PERCEPTIONS OF BLOCKCHAIN ADOPTION IN THE OIL AND GAS SUPPLY CHAIN: A QUALITATIVE UTAUT INVESTIGATION

By

Salisu Alhaji Uba (BSc, MSc, FCIPS)

201973077

Department of Design Manufacturing and Engineering Management

Faculty of Engineering

University of Strathclyde

Glasgow UK

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Previous presentation from this thesis

Some aspects of this thesis have been presented at academic and professional events and conferences and have received awards as well as endorsements. They are as follows:

Presentation at Academic peer-reviewed conferences

Uba, S. A. and Whitfield, I. R (2020) "Exploring the adoption of Blockchain technology in the oil and gas industry supply chain: a unified theory of acceptance and use of technology approach (Conference proceedings) at EUROMA conference 2020.

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Presentation at Webinars and professional events

1. Delivered a session to members the Member of the Nigerian Society of Engineers, Manchester UK monthly event (2022).
2. Delivered a special session at MSc Supply Chain Class at the University of Strathclyde, Glasgow (2022).
3. Delivered a special guest session at Digital Nigeria International Conference and Exhibition, Abuja, Nigeria (2022).
4. Delivered a webinar session at IEEE UK and Ireland Blockchain Group (2021).

Award and recognition

1. Endorsed by the UK Government as ‘Exceptional Talent in Digital Technology’ under the Global Talent visa programme by the Tech Nation in November 2022.
2. Award for best three Blockchain and Distributed Ledger Technology projects at the 5th International Blockchain School, European Blockchain Centre at IT University of Copenhagen, Denmark January 2022.
3. 1st Runner-up the best paper award at ERPBSS Middlesex University Dubai January 2020.

Dedication

This thesis is dedicated to my late, much-beloved father, Alhaji Uba Garba. He has always believed that acquiring the best education is the best thing an individual can do for themselves, and he has always been a source of encouragement for me to further my education.

And the Exalted Allah SWT said:

"*God will exalt those of you who believe and those who have knowledge to high degrees*" - (58:11)

Education promotes wisdom, competence, and value, and knowledge increases one's ability to serve others. I equally dedicated this thesis to everyone seeking and growing new knowledge frontiers, especially in technology, engineering and sciences.

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Abstract

The aim of this research is to investigate the perceptions of Blockchain technology adoption in the oil and gas supply chain in Nigeria. Although Blockchain has the potential to transform complex supply chain challenges such as the lack of transparency, accountability, trusted relationships and efficiency, there is a dearth of empirical evidence that predicts the adoption decision within the oil and gas supply chain and how it affects adoption of Blockchain among organisations. The Unified Theory of Acceptance and Use of Technology (UTAUT) is the theoretical framework for this research, and it has been utilised as a lens to predict stakeholder's perceptions of Blockchain adoption in the Nigeria oil and gas industry. The research was carried out using a systematic literature review to identify the knowledge gaps on the level of adoption, then, data was collected through semi-structured interviews with critical stakeholders from the Nigerian oil and gas industry's upstream, mid-stream, and downstream sectors, these data were analysed using thematic analysis method. The organisational revealed leadership and senior management, awareness and knowledge, business model, and commitment to adoption as influential factors for the adoption of Blockchain in the oil and gas supply chain. The institutional revealed industry dynamics, influence and control, and institutional collaboration as influential factors for the adoption of Blockchain in the oil and gas supply chain. The internet, infrastructure and connectivity, data security, implementation cost, and technology user acceptance were discovered to be technologically influential factors, and finally, the operational environment revealed emerging trends, government policy and support, regulation and regulatory framework as influential factors for the adoption of Blockchain in the oil and gas supply chain. The research also conducted UTAUT embedded analysis of the findings from the thematic outcome, and a member check to validate the research's findings. The results of the thematic analysis were organised into four categories: organisational, institutional, technological, and operational environment. Furthermore, the UTAUT embedded analysis confirms the relevance of the findings through the lens of the UTAUT constructs, and discovered that the business model, institutional collaboration, and emerging trends aligns within the construct of performance expectancy. The effort expectancy construct were awareness and knowledge, data security, and technology user acceptance. Social influences are aligns with leadership and senior management, and influence and control. While facilitating conditions aligns with level of commitment to adoption, internet, infrastructure and connectivity, government policy and support, and regulations and regulatory framework. However, the UTAUT embedded analysis conducted revealed the implication of industry dynamics as a construct that was discovered within the context of Blockchain adoption in Nigeria's oil and gas industry. The research contributed to theoretical and practical by being the first to empirically investigate the perceptions of Blockchain

adoption in the Nigeria oil and gas supply chain. The findings of this research provide an empirical basis for the adoption of Blockchain at the cross-organisational levels in a complex industry of the oil and gas. The steps taken in this research address the factors that will influence the adoption of Blockchain technology to solve supply chain challenges such as lack of transparency, trust, and efficiency. The novelty of this research is the first to conduct an in-depth analysis and identify the factors that influence Blockchain adoption in the oil and gas supply chain on organisational, institutional, technological, and environmental levels. It has also discovered industry dynamics as an additional construct of Blockchain technology adoption by the theoretical framework of the UTAUT model. The implication of this research highlighted the influence of factors on the adoption and how the Nigeria oil and gas will adopt Blockchain technology. This research provided basis for adoption of technology that provides transparency, build trust in relationship and increases efficacy which will help address the pain points in the Nigerian oil and gas supply chain. The findings were validated through a member check with seven of the stakeholders within the Nigeria oil and gas industry. The research has provided managerial implications of the findings and how the Nigerian oil and gas industry will approach the adoption of Blockchain to solve complex supply chain challenges such as lack of transparency, revenue leakages, efficiency, and downstream as well as subsidy regime.

KEYWORDS: BLOCKCHAIN TECHNOLOGY, SUPPLY CHAIN, UTAUT, OIL AND GAS, NIGERIA

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1 Introduction

The research presented in this thesis was funded by the Petroleum Technology Development Fund (PTDF), which the Nigerian government established as a funding body to build the capacity of Nigeria's oil and gas industry, as well as the entire economy, through high-impact research that provides new knowledge, techniques, and solutions. This research investigates how stakeholders perceive the adoption of Blockchain technology in Nigeria's oil and gas supply chain. The chapter discusses the research motivation, problems, aim, questions, and approach. In addition, the chapter outlines the research's novelty and the research process and summarises with an outline of the thesis structure.

1.1 Research motivation

Apart from the funding opportunity from PTDF, the motivation for this research is my background, interest and professional expertise in supply chain management. To begin with, as a member and Branch executive of the professional body of procurement, the Chartered Institute of Procurement and Supply (CIPS) in Nigeria since 2016. I am fortunate to travel to different parts of the world to participate in various conferences and events through CIPS. Because of this, I have been able to learn new things, engage with other people, and get first-hand information about the latest industry trends. I have a strong interest in technology and the role that it plays in the supply chain and procurement, my MSc thesis was on supply chain and financial technology. As a result of this, I was able to participate in two conferences in 2018. I was able to obtain a copy of the CIPS publication that was released in March 2018 on the future of procurement and supply management; CIPS has not commissioned any significant academic research on the future of the profession prior to the release of the future of procurement paper in the last 15 years. Blockchain technology, also known as distributed ledger technology, emerged as the primary focus of conversation over the direction the profession would go in the future.

Since then, I have had an increasing desire to learn more about Blockchain technology and the benefits that it may bring to the field of supply chain management. Then again, the fact that I work as a professional consultant and interact with organisations has allowed me to understand the practical challenges that many sectors are confronting. I was intrigued by the possibility of Blockchain, from a technological standpoint, to influence the future of the supply chain, in particular in the Nigerian oil and gas business; moreover, I needed to learn how to get started or where the technology is headed. As my fascination with Blockchain technology grew, I began to educate myself on the topic by reading books on the subject. For instance, I read (Blockchain for non-technical and Blockchain user cases). I read another paper on Digital Supply Chain

Transformation toward Blockchain Integration where the potential of the technology was dynamically investigated, and a model of Blockchain integration was proposed (Korpela, Hallikas, and Dahlberg, 2017a). Finally, in keeping with my desire for the topic, I read how Blockchain technology can change the supply chain and logistics industry by creating a Blockchain-based application that will empower stakeholder management and collaboration (Juhani Heikkinen and Lecturer, 2017). I have kept up with the news, and fortunately, that has given me a significant advantage of the fundamentals of Blockchain technology. Furthermore, the funding opportunity from PTDF provided me additional motivation to investigate the use of Blockchain technology in the supply chain focusing on the Nigerian oil and gas industry. In summary, which was my motivation to academically venture onto a journey to acquire a PhD in Blockchain for supply chain in the oil and gas sector, one of the most important industries in Nigeria.

