backward and forward integration. By analyzing data across various economies, the chapter compared how resource-rich countries retained value in their exports and the extent to which they remained dependent on external refining and processing industries. This analysis provided insights into the structural barriers that limited value retention in many oil-exporting developing countries, such as weak domestic refining capacity, limited technological capabilities, and a reliance on raw material exports. While the discussion on TiVA and value capture in GVCs remained central to the chapter, the focus was global, examining trends and challenges across multiple oil-producing economies.

By outlining the structural constraints and opportunities for value addition in oil-exporting LDCs, the chapter laid the groundwork for understanding the challenges faced by economies that remained primarily raw material suppliers. It also highlighted the best global practices and policies that enabled certain countries to successfully advance in the chains. The chapter concluded by reinforcing the importance of domestic industrial development, refining capacity expansion, and innovation systems in enhancing value retention within the global petroleum industry. Finally, it highlighted the gains and risks associated with GVCs and their specific implications for the petroleum industry. The review underscored the importance of understanding GVCs to grasp the dynamics of the global oil market, thus setting the foundation for later discussions on Nigeria's case in Chapter 5.

Chapter 3 offered a thorough analysis of National Innovation Systems (NIS), defining the concept and outlining its key components, types, and its significance in economic development. It examined the role of NIS in both advanced and developing economies, with particular attention given to how developing countries build innovation capabilities to drive industrial growth and technological progress.

The chapter discussed the benefits and challenges of NIS in developing countries, highlighting issues such as weak institutional frameworks, limited funding for research and development (R&D), poor university-industry collaboration, and policy inconsistencies. It emphasized how these nations could strengthen their NIS to foster knowledge diffusion, encourage technological innovation, and promote economic diversification. Special focus was placed on the petroleum sector, assessing the role of petroleum clusters in driving innovation and the barriers to effectively implementing NIS. The chapter also provided comparative insights from oil-producing nations, showcasing strategic policies that had successfully enhanced innovation-driven growth in the petroleum industry. By evaluating the relationship between NIS, innovation policies, and industrial competitiveness, the chapter provided valuable insights into how developing nations could leverage their NIS to foster technological progress within the oil sector. The chapter concluded with a summary of key findings, paving the way for Chapter 4's discussion on the integration of NIS and Global Value Chains (GVC).

Chapter 4 explored the integration of Global Value Chains (GVCs) and National Innovation Systems (NIS), analyzing how their co-evolution can drive industrial upgrading and technological development. It provided an overview of policy frameworks and best practices, presenting various perspectives on the relationship between GVCs and NIS, and how this integration can enhance innovation and global competitiveness. The chapter focused on strategies employed by developing countries to combine GVCs and NIS, identifying both opportunities and challenges in their linkages.

The chapter outlined the stages of GVC-NIS co-evolution, discussing the foundational elements, institutional linkages, and illustrative trajectories that shape their interaction. The analysis emphasized how successful economies align their NIS policies with global production networks to promote value retention, facilitate knowledge transfer, and encourage technological innovation. Key factors such as strong university-industry-government collaboration, targeted investments in R&D, and infrastructure improvements were highlighted as essential for maximizing the benefits of GVC participation. Ultimately, the chapter concluded with valuable insights on how developing nations can strengthen their NIS-GVC links to improve industrial competitiveness, enhance innovation capacity, and ensure long-term economic sustainability.

Chapter 5 shifted the focus from the global perspective of the oil industry in Chapter 2 to an in-depth examination of Nigeria's oil industry and its position within the Global Value Chain (GVC). The chapter began with a brief historical overview of the industry, tracing its development and structural evolution. It then examined the key drivers of the sector, emphasizing its economic significance, particularly its contributions to Nigeria's GDP, export earnings, and employment.

A primary focus of the chapter was Nigeria's participation in GVCs through the Trade in Value-Added (TiVA) framework. The findings revealed that Nigeria's involvement in GVCs is largely characterized by backward participation, where the country primarily exports raw materials, such as crude oil, while importing higher value-added products, such as refined petroleum. This paradox highlights Nigeria's limited capacity for domestic value addition and underscores the need for strategic interventions to enhance industrial upgrading and competitiveness. The analysis of data from the OECD TiVA database (1995–2020) confirmed that Nigeria's backward participation significantly outpaces its forward participation, further reinforcing its reliance on raw material exports rather than the production of refined products.

The chapter also directly addressed Research Question 1 by identifying the key reasons Nigeria continues to import refined petroleum despite being a major crude oil exporter. Key barriers to Nigeria's refining capacity include inadequate infrastructure, inconsistent energy policies, regulatory inefficiencies, and a lack of sufficient investment in domestic refining. The chapter aligned with Objective 1 by positioning Nigeria within the global petroleum value chain, illustrating its role as a raw material exporter with minimal value addition. It further addressed Objective 2 by mapping the domestic value chain in Nigeria's petroleum sector and assessing the economic impact of the country's reliance on imported refined petroleum. The findings revealed that this dependence hampers domestic industrial growth and leads to significant economic costs, including lost value addition, missed job creation opportunities, and limited technological development. By examining these structural deficiencies, the chapter emphasized the critical need for reforms in refining capacity, policy consistency, and industrial investment. These reforms are essential for improving Nigeria's ability to retain more value within its petroleum sector and strengthen its global competitiveness. The chapter concluded by summarizing the key findings, reinforcing Nigeria's current position in the GVC, and recommending policy improvements to enhance the sustainability and long-term economic impact of the oil industry.

Chapter 6 provided a detailed examination of Nigeria's National Innovation System (NNIS), shifting the focus from the global perspective of Chapter 3 to an in-depth analysis of Nigeria's innovation landscape. The chapter began with a historical overview, outlining the origins and recent developments in Nigeria's innovation system. It then evaluated the country's innovation performance using the Global Innovation Index (GII) reports (2011–2020), benchmarking Nigeria's standing against other oil-rich nations and examining key innovation pillars such as institutions, human capital, infrastructure, and knowledge outputs.

The findings revealed strengths in business sophistication but persistent weaknesses in knowledge and technology outputs, highlighting critical gaps in Nigeria's innovation ecosystem. The chapter also explored the broader economic and policy environment shaping Nigeria's trade performance. It examined the impacts of fuel shortages, subsidy policies, and state interventions in the oil sector, identifying major barriers to oil industry growth and value retention, such as political instability, inadequate infrastructure, and weak institutional frameworks. These challenges limited Nigeria's ability to enhance technological capabilities and move up the global value chain (GVC). A key focus of the chapter was the role of NNIS agents, particularly the interactions between universities, industry, and government. The findings highlighted poor collaboration among these stakeholders, with tertiary education institutions facing challenges such as inadequate funding, infrastructure deficits, and staffing constraints. The weak linkages between academic research and industrial application hindered innovation-driven growth, preventing Nigeria from fully leveraging its knowledge base to support industrial upgrading, especially in the oil sector. The government's role in fostering innovation was also critically assessed, with an emphasis on policy frameworks, funding mechanisms, and institutional support. While there had been policy efforts to drive innovation, inconsistent policies, low R&D investment (below 1% of GDP), and limited collaboration between the public and private sectors remained significant obstacles. Comparative analysis with other oil-producing economies, such as Norway, South Africa, Mauritius, and Algeria, revealed that Nigeria lagged in translating resource wealth into sustainable, innovation-driven economic diversification.

Also, this chapter specifically addressed Objective 3 of the study, which aimed to characterize Nigeria's National Innovation System and its relationship with the National Petroleum Industry (NPI). This analysis emphasized the need for a stronger alignment between the oil sector and Nigeria's innovation system to support the industrial upgrading and technological advancements necessary for moving up the GVC. By identifying the barriers and opportunities for improving the NIS in relation to the oil sector, the chapter set the stage for exploring potential strategies for enhancing technological capabilities, boosting industrial growth, and improving Nigeria's global competitiveness. To address these structural challenges, the chapter proposed strategic policy recommendations, including increased investment in digital infrastructure, stronger university-industry partnerships, and policy reforms to incentivize technological advancement. Strengthening Nigeria's National Innovation System was deemed essential for supporting oil sector upgrades, driving economic diversification, and improving Nigeria's global competitiveness. Ultimately, the insights from this chapter set the stage for Chapter 7, which further explored the Nigerian oil industry within the context of the NNIS, reinforcing the need for a more integrated, innovation-led approach to economic development.

Chapter 7 empirically analyzed Nigeria's oil industry within the National Innovation System (NNIS) framework, addressing Objectives 3 and 4 of the study. The chapter investigated various aspects of innovation within the sector, including innovation sources, firm turnover, R&D investment, product innovation, and external knowledge flows. Utilizing a self-structured questionnaire based on the Community Innovation Survey (CIS) methodology, the study gathered firm-level data to assess innovation performance across the oil sector.