1.2 Statement of the research problem

The oil and gas supply chain is critical to adding value and improving efficiency to the industry's operations (Saad, 2014). The concept of supply chain management encompasses the entire oil and gas value chain, including practices involving business partners, suppliers, government, and citizens. The supply chain serves as a function that can transform an organisation's processes, operations, and techniques, such as logistics, transportation, inventory, purchasing, information sharing, and coordination from upstream to downstream to meet customers' demands. However, the supply chain function in Nigeria's oil and gas industry has faced critical challenges that have resulted in numerous impediments, such as wastages, a lack of supply of petroleum products, corruption, manual processes, and a lack of accountability (Menhat *et al.*, 2019). These challenges and impediments are due to the supply chain function integrating various sources of information with the material and financial flow across oil and gas businesses, stakeholders, suppliers, and consumers. The integration of every activity in the supply chain provides the best value and drives trust, transparency, deliverability, accountability, and efficiency.

The Nigerian economy relies heavily on oil and gas as a major source of revenue, accounting for 80% of total fiscal revenue (Shaxson, 2009). However, it is currently suffering from massive revenue losses, a scramble for oil field development, a fuel shortage, oil bunkering, oil thefts, financial impropriety, sabotage in oil field facilities, and corrupt practices totalling billions of dollars each year (Itsekor, 2020; Akam, 2020). Nigeria's oil and gas industry is dependent on effective supply chain management to deliver lean strategy, local content capacity through indigenous petroleum company participation, refining and logistics, and transportation of petroleum products to final consumers. Over the years, the operational framework and systems have been deficient in managing transparency, increasing confidence, and accountability of the

industry's resources. For example, the industry's loss of revenue has reached a record high of US6 billion annually (Umar and Mohammed, 2020), and there has been an increase in discrepancies in data reporting from regulators and operators, resulting in significant losses (Watts and Zalik, 2020).

The emergence of Blockchain technology was initially well-known for the digital currency Bitcoin, but its potential application extends beyond financial applications and, more specifically, Bitcoin (Hughes, Park, Kietzmann, and Archer-brown, 2019). A Blockchain system enables the transaction between peer-to-peer which creates a chain of transactions containing information with a cryptographic hash of the previous transactions (Nakamoto, 2017). The system employs nodes to secure transactions in a tamper-resistant protocol by verifying each transaction prior to authenticating it to form a "Blockchain" of transactions (Pappalardo *et al.,* 2018; Hawlitschek, Notheisen and Teubner, 2018). Blockchain technology has gained popularity due to its potential to increase transparency, provenance, and eliminate the need for third-party verification in complex transactions. The financial application demonstrates its ability to disrupt traditional financial systems and data-sharing systems in favour of a decentralised network (Y. Chang, Iakovou, and Shi, 2020).

Blockchain is expected to revolutionise the supply chain by increasing trust, visibility, provenance, decentralisation and transparency (Francisco and Swanson, 2018; Wang, Han and Beynon-Davies, 2019; Stevenson and Aitken, 2019). Blockchain has the potential to impact supply chain and trading, regulatory, database management, and cyber security, including in the oil and gas industry (Lakhanpal and Samuel, 2018a). Based on Blockchain technology's capabilities and proposed solutions, it has the potential to address the challenges within the Nigerian oil and gas supply chain industry. Despite these potential opportunities, the use of Blockchain technology in the oil and gas supply chain has yet to receive much attention from stakeholders, particularly in developing countries where it arguably has the most benefit to deliver (Stevenson and Aitken, 2019). Even in mainstream supply chain literature, Blockchain adoption in the supply chain is still in its early stages. Scholars have identified areas that need to be investigated to forecast the factors that will drive Blockchain adoption in the supply chain. For example, (Queiroz and Fosso Wamba, 2019) emphasised the significance of behavioural examination of Blockchain technology adoption to address supply chain challenges, stating that "*the Blockchain adoption behaviour and the drivers for such adoption among organisations remain scarcely investigated."*

Therefore, research on Blockchain adoption was necessary due to a lack of theoretical insight that explored and interpreted the perceived factors for companies to adopt and use Blockchain technology in supply chain beyond the technological features (Kshetri, 2018). Furthermore, (Treiblmaier, 2018) outlined the need for companies to understand, predict, and, if necessary,

design Blockchain solutions that benefit their supply chains at the industry level. However, Queiroz, Telles and Bonilla (2019) highlighted that the focus of Blockchain literature is on developed economies; there is a need to examine Blockchain's maturity in emerging markets further to understand the factors that influence the technology's adoption. Investigating Blockchain in the oil and gas supply chain would help provide evidence on the factors that influences the adoption of the technology, and it will serve as evidence for the adoption decision to solve challenges of lack of transparency, trust and efficiency of the oil and gas supply chain.

There is the need to employ an empirical approach to investigate the adoption of Blockchain for the oil and gas supply chain based on the recommendation of (Queiroz and Fosso Wamba, 2019; Queiroz *et al.*, 2020; Queiroz, Telles and Bonilla, 2019). The major setback in the literature is a lack of empirical studies particularly on implementation, challenges and drivers for the adoption of the Blockchain in supply chain in emerging and call for research directly to understand the level of maturity of the Blockchain in supply chain. They further added that examining the maturity of the Blockchain in emerging economics should be explored with the view to diffuse the innovation around the technology. Furthermore, there is clear lack of theory to support the understanding, examination, and methodological approach to solving Blockchain in supply chain discussions (Wang, Y., Han, J.H. and Beynon-Davies, P., 2019). The Unified Theory of Acceptance and Use of Technology (UTAUT) is an critical model that benefits predicting innovative technology acceptance behaviour, and is an extension of the technology adoption model developed by (Venkatesh, Morris, Davis, and Davis, 2003). It is an applicable model for assessing and gaining knowledge about technology acceptance and use (Alqahtani, Al-Badi, and Mayhew, 2014).

1.3 Research aim and questions

The aim of the research is to investigate stakeholders' perceptions on the adoption of Blockchain technology in the oil and gas supply chain in Nigeria. This aim was aligned with a knowledge gap identified in the systematic literature review in Chapter 2. The research focuses on how the perception of the stakeholders' influences the adoption of Blockchain in Nigeria's oil and gas supply chain through identifying the factors and examining the factors based on the UTAUT model of technology adoption. To achieve the aim of the research, a systematic literature review was conducted. The systematic literature review covers the extent and relevance of Blockchain adoption in supply chain, smart contract and supply chain, Blockchain and trust on supply chain and the challenges of Blockchain adoption in supply chain. It then led to identifying the gaps in knowledge in the literature and conceptualised to the context of the research in the Chapter 3. Thus, the systematic literature review provides the basis for the critical research questions:

1. *What are the stakeholders' perceptions of Blockchain adoption in the oil and gas supply chain in Nigeria?*
2. *How does the perception affect Blockchain adoption in the oil and gas supply chain using the UTAUT model?*

As stated above, the UTAUT model was deployed to provide a theoretical basis for the investigation and analysis of the perception of the adoption of the Blockchain from the thematic findings from this research. The UTAUT constructs of performance expectancy, effort expectancy, social influence and facilitating conditions were used to embed the findings from the research in order to ascertain how the perception affects the adoption of Blockchain in the oil and gas supply chain.

This research adopted a qualitative thematic approach involving an exploratory investigation of data collected through in-depth semi-structured interviews with Nigerian oil and gas stakeholders. The approach was selected as the best in achieving the objectives of the research of conducting the investigation of the adoption of Blockchain in the oil and gas supply chain. Therefore, using the method and from the perspective of solving a phenomenal challenge facing the Nigeria's oil and gas sectors, of lack of transparency, visibility and trust among stakeholders. The UTAUT model was employed to conduct an embedded analysis of the thematic findings, this helps the research to deepen the context of the research through the lens of the UTAUT theory and identify the constructs for the adoption of Blockchain in the oil and gas supply chain. The outcome from applying these methods served as a basis for the adoption of Blockchain technology and improved research strategy to be adopted in Blockchain technology and supply chain.

1.4 The research novelty

There is a scarcity of empirical research on Blockchain technology adoption and the influential factors that predict Blockchain acceptance and use in the oil and gas supply chain. The novelty of this research is that it is the first to conduct an in-depth analysis and identify the factors that influence Blockchain adoption in the oil and gas supply chain on organisational, institutional, technological, and environmental levels. It has also discovered industry dynamics as an additional construct of Blockchain technology adoption by the theoretical framework of the UTAUT model. This research provided basis for adoption of technology that provides transparency, build trust in relationship and increases efficacy which will help address the pain points in the Nigerian oil and gas supply chain.