The findings revealed that domestic firms relied more on learning processes rather than formal R&D activities. In contrast, multinational corporations (MNCs) dominated the industry, exhibiting significantly higher turnover and R&D investments compared to indigenous companies. MNCs also led in technological advancements and innovation, benefiting from superior financial resources, access to global knowledge networks, and strategic partnerships. This dominance by MNCs limited the growth and competitiveness of local firms, as indigenous companies faced challenges such as inadequate funding, weak infrastructure, and limited access to advanced technologies. The chapter also highlighted the role of external knowledge sources, such as training programs and specialized services, in driving innovation within the sector. However, a key finding was the limited collaboration between local firms and universities, coupled with weak institutional support for R&D. This lack of collaboration and support remained a significant obstacle to building a sustainable innovation ecosystem that could foster technological progress and industrial upgrading.

To strengthen the statistical analysis, Chi-square tests were employed to assess the relationships between firm characteristics and innovation activities. This enhanced the validity of the findings by identifying significant associations and patterns that might have been overlooked using only descriptive statistics. For instance, the analysis indicated a near-significant difference between internal and external learning process, suggesting a greater emphasis on internal learning among Nigerian firms. Additionally, the results revealed no significant difference between internal and external R&D activities within Nigerian companies, as the overall level of R&D investment was found to be relatively low across both internal and external efforts. This underinvestment in R&D further highlighted the challenges to innovation and technological advancement within the sector.

This imbalance in R&D investment limited the growth potential and competitiveness of indigenous firms, which continued to face significant barriers such as inadequate funding, weak infrastructure, and restricted access to cutting-edge technologies. Despite these findings, data availability constraints posed a limitation, particularly for econometric modeling. Like many developing countries, Nigeria lacked comprehensive industry-level data, making it difficult to apply advanced econometric techniques for deeper quantitative analysis. Addressing this issue in future research would require enhanced data collection mechanisms and greater transparency in industry reporting.

This chapter built upon the foundation laid in Chapter 6, which addressed Objective 3 by characterizing Nigeria's NIS and its relationship with the petroleum industry. While Chapter 6 provided a broad structural and institutional analysis, Chapter 7 offered empirical evidence to validate these discussions. The findings confirm that innovation activities in the oil sector were largely informal and driven by experiential learning, rather than structured R&D investments. Additionally, it reinforced the weak linkages between universities, industries, and government institutions, which limited the ability of the NNIS to support industrial growth and technological advancement in the petroleum sector. These weaknesses underscored the need for stronger policy interventions and institutional reforms to enhance Nigeria's innovation capabilities.

Furthermore, this chapter directly addressed Objective 4, which assessed the potential of the NIS to upgrade Nigeria's position in the global petroleum value chain. The study demonstrated that Nigeria's weak innovation system hindered industrial upgrading and value retention within the oil sector. The low level of indigenous R&D investment, combined with institutional deficiencies, restricted Nigeria's ability to move beyond crude oil extraction into higher-value activities like refining, petrochemicals, and advanced energy services. The findings reinforced the need for strategic policy measures to increase R&D investment, promote technology transfer, and strengthen university-industry-government collaboration. Without these interventions, Nigeria's ability to improve its competitiveness in the global petroleum industry would remain limited. The chapter concluded by highlighting critical policy recommendations needed to strengthen Nigeria's NIS and enhance the country's industrial upgrading potential within the global petroleum value chain. These insights set the stage for the final chapter, which synthesizes the study's findings and outlines strategic policy directions for the future.

8.2 RESEARCH FINDINGS:

This section presents the key findings of the study, addressing the research questions and objectives outlined in previous chapters. The analysis is structured around the study's core research questions, providing insights into the role of Nigerian oil industry within the GVC and the capabilities of its innovation systems for upgrading.

(i) Our first research question is: "Why Nigeria, which is a net exporter of crude oil, is also a net importer of refined oil?"

The findings for Research Question 1, reveal significant insights into the structure and dynamics of Nigeria's oil industry. A noteworthy discovery in the research is the dominance of multinational corporations (MNCs) in Nigeria's oil sector, particularly in upstream activities. One key reason from the questionnaire trend is the high turnover of key industry players, which affects long-term investment in domestic refining capacity. MNCs are major players in the exploration and extraction of crude oil in Nigeria, but their focus on the upstream segment limits their investment in domestic refining capabilities. Despite their substantial technological expertise and financial resources, MNCs largely invest in refining operations outside of Nigeria. Thus, the concentration of investment in upstream activities has left Nigeria with a significant gap in domestic refining capacity, forcing the country to import refined oil to meet its domestic fuel needs.

This imbalance in the global value chain is underscored by Nigeria's backward participation in global value chains (GVCs), where the country primarily exports crude oil (a low-value raw material) while importing refined products. Data from the Trade in Value Added (TiVA) framework reveals that Nigeria’s participation in the refining portion of the value chain is minimal, highlighting the structural challenges that hinder the development of local refining capacity. The country’s backward participation points to the lack of technological and financial resources required to refine crude oil locally, and the failure to develop this domestic capacity continues to perpetuate Nigeria’s reliance on imported refined petroleum products.

Moreover, the lack of innovation within the domestic refining sector compounds this issue. Indigenous companies in Nigeria have shown limited engagement in product innovation, particularly in the refining process. Many firms are not investing sufficiently in developing new refining technologies or improving existing infrastructure to meet the demands of domestic fuel consumption. This stagnation in innovation limits the growth of local refineries and leaves Nigeria reliant on foreign refineries, to meet the country’s demand for refined petroleum products.

Additionally, Nigeria's dependence on crude oil swaps and inefficient trade practices further complicates the situation. Crude oil swaps, where Nigeria exchanges crude oil for refined products with other countries, have been a long-standing practice. However, this process is plagued by lack of transparency**,** inefficiencies, and corruption, all of which exacerbate the country’s dependence on imported refined oil. These systemic issues prevent the country from utilizing its crude oil resources to their full potential by refining them domestically and creating more value in the process.

The country’s infrastructure deficiencies also play a significant role in the reliance on imported refined oil. Existing refineries in Nigeria are outdated and underutilized, lacking the modern technology and capacity required for efficient refining. Despite being one of the largest oil producers in the world, Nigeria has not built or upgraded sufficient refining infrastructure to process its crude oil locally. This infrastructure gap, combined with political instability and policy inconsistencies, further hinders Nigeria’s ability to develop a self-sustaining refining sector.

In conclusion, the research highlights that Nigeria’s continued importation of refined oil, despite being a net exporter of crude oil, stems from several interrelated factors. The dominance of MNCs in the upstream sector, backward participation in the global value chain**,** lack of technological innovation in refining, and systemic issues such as crude oil swaps and infrastructure deficiencies all contribute to the country’s reliance on imported refined petroleum products. Addressing these challenges requires substantial investment in refining capacity, innovation, and infrastructure, along with policy reforms to enhance the domestic oil industry’s competitiveness and reduce reliance on foreign refineries.

(ii) The second research question is: “To what extent can the Nigeria’s NIS be used to upgrade the National Petroleum Industry in the Global Petroleum Value Chains?”

The study finds that the structural weaknesses of Nigeria’s NIS significantly hinder its ability to support upgrading and innovation in the oil sector. Despite policies aimed at fostering innovation and technological advancement over the past three to four decades, several factors undermine the effectiveness of the NIS. This ranges from socio-economic factors to environmental degradation and other violations including policy inconsistencies. Also, key findings from the questionnaire based on the Community Innovation Survey (CIS) methodology and the Global Innovation Index (GII) reports provide crucial insights into the extent to which Nigeria’s National Innovation System (NIS) can drive upgrades and innovation in the oil industry.

The GII results (2011–2020) indicate that Nigeria lags behind other oil-rich nations in key innovation pillars**,** such as knowledge and technology outputs, infrastructure, and human capital. While the country demonstrates strengths in business sophistication, its weak performance in technological innovation and knowledge creation suggests that the current NIS lacks the capacity to significantly upgrade the oil industry. This aligns with the questionnaire findings, which reveal limited engagement in R&D and innovation-driven activities among domestic firms. The responses highlight that while some firms invest in process innovation, product innovation remains significantly low**,** particularly in the refining segment of the industry. This contributes to Nigeria’s continued dependence on imported petroleum products, as indigenous companies struggle to develop and commercialize new refining technologies.

A key observation from the questionnaire analysis is the limited commitment to R&D activities among domestic firms. The findings indicate that only 14.3% of indigenous companies actively support R&D within Nigeria**,** reflecting a critical gap in research investment. Additionally, the number of established R&D departments within Nigerian firms remains notably low, with only six respondents confirming the presence of such departments, compared to 19 who indicated their absence**.** This insufficient R&D investment constrains the development of new technologies and innovations essential for upgrading the oil sector, reinforcing Nigeria’s dependence on external sources of refined petroleum.

The survey also reveals a dismally low level of university-industry collaboration, a key factor in fostering innovation within a well-functioning NIS. The results indicate that university partnerships received an average importance score of less than 20%**,** highlighting a significant gap in collaboration between academia and industry. Given that effective NIS frameworks rely on strong linkages between universities, industries, and the government, this weak synergy hampers knowledge transfer, industrial learning, and the commercialization of research outputs. In contrast, successful oil-producing economies such as Norway and Brazil have prioritized strong university-industry-government linkages, enabling their NIS to actively support technological advancements and industrial growth.