In addition to expanding the body of knowledge on Blockchain technology adoption, this research has made a significant contribution by identifying and qualitatively analysing the factors that influence

acceptance and use. Through empirical findings, fourteen themes were identified and classified into four categories. The research also aligned with the UTAUT model, identifying consistencies and inconsistencies and extending the theory to capture industry-specific factors that had not been previously considered. This research stands out for identifying themes from a broader set of stakeholders and the UTAUT model's ability to predict adoption. Furthermore, this research is the first to have empirically investigated the factors that influence the adoption of Blockchain within the oil and gas industry. The findings included the identification of industry dynamics as a construct for Blockchain adoption and the alignment of other factors with the existing constructs of the UTAUT model. These outcomes will support oil and gas firms in Nigeria in considering Blockchain technology in their supply chain across organisational, institutional, technological, and operational environments.

1.5 Structure of the thesis

This thesis is divided into nine chapters organised logically to convey the research process and justification for each aspect of the presented thesis. Every chapter begins with a brief introduction and the content of the chapter whilst briefly summarising the previous chapter's content to provide a link and synthesis for better understanding. The chapter is divided into sections to simplify and convey the thesis information based on the chapter's relevance and discussion. Each chapter concludes with a summary.

Chapter 2 systematically reviews the state-of-the-art literature, beginning with a concept review of Blockchain technology, distributed ledger technology, and the mechanism of Blockchain technology. The concept review also discusses the supply chain, supply challenges, and the role of Blockchain in the supply chain. The systematic review was the second part of the literature review, covering the systematic protocol, execution, and reporting. The chapter includes a summary of the gaps identified in the systematic literature.

Chapter 3 describes the research context of Nigeria's oil and gas industry. A review of the oil and gas supply chain and a discussion of the industry's structure are provided. The chapter also discusses the types of contractual models used in the industry and the supply chain challenges confronting the Nigerian oil and gas industry. The Blockchain landscape in Nigeria and the development of Blockchain within the Nigerian economy are also covered in this chapter's review. The summary contextualises the research and supports the development of the research's goal.

Chapter 4 presents the theoretical framework of the research. The theoretical framework is a critical process that aids in viewing the problem and proposing research approaches through a theoretical lens, the process includes reviewing relevant technology adoption models. The theoretical framework for the research was UTAUT, and the chapter reviewed the UTAUT literature to

establish relevance. The chapter analyses how the UTAUT model aids in predicting technology acceptance and use, focusing on Blockchain technology research. This chapter serves as the theoretical framework for the research and supports the development of the research focus and methodology.

In Chapter 5, the research methodology and methods are presented, as well as the philosophical framework and justification for a qualitative approach. The qualitative approach, the research design, the data collection process, the interview questions, the protocol, and the interviewee's selection follow this. Following that are the data analysis methods, the validation section, and a discussion of the ethical considerations.

Chapter 6 presents the detailed thematic analyses conducted using data collected from semi-structured interviews. It begins with the interviewees' backgrounds and the themes identified. The themes were divided into four categories: organisational, institutional, technological, and environmental, and were presented by the classifications. Interview quotes were incorporated into the analysis to provide rich data and a thorough presentation of the findings.

Chapter 7 presents the UTAUT embedded analysis. The UTAUT model is a significant theoretical lens used to explain, interpret, and predict technology adoption behaviours. The chapter describes the UTAUT embedded analysis process, followed by a presentation of the UTAUT embedded analysis prepared according to the theory's four constructs of performance expectancy, effort expectancy, social influence, and facilitating condition. An additional construct, not currently contained within the UTAUT model, was discovered that should be considered when implementing Blockchain technology in the oil and gas supply chain. The chapter also describes the conducted research validation, which is a significant process which involves a member-check approach to validate the thematic and embedded UTAUT analysis.

Chapter 8 is the closing remark of the thesis, it discusses the research findings and their contribution to the research objective. A remark of the research findings' generalisation. The chapter also discussed the research contribution, managerial implications, and research limitations before and concludes with a summary of the research, a list of references and appendices.

2 Literature review

The research literature review is presented in this chapter. It includes a conceptual review of the definitions and understanding of Blockchain concepts, distributed ledger technology, Blockchain technology mechanisms, and supply chain challenges and Blockchain in the supply chain. The conceptual review is important because it lays the foundation for the literature review of the research and provides a consistent background in the subject area.

The systematic literature review is presented in the chapter's second section. It begins by defining the systematic literature review process and outlining the systematic literature review protocol and execution. The reporting of the systematic literature review includes the application of Blockchain in supply chain, the level of adoption of Blockchain in supply chain, challenges of Blockchain technology adoption and the gaps in the Blockchain and supply chain literature. The systematic literature summary completes the chapter.

2.1 Conceptual review

The conceptual literature review aims to demonstrate the essential concepts of this research– Blockchain technology and supply chain. Since concepts can transcend disciplines (Rowley and Slack, 2004), it is critical to clarify how the fundamental concepts of this research of Blockchain technology adoption are conceived in supply chain management within the context of this research and the field of supply chain management. This includes the meaning of Blockchain technology, an explanation of distributed ledger technology, mechanism of Blockchain technology and a detailed explanation of the supply chain concept, challenges and Blockchain in supply chain. Despite the importance of the oil and gas context in this research, the chapter did not find relevant literature, hence Chapter 3 is dedicated to the context that is the Nigeria oil and gas supply chain.

2.1.1 Blockchain technology concept

Blockchain technology is one of the emerging technologies in the 21st century (Kosba et al., 2016), Blockchain technology is also among the disruptive technologies that is disrupting many businesses and industries. The concept of Blockchain technology was originated by Nakamoto in 2008 in a white paper that was released (Nakamoto, 2008). The Blockchain technology uses a shared data infrastructure that updates itself in real-time and can process and settle transactions in minutes using computer algorithms, with no need for third-party verification. The technology began with application in the financial sector and serves as a means for management of financial transactions with no need of any intermediaries such as banks (Thomason *et al.*, 2018; Kosba et al., 2016).

The popular application of Blockchain technology in the financial transaction is the cryptocurrency and bitcoin (Anish Dev, 2014; Barkatullah and Hanke, 2015; Ziegeldorf, Grossman, Henze, Inden, and Wehrle, 2015). According to Pilkington, (2016) the applications of Blockchain are concentrating primarily on financial transactions by using a form of distributed ledger system as a new form of decentralised transaction. Nevertheless, Blockchain technology has been applied within various sectors including supply chain, asset management, and music industry. In order to build on the discussion of what the Blockchain technology has to offer for the supply chain, it is important to clearly understand the definition of the Blockchain technology (Wright and De Filippi, 2015; Pilkington, 2016).

The word 'Blockchain technology' was first defined in 2008 in a published "Bitcoin" cryptocurrency whitepaper (Nakamoto, 2008). As the first Blockchain whitepaper described how online payment is possible via a peer-to-peer network without the need for a financial institution. The transaction within the network is time-stamped and integrated into a chain using a computer algorithm based on hash-based system that trace and connects chains of transactions. The Blockchain technology was equally conceptualised to solve the double spending problem where a central based system can easily make a double transaction due to error or total control nature of a traditional system that is inherent in centralised electronic transactions (Nakamoto, 2008). Bitcoin technology comprises the core system of Blockchain, a form of a digital currency that runs on a Peer-to-Peer network without any trusted third parties and was the first application of Blockchain in a financial industry (Pilkington, 2016).

Furthermore, any transactions on Blockchain get recorded and locked into decentralised digital blocks, which, when combined form an asset-specific online information chain (Kumar, 2016; Lemieux, 2016; Twesige, 2015). The system supports an electronic transaction based on cryptographic proof instead of trust which allows parties willing to transact directly with no need for a trusted third part (Kim and Laskowski, 2018; Zhao, Fan, and Yan, 2016). Then Blockchain creates an open, shared, and distributed ledger that enables information disclosure and responsibility attribution, and it is suitable for dealing with valuable information (Pazaitis et al., 2017).

To explore more into the context of the supply chain on adoption of the Blockchain, a supply chain that is Blockchain enabled allows companies to record every event or transaction within a distributed immutable ledger, which is shared among all participants, making it secure and irrevocable (Boschi, Borin, Raimundo, and Batocchio, 2018). That makes it possible to predict future occurrence of risk in supply chain due to the availability of information across all stakeholders that enables trust building and that means tracking back every product to the origin of

the raw materials, and transactions can be linked to identify users of vulnerable parts and devices at a reduced cost to the supply chain (Boschi et al., 2018).

Blockchain technology has been described in various ways depending on the context and the applicability to provide use case within the context. Consequently, Blockchain technology has been explained as a form of ledger that is distributed and stores value or data in blocks. These blocks are combined in sequential order (collection of numbers in a specific order or a collection of numbers that follow a pattern) form an incorruptible chain, and this chain is shared and distributed to all the participating entities.