Further analysis from the questionnaire responses underscores the structural weaknesses within Nigeria's innovation ecosystem**.** The Chi-square test results confirm a near-significant difference between internal and external learning approaches among oil firms**,** with internal learning methods, such as process adaptation and informal knowledge sharing, being more dominant than structured external learning through R&D collaborations. Moreover, the test results reveal no significant difference between internal and external R&D investment, indicating that overall R&D expenditure remains consistently low across the sector**.** This suggests that domestic firms are not investing sufficiently in formal research and development**,** further limiting their ability to achieve industrial upgrades.

Additionally, policy inconsistencies and regulatory challenges have weakened the NIS's ability to foster innovation in the oil sector. Frequent shifts in industrial policies, bureaucratic inefficiencies, and inadequate enforcement of intellectual property rights create uncertainty for businesses, discouraging long-term investments in research and development. Compared to countries like Norway and Brazil, where strong policy frameworks and government incentives support innovation in the petroleum sector, Nigeria's fragmented approach has resulted in a lack of coordinated efforts to enhance domestic technological capabilities**.**

Despite these challenges, the findings suggest that Nigeria's NIS has the potential to support industrial upgrades if key reforms are implemented. Strengthening university-industry-government collaboration is essential for fostering a knowledge-driven oil sector. Additionally, targeted policies should encourage technology transfer from multinational corporations (MNCs) to indigenous firms**,** ensuring that local companies can benefit from advanced expertise and innovations. Increasing R&D investments, providing financial incentives for domestic technology development, and improving industrial infrastructure are also crucial steps toward enhancing the NIS's effectiveness.

In conclusion, while Nigeria's current NIS lacks the capacity to drive significant innovation in the oil industry**,** the research findings highlight specific areas where targeted interventions can strengthen its role. Addressing low R&D investment, weak institutional linkages, and policy inconsistencies is critical for enabling Nigeria's NIS to support industrial upgrades and improve its global competitiveness in the petroleum sector.

8.3. LIMITATIONS OF STUDY AND FUTURE RESEARCH

While the study makes valuable contributions to the understanding of the oil sector in the National Innovation Systems (NIS), it is essential to acknowledge and communicate the limitations. Here is a summary:

- The study primarily focuses on a specific country (Nigeria) and within the oil sector, including its interaction with GVC and NIS. Thus, the findings tend to have limited generalization beyond the specific context. Although comparisons were made with other oil-producing nations, the analysis remains country- and sector-specific.

- Data availability pose challenges, particularly in areas such as R&D expenditures and industry-wide technology adoption. Some respondents provided incomplete or inconsistent information**,** limiting the depth of statistical analysis. The sensitivity of oil-sector data also restricted access to comprehensive datasets.
- The oil sector is diverse, encompassing upstream, midstream, and downstream activities. The study did not fully capture the heterogeneity within the industry as focus was more on the refining sub-sector production and its innovation performance.
- External factors such as economic downturns, political instability, and global events exert significant influence on both the oil industry and the effectiveness of the National Innovation System (NIS). However, these broader macroeconomic and political dynamics were not extensively examined in this study, leaving room for further investigation into their impact on innovation and industrial upgrading within the Nigerian context.

Although this study enhances the credibility of the research, it tends to provide a foundation for future studies to build upon the findings. Additionally, recognizing these limitations allows actors, readers and stakeholders to interpret the results within the context of these constraints.

In the aspect of further research on the National Innovation Systems (NIS) within the Nigerian oil sector several factors could be explored to deepen understanding and guide policy interventions. Other potential areas for future research include:

1. **Exploration of Econometric Models**: Future research could employ advanced econometric models to quantitatively assess the relationship between Nigeria's petroleum industry, innovation policies, and economic performance. Given the limitations in firm-level data availability, future studies should integrate longitudinal datasets and employ econometric techniques to provide more robust empirical evidence for policy recommendations. This would help assess the long-term impact of NIS interventions and identify trends in innovation adoption.
2. **Technological Innovation and Sustainability in the Oil Sector**: Investigating how emerging technologies, such as digital transformation, automation, and renewable energy integration, can enhance the efficiency, sustainability, and competitiveness of Nigeria's petroleum sector. This would provide insights into balancing economic growth with environmental responsibility particularly as Nigeria seeks to diversify its energy mix and align with global sustainability goals.
3. **Effectiveness of Existing NIS Policies in Promoting Innovation**: A detailed analysis of the effectiveness of current NIS policies in fostering innovation within Nigeria's oil industry is necessary. Future studies could assess the outcomes of specific policies, identify gaps, and propose refinements to better align with industry challenges and opportunities.
4. **Pathways for Local Content Development and Industrial Upgrading**: Given Nigeria's position in the global petroleum value chain, future research could focus on strategies for

enhancing local content participation, developing indigenous technological capabilities, and upgrading domestic industries to move beyond primary resource extraction. This would support long-term economic diversification and resilience.