2.1.2 Distributed ledger technology

The term "ledger" has been used to describe the system of record for financial transactions that organisations maintained to manage assets with others for many decades before now. In a distributed ledger transaction, every party has the responsibility to keep their own ledger, with no central authority or shared ledger (Plant, 2017). In a ledger that is not distributed the maintenance of independent ledgers by each organisation increases the possibility of differences in records. For example, a ledger of one organisation could show that an account has been settled or goods have been delivered, whilst the ledger of the other shows that it has not been settled or that there was an issue with all or part of the delivery.

In recent times, ledger has taken another dimension, the distributed ledger technology, it is described as a system that allows users to store and access information pertaining to a certain set of value and their holders in a shared database of either transactions or account balances. The set of information is disseminated to users, who may subsequently use it to settle transfers of values and cash without relying on a trusted central validation mechanism ((Pinna and Ruttenberg, 2016).

Christidis and Devetsiokiotis (2016, p. 2293) defined distributed ledger technology as "a distributed data structure that is replicated and shared among the members of a network". Conte de Leon *et al.*, (2017) stated that it is a digital information recording method capable of recording data using a logbook approach with the following essential characteristics: of ordered, incremental, sound (cryptographically verifiable up to a given block) and above all digital (Conte de Leon et al., 2017).

Moris and Popper, (2016) posited that distributed ledger is a database system capable of maintaining an endlessly growing list of data records secured from altering and stored in blocks, holding batches of individual transactions. In every block it contains a timestamp and a link to a previous block.

Pearson *et al.*, (2019) described distributed ledger as a database that records peer-to-peer electronic transactions permanently, so that transactions can only be accessed, inspected and updated powered by the Blockchain technology. It achieves this using cryptographically secure keys to link all transactional elements, placing trust directly in the network, and avoiding the need for central trust institutions. The trust in a distributed ledger is applied to supply chain data management, transaction, processes, identities and any form of digitalised asset. Supply chain using distributed ledger will have a place in which data can be linearly stored semipublicly in a container (a block) that anyone can verify the data has been placed in a container, but only the 'owner' of the data (the one who added the data) can unlock the content of a container using private keys.

The point about distributed ledger technology is that it is a system that stores and shares data across entities. This in a supply chain context will allow multiple parties to share, access, and store information without being controlled by a single entity. Based on the elaborated definitions and descriptions, distributed ledger technology can also be interchanged or used to describe a Blockchain-based solution for supply chain management. However, not all distributed ledgers and Blockchain technologies are distributed.

2.1.3 Mechanism of Blockchain technology

Blockchain and distributed ledger provides a way to organise records in a distributed manner through the use of underlined mechanism that make everything seamless (Lu and Xu, 2017). The key features of distributed ledger technology and Blockchain is the provision of the following unique features as summarised by Woodside, Augustine and Giberson, (2015):

- Immutable record: the ability to add data to a ledger that cannot be changed, secured and preserved for the life of the ledger with the agreement of the participating parties to the system.
- Disintermediation: this happens when the nodes are able to interact directly without the need for trusted or intermediary to validate the transaction for entry of the data to the ledger. Transaction will be initiated and confirmed by all the parties involved.

The Blockchain features above specified the technology as capable of transforming the tradition system or database for exchange of information that was based on intermediaries and was mutable.

Furthermore, in addition to the above Table 2-1 summarises Blockchain mechanism as highlighted by (Maull et al., 2017).

Table 2-1 Blockchain Mechanism

Mechanism	Description
Encryption	The ability to provide public and private keys, where the first is used to encrypt the data, and the private key to authenticate the participation.
Consensus	The ability to provide an algorithm that allows secure updating of records only if the majority agree on them
Contract	The ability to provide contracts among participants that automatically verified and enforced terms.
Peer to peer	The ability for perform or exchange data seamlessly without any party in between.
Login	The ability to provide a database maintaining different nodes that each containing all the transactions stored in immutable and chronological order.
Tracing	The ability to provide access, inspect and add to the ledger, hence create an immutable audit trail of the transaction.

Blockchain technology based on the above mechanism can have significant implication to the way supply chain information and transactions are conducted. The ability to store digitised representations of real-world transactions that may be trusted to prove the history of an asset or object based on the features outlined above. As such, transaction in a decentralised mode without the control of a central authority and with each party having the same copy of the ledger will make a use case for supply chain management since it is about the flow of information, material and finance with different function and different entities with common goal.

Despite the features and mechanisms discussed above, Blockchain is classified into three types by Wüst and Gervais, (2018) based on his study of whether we need Blockchain:

1. Permissionless (public): allows everyone to freely download the software, submit messages for processing and/or be involved in the process of authentication, verification, and reaching consensus. This is the main principle of Blockchain technology - achieving consensus over a set of shared facts through the community without any dependency on the authority of a single entity.

2. Permissioned (private): allow members to be preselected or subject to conditional entry on satisfaction of certain requirements or on approval by an administrator. This allows for agreement on the facts of each transaction to be reached “by decision of a single trusted third party or designated administrator or a consensus of distributed shared and voting “notary servers” built for just that purpose.

3. Hybrid: allow for the degree of centralisation to be defined that those in charge of setting

up a distributed ledger wish to achieve. One specific example provided is for a permissionless distributed ledger having encryption of transactions and supported with a strong identity framework.

The classification described above has strengthened the narrative and highlighted the capability of Blockchain technology for use in supply chain management. Both public, private, and hybrid solutions may have a place in the various elements of the supply chain.

Public accessibility means that all information stored within the Blockchain is publicly accessible to everyone. For example, in supply chain management, customers can request specific information across the supply chain, such as the origin of the product or the process the product went through to ensure there are no issues or concerns. Having this type of information on a public Blockchain will help. Immutability means that information added to the chain of ledger transactions cannot be changed, altered, or removed; in this scenario, information auditing is critical for compliance, sustainability, and accountability. Because of the demand for sustainability and other environmental associated forces, this will be applicable to the supply chain. Immutable information about compliance with ethics will ensure the supply chain's integrity and give parties the confidence to check and verify information at any point.

2.1.4 Overview of supply chain concept

The supply chain is defined as the primary function that concerns all types of organisations when dealing with cross functional levels on an inter-organisational linkage; it involves two or more companies with business goals and relationships that lead to productive business outcomes for the consumer's benefit (Bowersox, 2000). Since its inception as a branch of management that handled the transaction, processing, and delivery of goods and services from raw materials to finished goods, the term supply chain management has gained traction (Larson and Rogers, 2015). Further, supply chain is defined as the life cycle operations involving physical commodities, information, and financial flows with the goal of satisfying end customer requirements with goods and services from various, connected suppliers (Stock and Boyer, 2009).

The term "supply chain" is commonly used to describe operational responsibilities in businesses (S. Min, Zacharia, and Smith, 2019). According to Barney, (2012) supply chain is a collection of methods used to effectively coordinate suppliers, producers, depots, and stores so that commodities are produced and distributed in the correct quantities, to the correct locations, and at the correct time, in order to reduce system costs while meeting service level requirements. This has significant fundamental concerns on effective supply chain management and the primary idea behind the criteria that it must be regulated in order to be fast and trustworthy, cost-effective, and flexible

enough to meet the needs of clients.

The critical aspect of supply chain is the network of relationships within a company and between organisations and business units that depend on each other to function. These relationships include material suppliers, purchasing parties, production facilities, logistics, marketing, and other systems that allow the forward and backward flow of materials, services, finances, and information from the original producer to the final customer. This helps add value, maximise profits through efficiencies, and satisfying customers' demands (Stock and Boyer, 2009). In a summary by Mentzer et al. (2001) supply chain centred on the systematic and strategic coordination of traditional business operations with the strategies inside a given firm and across businesses with the aim of enhancing the long-term performance of the individual business.

Consequently, coordination between various supply chain entities is a crucial factor in an effective supply chain. No supply chain can deliver value unless every component of the value chain operates in performance. The supply chain can therefore be viewed as the design and management of all sourcing and purchasing, logistics management, and operations. To deliver value, it also includes coordination and collaboration with network partners, who may be suppliers, intermediaries, third-party service providers, and customers. In the context of this research, the implementation of a system that facilitates the flow of information and resources for the process's benefit is crucial to achieving the ultimate objective of the supply chain among its stakeholders. The coordination and collaboration process helps deliver value but requires trust, transparency, accountability and efficiency.

In recent years, advancing supply chain has gained traction due to its significance across multiple industries. This has resulted in the creation of greater strategic business value, particularly as a result of the development of the internet and the accessibility of other advanced technologies via the internet. In this context, Blockchain technology has grown in popularity to improve supply chain management practises (Saberi et al., 2018). Despite these promising prospects for the significant improvements of supply chain, there several challenges facing supply chain. These obstacles are intensifying and vary depending on the nature of the business, its industry, and the operational and regulatory environment.

2.1.5 Supply chain challenges

The general notion is that the supply chain is complex in nature due to the wide range of activities, people, networks, and demands, and as a result of its components, the concept of supply chain management has advanced rapidly but with challenges underpinning its efficiency (Foerstl,

Schleper, and Henke, 2017). For example, in supply chain networks, globalisation, diverse regulatory policies, and diverse cultural and human behaviour make it nearly impossible to evaluate information and manage risk without compromise (Sarpong 2014; Ivanov, Dolgui, and Sokolov 2018). While globalisation is an important feature of today's supply chain, it can have a significant impact on inefficient transactions, fraud, pilferage and a greater trust deficit (Dolgui, and Sokolov 2018). Lotfi *et al.*, (2013) emphasised that the lack of essential flow of information among the actors involved in the supply chain creates a supply and demand issue that affects business improvement, customer satisfaction and profitability. Furthermore, lack of transparency is a fundamental issue in supply chain that is limiting optimisation of supply chain management and the effective use of resources across participating partners (Abdoli Bidhandi and Valmohammadi, 2017). Another fundamental challenge of supply chain is the lack of traceability, this involves the tracking of the movement of products across the supply chains and is regarded as an essential factor that is rendering efficient flow of material and information. In dealing with traceability, a collaborative approach to supply chain traceability is regarded as a challenging factor (Foti, Scuderi, Stella, and Timpanaro, 2019). Furthermore, technology has helped in contributing to solving supply chain challenges, however, the recent centralised system are sometimes incongruent and stand-alone information management systems that are not visible to all stakeholders in the supply chain (Elbardan and Ali, 2011). Typically, Enterprise Resources Planning (ERP) systems is one of the most common systems applied in supply chain to create efficient operations, but it has its own downsides because supply chain require significant trust to relying on one single organisation as a means of information (Abeyratne and Monfared 2016; Dong et al. 2017). Table 2-2 is a summary of the supply chain challenges as reviewed in the literature. The table provided the description of these challenges.

Table 2-2 Summary of supply chain challenges from the literature

Supply chain challenges	Description from the literature
Globalisation	Diverse regulatory policies, cultural and human behaviour make it nearly impossible to evaluate information and manage risk without compromise. It can also lead to inefficient transactions, fraud, pilferage, and a greater trust deficit.
Lack of essential flow of information	The lack of essential flow of information among the actors involved in the supply chain creates a supply and demand issue that affects business improvement, customer satisfaction, and profitability.
Lack of transparency	A fundamental issue in the supply chain that is limiting optimization of supply chain management and the effective use

Supply chain challenges	Description from the literature
	of resources across participating partners.
Lack of traceability	Involves the tracking of the movement of products across the supply chains and is regarded as an essential factor that is rendering efficient flow of material and information. A collaborative approach to supply chain traceability is regarded as a challenging factor.
Incongruent and stand-alone information management systems	Centralized systems are sometimes incongruent and stand-alone information management systems that are not visible to all stakeholders in the supply chain.
Decision support	Supply chain requires decision support inside and outside the business through visibility, transparency, cooperation, and control throughout and beyond the company.
Lack of trust-based solutions	Supply chain requires significant trust-based solutions to relying on multiple sources of information.
Complexity	Complexity associated with demand management, production planning, information management, and tracking management have affected the efficiency of the supply chain. Such complexities are attributed to the dynamic and uncertain operational environment in which supply chains operate.
Technology limitations	While technology has helped in contributing to solving supply chain challenges, recent centralized systems are sometimes incongruent and stand-alone information management systems that are not visible to all stakeholders in the supply chain. ERP systems are one of the most common systems applied in supply chain to create efficient operations, but it has its own downsides because supply chain requires significant trust in relying on one single organization as a means of information.
Digitisation and technology adoption	Supply chains are undergoing transformations through continued digitization and technology adoption, including emerging technologies like Blockchain and distributed ledger technology.
Sources: adopted from the literature reviewed in this section	

The complexity associated with demand management, production planning, information management, and tracking management have affected the efficiency of the supply chain. Such complexities are attributed to the dynamic and uncertain operational environment in which supply chains operate. According to Serdarasan, (2013) supply chain is a complex system with many companies, a high number and variety of relationships, processes, and interactions between and within companies, dynamic processes involving many level systems, and a lot of information needed to some level of control. Where static complexity comes from the connectivity and structure of supply chain subsystems (e.g., companies, business functions, and processes); supply chain

complexity comes from the operational behaviour of the system and its environment; and decision-making complexity. Hence, the purpose of supply chain is to serve as a system and process capable of rational planning, management, coordination and control of the supply chain and logistics, supporting stakeholders to accurately monitor and quickly respond to business issues in an event of disruptions.

Furthermore, technology has help in contributing to solving supply chain challenges, however, the centralised system are sometimes incongruent and stand-alone information management systems that are not visible to all stakeholders in the supply chain (Elbardan and Ali, 2011; Sarpong, 2014). Typically, the ERP systems are one of the most common systems applied in supply chain to create efficient operations. The ERP system gathers and processes data and supports operations like sales and services, procurement and logistics execution management, product development and manufacturing all integrated. But supply chain requires decision support inside and outside the business through visibility, transparency, cooperation, and control throughout and beyond the company, that are beyond transactional based approach of an ERP solutions (Bose, Pal and Ye, 2008; Singh and Kumar, 2013; Banerjee, 2018). Supply chain requires significant trust based solutions to relying on multiple sources of information (Abeyratne and Monfared 2016; Dong et al. 2017).

However, supply chains are undergoing transformations through continued digitisation and technology adoption including emerging technologies like Blockchain and distributed ledger technology. Supply chains are evolving into value-creating networks where the role of technology adoption itself turns into a vital source of competitive advantage (Herden, 2020). Developments are in progress to integrate Blockchain technology leading to novel structures of modern supply chains, new partnerships, as well as new ways of collaboration and value creation across supply networks (Pérez et al. 2017).

2.1.6 Blockchain in supply chain

Despite the mechanism of Blockchain technology in Section 2.1.3, Blockchain technology has many potentials within the supply chain management. Blockchain technology is capable of increasing transparency and traceability and increases trust in supply chain (Dutta, Choi, Somani, and Butala, 2020). The advantage of transactions between two parties without the need for any third-party validation in a peer-to-peer structure has benefit for supply chain transactions, in areas of asset integrity, payment and any activities involving many parties to facilitate supply chain activities (e.g., physical assets and financial flow), without the need for third party validating the transaction or serving as the point of control. Tian (2016) found that when Blockchain is compared

to other technologies that offer a standardised, decentralised system, it has the potential to challenge the status quo by giving consumers and stakeholders an easy-to-use system that lets them find out where a product came from and follow it through the supply chain.

That means Blockchain has vast potential for making supply chains more agile by creating efficiency without intermediation through automated smart contract functionalities (Azaria et al., 2016; Casey and Wong, 2017; Christidis and Devetsikiotis, 2016; Condliffe, 2017).

According to Kshetri, (2018) Blockchain technology can transform supply chain and change several behaviours through the elimination of the need to trust a partner through third parties and that shows that supply chain is an area for the Blockchain adoption especially in a complex supply chain structure. Table *2-3* below outlined the benefits of Blockchain to supply chain.

Table 2-3 Benefits of Blockchain to supply chain – adapted from (Wang, Singgi*h, et al*, 2019)

Blockchain benefits to supply chain	Description
Supply chain visibility	• Reduction in the need for double checking and guess working. • Automation of data for forecasting, assent monitoring, optimisation and lean improvements • Provenance of product across supply chain for high valued items • Capability to trace and track
Secured information sharing and trust embedded system	• Serves as one single point of truth for all stakeholders. • Powered by secured underlined technology as demonstrated by bitcoin. • Built-in trust and reduces third party verification.
Operational improvements and efficiency	• The quality of the data volume and accuracy accelerate performance, speed and effective decision making. • Supply chain resilience die to the ability to sport challenges or errors before they occur. • Increases end-to-end supply chain seep for effective execution of task.
Adapted from: (Azaria et al., 2016; Casey and Wong, 2017; Christidis and Devetsikiotis, 2016; Condliffe, 2017; Wang, Singgi*h, et al*, 2019)	

Blockchain offers several benefits for supply chain, and it has been studied in terms of its usability and capacity. The three areas where Blockchain has been discovered to help supply chain are listed in Table 2-3 above (Wang, Singgih, *et al*, 2019). This research has further elaborated on the opportunities of Blockchain technology to supply chain. For example, in a paper by Di Vaio and Varriale, (2020) on Blockchain technology in supply chain management for sustainable performance, they looked at how Blockchain works with supply chain and sustainable performance. They discourse about the case of a Blockchain platform that helps people work together at an aviation industry, it also highlighted the cooperation between major players in the aviation industry and the air traffic controllers to reduce fragmentation, inefficiency, and operations that are not

coordinated. This is a typical situation in which Blockchain may increase transparency and confidence among numerous participating organisations. Another interesting benefit was on modelling Blockchain that enabled traceability in supply chain. It was found that Blockchain technologies will offer traceability, auditability, immutability, and provenance are the most important ones in the agricultural sector (Kamble, Gunasekaran, and Sharma, 2020). Blockchain technology in supply chain may give a stronger foundation of confidence, and the advantages from the lack of centralised authority and intermediation. As a result, Blockchain might be used to record asset ownership, permissions, and activity logs. This enhances the traceability of information, accuracy, and process flows, allowing for more accurate product and service tracking (S. E. Chang and Chen, 2020) .