By exploring these study areas, future research can contribute to the ongoing efforts to reform Nigeria's petroleum sector and strengthen its innovation ecosystem for sustainable growth. Innovation scholars, policymakers, and industry stakeholders can collaborate and generate valuable insights to inform effective strategies, policies, and collaborative frameworks, ultimately enhancing innovation performance and fostering the sector's long-term competitiveness.

8.4. STRATEGIC POLICY RECOMMENDATIONS

Based on the findings from this study, several strategic recommendations are proposed to strengthen Nigeria's National Innovation System (NIS) and improve the country's oil sector innovation performance. These recommendations focus on policy reforms, fostering collaboration, and supporting local innovation, with the goal of building a more competitive and sustainable oil sector.

1. **Strengthen R&D Investment and Infrastructure**: To address the challenges in technological innovation, it is critical to incentivize and support research and development (R&D) within Nigeria's oil sector. The government should introduce tax incentives, funding programs, and grants to support R&D investments in the oil industry, particularly in refining technologies. Establishing and supporting R&D departments within local firms will be key to building technological capabilities. Additionally, enhancing the country's research infrastructure, such as laboratories and innovation hubs, will enable domestic firms to engage in cutting-edge research and contribute to the development of relevant technologies.
2. **Promote University-Industry Collaborations**: One of the main barriers to innovation in Nigeria's oil sector is the lack of collaboration between universities and the industry. Strengthening the ties between academia and the oil sector is essential to creating a more robust domestic innovation ecosystem. University-industry partnerships should be promoted to facilitate joint research, knowledge transfer, and technology commercialization. Encouraging academia to work alongside industry experts will help develop solutions tailored to the specific challenges of Nigeria's oil sector, enhancing innovation and addressing local industry needs.
3. **Align and Stabilize Policy Frameworks**: The lack of consistent and aligned policies across government administrations has hampered long-term strategic planning in Nigeria's oil sector. It is crucial for the government to create a stable and aligned policy framework that supports local content development and technology transfer. Long-term policies should focus on enhancing the innovation capacities of domestic firms, incentivizing them to invest in technology and R&D. Moreover, policies should be well-

enforced to ensure that objectives aimed at enhancing technological capabilities and local content are consistently achieved.

4. **Improve the Business Environment for Innovation**: The business environment in Nigeria needs to be more conducive to innovation. The government should focus on improving infrastructure, particularly in areas such as energy supply, transportation, and telecommunications, to lower the cost of doing business. Additionally, improving intellectual property protection will encourage domestic firms to invest in innovation with confidence. Establishing sustainable and transparent business practices within the oil sector, such as in crude oil swaps and refining processes, will reduce inefficiencies and foster greater industry trust.
5. **Foster Local Content Development and Diversification**: To reduce Nigeria's dependence on multinational corporations (MNCs) and foreign technologies, it is essential to prioritize local content development. The government should implement policies that encourage the growth of indigenous firms, including tax incentives, training programs, and investment in local technologies. Furthermore, Nigeria should explore economic diversification beyond the oil sector, fostering innovation in agriculture, renewable energy, and manufacturing. This diversification will help Nigeria build resilience against global oil price fluctuations, create new industries, and ensure long-term sustainable growth.

These strategic recommendations aim to address key barriers to innovation in Nigeria's oil sector and promote the growth of a robust National Innovation System (NIS). By strengthening R&D efforts, enhancing collaboration between academia and industry, aligning policy frameworks, improving the business environment, and fostering local content development, Nigeria can build a more competitive, innovative, and diversified oil sector. These efforts will help the country move up the value chain, ensuring greater economic resilience and long-term sustainability.

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ANNEX

USC
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THE OIL INDUSTRY IN THE NIGERIAN INNOVATION SYSTEM

Presentation of the Study:

Dear Madam/Sir: Please, can you take a few minutes to complete this survey? This is a part of a PhD methodological design aimed at gathering data on the oil industry in Nigeria's National Innovation System with regards to how economy & knowledge interactions can be combined to generate transformation. I assure you that the information obtained is for educational purpose and will be treated confidentially. In case of any constraint, you can communicate with me via +34602166403. Thank you.
Sincerely,
Eno Henry.