It is crucial to note that the setting of this research has recognised the relevance of Blockchain technology in supply chain and the applicable concept of supply chain management that will benefit from Blockchain solutions such as the oil and gas supply chain. The conceptual review offered an overview of the important parts of the research as a prelude to the presentation in the next section. The systematic literature review that follows was carried out to identify the knowledge gap in the literature on Blockchain and supply chain and to offer direction for the research process based on the motivations and practical industry case.

2.2 Systematic literature review

In this section, the systematic literature review is presented. The purpose of conducting a systematic literature review is to demonstrate an awareness of the current state of knowledge in the field and to invigorate the researcher's understanding of the current state of knowledge as well as providing a solid foundation for the research (Easterby-Smith et al 2015). According to Randolph (2009), a literature review generally is a pillar for relating what is already known, and what needs to be known. Hence, the review is an analytical summary of the existing body of the research in the light of a particular issue under investigation (Piper, 2013). Since this research employs the use of a systematic literature review to understand the state of the art of published research, as well as identifying a gap in the literature, it is important first to understand systematic literature review through defining its concepts.

On definition, Cook, Sackett and Spitzer, (1995) defined a systematic review as "the application of scientific strategies that limit bias by the systematic assembly, critical appraisal and synthesis of all relevant studies on a specific topic". One of the most comprehensive articles on systematic literature review by Wright *et al.*, (2007) on *"how to write a systematic literature review*" describes it as a review of the evidences on a clearly conveyed inquiry that uses systematic and unambiguous

methods to identify, select and critically evaluate relevant information, and to extract and analyse facts from the studies that are involved in the review".

The essence of conducting the systematic literature review is for rigour and replicability of the process of conducting a review of relevant literature in this research. In this research, the subject of Blockchain in supply chain. Due to the paucity of research in the literature of Blockchain and supply chain it is still considered that research is still in its infancy stage; hence, and systematic literature review of current literature is the most appropriate forms of review (Henderson *et al*, 2010). The systematic literature review will establish a solid foundation by leveraging an in-depth understanding of the critical subject areas adoption of Blockchain in supply chain and identify the knowledge gaps.

Though there exists a scarcity of a systematic literature review of the current Blockchain adoption and applications, predominantly in the context of supply chain, this research has established that some studies do exist. Studies that have adopted a systematic literature review in the field of Blockchain and supply chain and established the rationale for their studies as a way of identifying the relevant research that have been conducted. For example, Casino et al. (2018) employed a systematic review to generate an understanding of the Blockchain technology features and provides an overview of current Blockchain-enabled applications across sectors based on content analysis. Surjandy et al. (2019) conducted a systematic review on the latest adoption of Blockchain technology in supply chain management and found 21 success factors within the pharmaceutical industry. These factors are namely, traceability, track, transparency, trust, real-time, provenance data, security, private data, cost savings, serialization, authentication, auditability, visibility, efficiency, automatically, immutable, consensus-driven, and reliable. Queiroz et al. (2019) identified, analysed, and organised the literature relating to the application of Blockchain in supply chain context using systematic review and set out an agenda for future research. Their research has established the current challenges of Blockchain application in supply chain management are as well as what the future of Blockchain holds for supply chain management.

Further, Tribis et al. (2018) employed a systematic review and provided a mapping of research on supply chain management based on Blockchain capabilities. Grover et al. (2018) also conducted systematic literature review and identified the literature gap on the application of Blockchain and the benefits it offers to supply chain and to business in relation to consumers, and government. The research recognises that the choice of systematic literature review for this research is relevant to the context of Blockchain and supply chain evidence from attempts by previous scholars. Though the systematic review that was conducted focuses on the potentials, the benefits, or the technological capability of the technology. This review will focus on the extent of adoption of

Blockchain technology in supply chain. The systematic literature review process in this research follows the recommended process by (Petersen *et al.*, 2008), which encompasses defined research question, review scope, conduct search, all papers, screening of papers and relevant papers. The process includes the use of key wordings from abstracts, classification scheme of papers, data extraction and mapping process and end with systematic mapping and reporting.

The process gives strong guide for the implementation of the systematic literature review protocols which helps in achieving the goal of the review (Teherani, Martimianakis, Stenfors-Hayes, Wadhwa, and Varpio, 2015). Evidently, the process deployed in conducting this systematic literature review is consistent with previous studies in the field. The choice of systematic literature review instead of other review is that it seeks to methodically find, evaluate, and synthesise research findings, frequently conforming to review procedures. It also provides a basis for dependability, repeatability and transparent of improving the quality of the outcome (Grant and Booth, 2009).

2.2.1 Systematic literature review protocol

The first step to start a systematic literature review to is to start with formulating the protocol, which is also the element that has been described as the review protocol. In a systematic literature review, the goal of the research protocol is to allow for the formulation of a well thought search protocol at planning stage before embarking on the literature search that is the execution stage (Henderson et al., 2010) . The planning stage helps to increase the efficiency of the review, reducing the time toward execution and reporting through first identifying the sources (database) and the exclusion and inclusion criteria that are fair and consistent (Wright, et al., 2007).

Another aspect of the systematic literature review protocol is the identification of key words, which are used to capture the exact terms that the execution stage will use as a guide. Table 2-4 has provided the key search words and the most possible synonyms as identified in the subject areas (Wang et al. 2019; Grover et al. 2018). Although the oil and gas supply chain was missing in the search term and in the literature it was due to the reasons for the scarcity of papers on the intersection of blockchain technology and supply chain in the oil and gas industry. To begin, blockchain technology adoption is still relatively new and untested in many industries, including the oil and gas sector. As a result, there is a scarcity of empirical evidence and case studies on the use of blockchain technology in the oil and gas industry or under-reported. Blockchain technology is a rapidly evolving field with new research constantly emerging, the literature on the topic may simply not have been developed yet. Overall, while the lack of papers is a challenge, it also provides an opportunity for additional research and exploration through this research. The search terms are representative of the words that are most often used in the fields of Blockchain technology and

supply chain. This comprises terms that are synonyms of each other or words that are considered among the most alternative words that indicate identical applications in the literature.

Table 2-4 Key words

Search word	Search word
"Blockchain"	"Supply Chain"
"Block chain"	"Logistics"
"Distributed Ledger Technology"	"procurement"
"Smart contract"	"Operations management"

Once the key words were identified, another protocol to follow in systematic literature review is the use of Boolean techniques to bring together the relationship between different search words to develop the overall search strategy. The use of words (AND, OR, and NOT) support the generation of more focused and dynamic results (Egger, Smith, and Altman 2001). The Boolean strategy comprises in the review are the use of (AND, OR NOT) that helps to finds articles with all the search words or the key terms of the search. For example, the search of "Blockchain" is synonymous to Distributed ledger technology, so the AND was applied to check for both words. Researchers ignore certain results from the records by using strategies like NOT in the search to accurately get the search right. See example of the use of the Boolean technique within the search words in (see Table 2-5) below.

Table 2-5 Boolean application

Field		**Field**
"Blockchain"		"Supply chain"
"Blockchain technology"		"Logistics"
"Distributed ledger technology"	AND	"Procurement"
"Smart contract"	OR	"Operations management"

Another critical planning stage was the identification of the database to be used for the search. Databases are a critical component of identifying relevant literature, the choice of database was conducted and rationalised based on the majority search in the library on the topic of engineering management, operations management and business management. Table 2-6 shows the database and their areas of coverage in the field. These sef database are most considered accessible to the field of engineering management and supply chain and due to their wider coverage and accessability within the university. Throughout the research the search engines were activated to notify the research of any new paper and content were considered when found relevant.

Table 2-6 Database

Search engines	Database topics
Scopus	All database Management and operations
ABI inform	All database business management and economic
IEER xplore	All management and operations management
Web of science	All management and engineering

In order to establish a robust approach to the systematic review protocol employed for this research, the protocol and steps followed are enumerated below (see Table 2-7) which also provides details of the inclusion and exclusion criteria for the study.

Table 2-7 Review protocol

Protocol	Description
Databases	Scopus is the database with the highest number of articles from the above table, the database itself is one of the largest databases of peer-reviewed scientific journals, books, and conference proceedings. Additionally, the search was performed in other leading databases web of science and ABI/Inform and most of the relevant articles were found from IEEE xplore Digital Library.
Publication type	The review only considered peer-reviewed journals and conference proceedings.
Language	Only papers published in English in order to generate wide coverage were considered.
Date range	2008-Date, since Blockchain itself started in 2008.
Search field	Titles, abstract and keywords
Search terms	("Blockchain" OR "distributed ledger technology" OR "smart contract") AND ("supply chain" OR "procurement" OR "logistics" OR "operations management"). The result of the search was organised in a spreadsheet and duplicates from the three databases were removed, also inclusion and exclusion, tittle/abstract read, the relevant studies were maintained for further processes.
Inclusion criteria	Only papers that presented Blockchain technology and supply chain/logistics/procurement/operations management. In addition, the review focuses on finding conceptual papers or empirical analyses of the application, design, use, or implications of Blockchain technology for supply chains. As widely critique of systematic literature reviews (Boell and Cecez-Kec- manovic 2014), the researcher addressed the review by also considering the citations of selected papers to determine whether any of the referenced research papers that had inadvertently overlooked in the initial selection process (Webster and Watson 2002).
Exclusion criteria	For reasons of quality assurance, all working papers and workshop proceedings are excluded. Any paper that is not relevant to the research question was excluded. Also excluded were manifold statements, ideas, and visions of Blockchain enthusiasts and opponents in public press, media, and whitepaper collections. Although the study acknowledges that there are enormously influential whitepapers that have shaped the discussion of Blockchain in industry as well as academia (esp. Back et al. 2014; Buterin 2014a; Nakamoto 2008; Rosenfeld 2012; Schwartz et al. 2014; Wood 2014), but this are all noted in (Tschorsch and Scheuermann 2016; Yli-Huumo et al. 2016). The review excluded papers that solely focused on technology or on cryptocurrency performance or related trends. Technical papers improving or proposing algorithms

Protocol	Description
	were also discarded. In order to ensure consistency in the selection procedure the review focuses on Blockchain and supply chain related areas. Hence, all technical related papers or other subject matter are excluded. Lastly, from reading the selected literature, some papers were removed on the account that they did not target the focus area as expected from the abstract.
References	Nakamoto (2008), Alexander et al (2014), Pereira et al (2014), Adam R.J, Smart, P and Huff A.s (2017), Risius, M. and Spohrer, K., (2017), Friday et al (2018), Maciel M Q et al (2019),

2.2.2 Execution of systematic review and extracting information

The initial execution stage of the systematic literature review was to identify the research that are relevant to the defined protocol above. The first search for the literature began on the 11$^{th\ of}$ January 2019. The search was conducted on individual database that are identified as relevant to the field of engineering management. The Table 2-8 provides valuable insights into the screening process involved in conducting the paper section for the review. It specifies the stages involved in selecting papers for inclusion, as well as the number of papers rejected at each stage. Such transparency is critical in justifying the selection of papers in a literature review and in providing academic rigour to the research. The initial search, as indicated in Stage A, yielded 132 papers, a substantial amount of literature that required careful screening to ensure relevance to the research question.

Table 2-8 Selection of relevant papers

Stage	Group name	Number of papers	Excluded
A	Initial search	132	40
B	Relevant based on the tittle	92	20
C	Abstract analysis	72	

Following a title-based screening, 92 papers were deemed relevant, while 40 papers were excluded. In Stage B, titled "Relevant based on the title," the remaining papers were screened based on their titles. 92 papers were deemed relevant at this stage, while 20 papers were rejected. Stage C, which involved abstract analysis, resulted in 72 papers being considered for inclusion in the literature review. It is important to note that the final number of 72 papers represents the total number of papers deemed relevant for the literature review after a rigorous screening process. This table adds to the justification and credibility of the literature review by providing a clear and transparent account of the screening process. In addition, due to the scarcity of research in the subject, no further stringent downward review of the articles was conducted. Table 2-9shows the combination of search articles from the three databases.

Table 2-9 Sources of the full articles under the review.

Database	Number of studies
Web of Science	31
Scopus	23
ABI/Inform	18
Total	72

Consequently, upon the selection of the appropriate papers that the research considered relevant to the objective of the systematic literature review. The next step was the streamlined studies, conducting screening and extraction of relevant information. The data screening involves reading the full paper to ascertain the quality and relevance of the content, with consideration of the references of the paper before any conclusion to select the paper. Extracting information from screened papers is challenging particularly in ensuring that all relevant information were collected. A data extraction form was used to help reduce the chance of errors (Henderson, Craig, Willis, Tovey, and Webster, 2010). The researcher employed the NVivo software to help analyses and extract data for the systematic literature review. NVivo was created to support data analysis that allows one to import and code textual data, edit the text, retrieve, review, and record coded data. The data can be searched for combinations of words in the text or patterns in the coding, and then exported to other applications. The application of NVivo for the systematic literature review is very common in research across many fields of studies and particularly with respect the medicines, management and social sciences (Di Gregario, 2000). NVivo provides support in the analysis and identifying relevant themes within the literature for synthesis, in this case, getting the synthesis is regarded as one of the most important aspects of the systematic literature review findings since it provides the flow of the review and provides the logical reason to arrive at the critical stage of identifying what is known and needs to be known (Bandara, 2006).

The systematic literature review may have several challenges due to a particular approach to searching the literature or diverse studies that can lead to false conclusion – the quality of the assessment is an important step in conducting the synthesis and if not done properly can lead to subjectivity of selection and interpretation of findings also a form of bias. The research has explored the scope of the research to ensure that the exclusion and inclusion criteria was implemented in the whole process and uses thematic analysis to exact relevant data from NVivo. The next section presents the outcome of the systematic literature review. The sections in the reporting stage comprises of the application of Blockchain technology in supply chain, level of adoption, the challenges of Blockchain technology adoption and the gaps identified.

2.2.3 The application of Blockchain in supply chain

The literature has shown the academic relevance of Blockchain in the field of supply chain management and how it has been gaining potential in sharing data in a secured information system (Kshetri, 2018). The realisation of the growing interest have provided the potential of Blockchain Technology to influence supply chain-oriented applications in logistics, procurement and material management for transparency and visibility (Saberi, Kouhizadeh, Sarkis, and Shen, 2018). The complexity within modern supply chains has provided many areas of application that suits Blockchain technology according to research and found the link between Blockchain technology and its application in supply chain (H. mname Kim, Laskowski, and Nan, 2018). One of the key attributes of the Blockchain technology is to facilitate supply chain network information management through the provision of real-time tracking, verifiability and security. The combination of Blockchain technology and supply chain has become a new trend across industries, providing the advantages of decentralisation and a source of reliable data due to the security attached to the network.

For the relevance of the application of Blockchain in supply chain, for example, in 2009, Toyota announced a recall of four million vehicles due to faulty gas pedals which has estimated cost of US$2 billion to the company (Toyoda, 2017). At that time due to multiple suppliers for the pedals, the company lacked mechanisms to track the suppliers that were responsible for the faulty pedals. Blockchain can be applied into such situation and provides a solution to the problem of visibility and traceability across the Toyota supply chain while prepending such recalls (Kshetri and Loukoianova, 2019). Another interesting findings from the literature on the application of Blockchain in supply chain identifies how Blockchain improves supply chain performance through the concepts of information lighthouse, exploitation technology and relationship-building technology (Hald and Kinra, 2019). Blockchain for supply chain collaboration can change how partners in modern supply chains work together by making it easier for them to share information and supporting decision making in a more transparent, and trustworthy way (Rejeb, Keogh, Simske, Stafford, and Treiblmaier, 2021). Likewise, Kakarlapudi and Mahmoud, (2021) described Blockchain technology application on the basis of private data and management capabilities. In turn this could support supply chain as a means to digitally encode and store transaction records in transparent, shared databases protected from deletion, tampering, and revision. According to research by Korpela et al. (2017) on digital supply chain transformation toward Blockchain integration, pointed out that Blockchain works as distributed sources of recorded information that integrates the function of supply chain through enabling tracking, and sharing information in a secured system For supply chain this helps stakeholders to share information and have access to a real-time digital ledger of all the activities in the supply network.

From the reviewed literature, the relevance of the application of Blockchain technology to supply chain has been established, and areas of opportunity have demonstrated the capability of Blockchain technology to transform supply chain, improve performance, transparency, and the source of data sharing in a distributed format across supply chain, which will benefit stakeholders and partners.

2.2.4 Smart contracts and supply chain

Another key term of the systematic literature review is the 'Smart Contract' though it was first introduced by Nick Szabo in 1997 as a set of promises, specified in digital form, including protocols within which the parties perform transactions (Bogner, Chanson and Meeuw, 2016). Researchers have described it as a form of programmes that allows for self-execution of terms of agreements between two parties (Editor, 2018). Smart contract was as essential line of executable code that is accompanied by conditions automatically checked if all conditions are met it will then execute the next line of actions. In practice, the main objective of the smart contract component is to digitise the paper based or manual procedure of putting down the terms and conditions of contractual arrangement (De Giovanni, 2020).