Company and person in charge of filling-in the questionnaire:

We suggest that the questionnaire is filled-in by a person in charge of relevant production and innovation activities

Name of the company or group(Please indicate) ______________________

Name ______________________ Charge that occupies in the company ______________________

Telephone ____________ Fax ____________ And-mail ____________

A - GENERAL ASPECTS

A.1 - Main economic Activity

Main activity **which generates more value added.**

Description:

A.2 - Geographical Origin of the main or proprietary shareholder of the company:

Geographical origin of the main shareholder

☐ Nigeria ______________________

☐ Other Country (please name the country): ______________________

A.3 - Year of establishment in Nigeria:

|_|_|_|_|

A.4- Economic Data

It includes total turnover from sales of goods and services, exports and taxes, except Value Added taxes.
The companies belonging to foreign groups must indicate only the turnover and the exports in Nigeria.

	Year 2020	Year 2021	Year 2022
Total turnover	$	$	$
Total personnel			

B- MARKET AND PROVISION OF THE COMPANY

B.1 – Please indicate the approximated percentage of your turnover for the last exercise at:

Nigerian market	%
African market (without Nigeria)	%
EU market	%
US market	%
Other markets	%

B.2 – Please indicate the approximated percentage of the amount spent on inputs and means of production for the last exercise from:

Nigerian providers	%
African providers (without Nigeria)	%
EU providers	%
US providers	%
Other providers	%

C – NEW KNOWLEDGE ACQUISITION

The incorporation of new knowledge consists in the acquisition of the capacities/*Know how* that can boost creative skills and innovation for the realization of significant improvements or creation of new products/services, processes, organisational methods or of commercialization.

C.1 – Please indicate according to importance to your company the channels of incorporation of new knowledge:

		Very Important	Quite Important	Little Important	At all Important	It was not used
Internal	R&D activities undertaken by the company **in Nigeria**	☐	☐	☐	☐	☐
	R&D activities undertaken by the company in **other countries**	☐	☐	☐	☐	☐
	Pocesses of internal learning of the company **in Nigeria**	☐	☐	☐	☐	☐
	Pocesses of internal learning of the company in **other countries**	☐	☐	☐	☐	☐
External	Hiring qualified personnel from **Nigeria**	☐	☐	☐	☐	☐
	Hiring qualified personnel from **other countries**	☐	☐	☐	☐	☐
	External training hired by the company in **Nigeria**	☐	☐	☐	☐	☐
	External training hired by the company in **other countries**	☐	☐	☐	☐	☐
	Hiring specialized services (consultants, technological centres, universities, etc.) **from Nigeria**	☐	☐	☐	☐	☐
	Hiring specialized services (consultants, technological centres, universities, etc.) **from other countries**	☐	☐	☐	☐	☐
	Purchase or use, under licence, of patents or inventions no patented **from Nigeria**	☐	☐	☐	☐	☐
	Purchase or use, under licence, of patents or inventions no patented from **other countries**	☐	☐	☐	☐	☐
	The joint projects of innovation with **Nigerian** Universities and/or technological centres	☐	☐	☐	☐	☐
	The joint projects of innovation with Universities and/or technological centres **from other countries**	☐	☐	☐	☐	☐
	Any type of contact/relation with **Nigerian** clients, providers, personal of other companies, etc.., that derives in incorporation of knowledge (Ex.: The contact in fairs or congresses)	☐	☐	☐	☐	☐
	Any type of contact/relation with clients, providers, personnel of other companies **from other countries** etc.., that derives in incorporation of knowledge (Ex.: The contact in trade-fairs or congresses)	☐	☐	☐	☐	☐
Other	Specialized publications	☐	☐	☐	☐	☐
	Others (Indicate): ____	☐	☐	☐	☐	☐

C.2. – Indicating the importance of the following agents or sources of acquisition of new knowledge for your company:

	Very Important	Quite Important	Little Important	At all Important	No relation with this agent
Clients from Nigeria	☐	☐	☐	☐	☐
Clients from other Countries	☐	☐	☐	☐	☐
Providers from Nigeria	☐	☐	☐	☐	☐
Providers from other Countries	☐	☐	☐	☐	☐
Personnel of other companies of the same group in Nigeria	☐	☐	☐	☐	☐
Personnel of other companies of the same group in other countries	☐	☐	☐	☐	☐
Companies competitors or companies of his same branch of activity in Nigeria	☐	☐	☐	☐	☐
Companies competitors or companies of his same branch of activity in other countries	☐	☐	☐	☐	☐
Expert and personal of consultants firms from Nigeria	☐	☐	☐	☐	☐
Expert and personal of consultants firms from other countries	☐	☐	☐	☐	☐
Universities, centres of investigation and other similar organisms from Nigeria	☐	☐	☐	☐	☐
Universities, centres of investigation and other similar organisms from other countries	☐	☐	☐	☐	☐
Others (pointed out): ____	☐	☐	☐	☐	☐

2

D– INNOVATION

An **innovation** is the new **implementation or significant improvement** in product quality (good or service), of a process, of an organizational method or of commercialization, of the organisation of the workplace or of the external relations of the company.

D.1 – R&D internal activities

1.a Does your company have an R&D department in Nigeria?

☐ Yes ☐ No

2.a Number of R&D employees in Nigeria?

Year 2022	Year 2021

1.b Does your company have an R&D department in other countries?

☐ Yes ☐ No

2.b Number of R&D employees in other countries?

Year 2022	Year 2021

D.2 – During the period 2021-2022, did your company undertake any of the following activities, aimed at achieving new or improved products (goods or services) or processes?

In affirmative case, please indicate the spent amount (in thousands of dollars)

Activities:	Definition:	YES	NO	Amount 2021	Amount 2022
1. Internal R&D	Creative work carried out within the company to increase the volume of knowledge in order to develop new or improved products and processes (including the development of software)	☐	☐	$	$
2. Acquisition of R+D (external)	The same activities indicated above but accomplished by other companies (including others from the same group), public or private research bodies, purchased by the company	☐	☐	$	$
3. Acquisition of machinery, equipments and software	Acquisition of machinery, equipments and advances *hardware* or *software* for the production of new or improved products, processes, etc (not included in R&D)	☐	☐	$	$
4. Acquisition of other external knowledge	Purchase or use, under licence, of patents or inventions not patented from other companies or organisations to use in the innovations of your company	☐	☐	$	$
5. Training	Internal or external training of your personnel, destined specifically to the development or introduction of new or improved products or processes	☐	☐	$	$
6. Introduction of innovation in the market	Activities for the introduction of new or improved goods and services including market investigation and advertising of new products	☐	☐	$	$
7. Other arrangements for production and distribution	Procedures and technical arrangements to develop and/or introduce new products or not included in other points	☐	☐	$	$

D.3 – Within the period 2021-2022, did your company introduce innovations or significant improvements in the following fields?

		YES	NO	Field of the novelty: For the market	Field of the novelty: Only for your company
Product Innovations	Goods	☐	☐	☐	☐
	Services	☐	☐	☐	☐
Process innovations	Methods of manufacture or production of goods or services	☐	☐	☐	☐
	Logistical systems or methods of delivery or distribution for inputs, goods or services	☐	☐	☐	☐
	Support activities for processes, like IT systems maintenance or operations, purchasing or accounting, etc	☐	☐	☐	☐
Organisational innovations	Systems of management of the knowledge destined to improve the utilization or the exchange of information, knowledge and competences inside your company	☐	☐	☐	☐
	Important modification at the organisation of the labour in your company, like changes at the management structure or the integration of different departments or activities	☐	☐	☐	☐
	Changes in relations with other companies or public institutions, for example, by means of alliances, association or subcontracting	☐	☐	☐	☐
Marketing innovations	Significant modifications of the design or packing of goods/services (Excluding routine or seasonal changes...)	☐	☐	☐	☐
	Selling or distribution methods, like internet sales, franchises or licenses	☐	☐	☐	☐

Remarks/ Other observations:

Thank you for your collaboration

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With globalization, firms change methods of trade and interactions, supported by diverse Knowledge in science and technologies. This study examines the role of National Petroleum Industry (NPI) within the Global Petroleum Value Chains (GPVCs) and the National innovation systems capability in upgrading this industry. Oil is the mainstay of Nigeria's economy, yet, despite being the largest producer and supplier of crude oil in Africa and one of the top ten global exporters with approximately 38 billion barrels of proven oil reserves, Nigeria imports nearly all its refined petroleum. The country has four refineries with 455,000 combined capacity installment, but declining refining capacity has led to high import values and insufficient local supply. Multinational corporations (MNCs) dominate Nigeria's oil industry, focusing on upstream activities within the country and downstream activities abroad., resulting in inadequate refining capabilities and challenges such as limited foreign exchange liquidity, environmental degradation and technology transfer deficits.