On a Blockchain platform, codes are used to execute terms and condition for specific purpose for example contract agreement. The approach serves as tool that can track process status from across the whole spectrum of the supply chains. Min, (2019) described smart contract as a computer protocol intended to facilitate, verify, or enforce contractual obligations by embedding contractual clauses (e.g., collateral, bonding, delineation of property rights) in the computer system and then automating contract execution process. The concept does not only define the rules and penalties around a contractual agreement in the same way that a traditional contract does, but they also in force all obligations automatically. Furthermore, the strong attribute of smart contract is the ability to self-verify and execute agreements that allows for the automation of contract lifecycle toward stick compliance, risk management and increase efficiency. For a smart contract it must have the ability to rectify where requirement of law failed to satisfy the terms of the agreement as agreed in the initial programming language.

Smart contract has critical applicable areas within the supply chain ecosystem, it could disrupt the procurement, contract management and service level agreements. The potential of smart contract to transform supply chain context, for example, when goods are returned and received by a company, an automatic payment can be made through the smart contract. Conversely, the suppliers may be informed about such a return that can influence their future demand management and planning system and this will in turn bring about efficiency, automation, and customer satisfaction.

For that reason, it serves as a competitive edge to supply chain that a factor that will influence the adoption of smart contracts (Casado-Vara et al. 2018). Sulkowski *et al.*, (2019) posited that in Blockchain, Business supply chains, sustainability, and law, that a smart contract can be use in Blockchain ledger to create self-executing agreements that will remove human interference which creates complexity in supply chains activities. He further underlined that there is needed to further elaborate on legal and regulatory framework that will guide the implementation of smart contract in supply chains particularly in procurement systems (Sulkowski et al., 2019).

In the context of the supply chain, smart contract application experiments were conducted. However, the implementation process varies based on the initial design and its intended use. In all cases, smart contracts facilitate the process of converting contracts into computer codes, which are then stored across a network of computer systems. A supply chain with smart contracts could facilitate the transparent, conflict-free exchange of financial transactions, properties, shares, and anything of value in a system without middlemen (Blockgeeks, 2017; Soto *et al.*, 2021). Smart contracts are programmable contracts that enforce the occurrence of predefined conditions. The implementation focuses primarily on financial aspects, but there are also lingering concerns regarding process, speed of settlement, fraud risk, and operation risk. The central argument is that trust is a crucial aspect of contractual arrangements, which would be a factor in the implementation of smart contracts in the supply chain.

2.2.5 Blockchain and supply chain trust

The emphasis was placed on trust and supply chain relationships whenever Blockchain and its capability as a trusted technology were discussed. To elaborate further on trust, it is necessary to determine what the term trust means. As a result, there is no single definition of what trust is, but the central point that applies to every aspect is that trust is a crucial element when at least two parties intend to enter a transaction. Lawrence and McAllister, (2005) argues that trust is a cognitive judgement of oneself regarding another's competence or dependability, as well as an emotional bond of one individual toward another, referred to as “affect-based trust”.

Different perspectives exist regarding the importance of trust in the supply chain, despite the fact that it is a crucial element that enables all parties to transact, share information, and collaborate with a sense of belonging. For instance, Ozalp, (2012) describes trust in the supply chain as the key to effective collaboration and competitive advantage. Trust is an essential element of supply chain partnerships. For any supply chain, this necessitates the significance of trust in building effective function; however, this does not imply that the partners must trust one another for the supply chain to function. In relation to the initial discussion, Blockchain technology eliminates the disadvantage

of trust formation by virtue of its decentralisation and disintermediation capabilities (Tapscott and Tapscott, 2017). The consensus agreement process on Blockchain is designed to allow the technology to supplant the need for trust, since the database provides consensus as a mechanism for establishing trust between parties (Zlu and zhou 2016). Several papers have asserted that Blockchain and supply chain trust building can improve and facilitate working relationships between partners without any party's fear of exploitation (Casado-Vara, Prieto, La Prieta, and Corchado, 2018). Lack of trust adversely impacts supply chain partners and generates conflicts and disagreements. Consequently, the literature acknowledges the significance of Blockchain's emergence and how it will address the challenges of a trust-less network ecosystem, influencing confidence in the adoption of Blockchain for supply chain.

Nonetheless, there are opinions that a lack of trust between supply chain partners is a problem that impedes a resilient supply chain, and there is now recognition for Blockchain, which could enable organisations to build trust that is relatively safe, secure, and cannot be stolen or corrupted. To continue the discussion, digital trust, as described by a number of supply chain papers, is the innovation surrounding digitally building trust and anything that aids in preventing partners in the supply chain from engaging in unethical conduct and reduces the likelihood of opportunistic advantage in data, digital, and transactions. Several studies have linked the influence factors for the adoption of Blockchain technology, including (Y. Wang, Han, and Beynon-Davies, 2019), which investigates how Blockchain technology may influence future supply chain practises and policies. The majority of the literature in the field of supply chain focuses on Blockchain technology as a means of enabling organisations and individuals to conduct and verify transactions without the need for a central controlling authority. This appears to justify the future of digitalisation and disintermediation in the supply chain, as well as resolve issues associated with inter-organizational trust and trust building among patterns, which are largely regarded as neglected areas.

The review also found the disintermediation as a trust element and the assertion that the integrity of data in a Blockchain is guaranteed by the network as a whole, rather than by an intermediary (Michelman, 2017). By removing intermediaries from the supply chain, Blockchain reduces transaction and verification costs (Kuhi, Kaare, and Koppel, 2018). However, Wang, (2018) argued that the P2P network is not particularly useful for temporary business relationships because it only reduces the cost of establishing trust. This indicates that the cost savings realised through disintermediation are not sufficient to cover the cost of investment in the Blockchain itself. However, a greater emphasis was placed on the business's long-term viability than on its short-term viability.

Watanabe *et al.*, (2016) have developed a Blockchain-based permission management system for recording identities in the supply chain. Tian, (2017) posited that there is a developed Blockchain- and RFID-based system for agricultural product supply chain traceability. The system automates the storage and collection of information and integrates the process. An additional enthralling product is that of Toyoda, Mathiopoulos and Member, (2017) who developed a Blockchain-based smart contract model for supply chain management using the prevalent Ethereum architecture. IBM, in partnership with Walmart and Tsinghua University, developed a food supply chain management system on the Hyperledger Blockchain to manage pork supply information almost simultaneously. Reflecting on how businesses are constructing supply chain solutions, it is evident that trust, stakeholder integration, and efficiency are crucial to the success of any adoption.

In summary, the application of Blockchain to enable trusted relationships, transactions, and a trusted network of partners to share information is essential to achieving the core supply chain objectives of every industry. The future of Blockchain technology in supply chains will be determined by its acceptability and ability to deliver trust capabilities where intermediaries and third parties will be required to embed the trust. The fact that the safety and security of data is no longer under the control of a central authority is a crucial driver for the adoption of Blockchain technology, which is an aspect that will benefit the reliability of information provided among trading partners. In a complex structure, this makes the entire supply chain more transparent to stakeholders, regulatory authorities, and consumers. Despite the potential benefits of the technology, there is no evidence in the literature of the experience of the stakeholders on adoption and how adopted solutions have created trust-embedded opportunities.

2.2.6 Blockchain technology enabled transparency in supply chain

While transparency offered by applications of Blockchain technology is necessary, another element from the literature is the importance of trust in supply chains. Due to the lack of transparency throughout the process, the supply chain's network of diverse and numerous actors makes it susceptible to a wide range of unethical practises. The review discovered evidence regarding how Blockchain facilitates supply chain transparency and improves provenance, compliance, and trust. (Shafiq, Johnson, Klassen, and Awaysheh, 2017) described transparency as the extent to which information made available to all parties or to outside observers. In the context of supply chain transparency deals with the degree to which participants have access to relevant information about product, processes and flows of resources delay or distortion (Francisco and Swanson, 2018). It is imperative to say that supply chain transparency is a key indicator of trustworthy supply chain operations. Researcher have shown that it is through supply chain transparency that product quality, source, quantity can be rectified, verified and access for relevant supply chain decisions can be

obtained and be trusted. Lack of transparency is a key factor that makes supply chain vulnerable in its entirety (Kalfagianni (2006); Pagell, and Wassermann, (2010), 54; Wognum et al. (2011); Trienekens et al. (2012).

Hughes, et al., (2019) investigated what Blockchain means for firms and how customers can be protected by Blockchains from deceptive counterfeit fraud. The validity of the goods can be permanently kept by recording the first purchase on a Blockchain, and the ownership of the certificate can be transferred in a transaction that is controlled by smart contracts. Another component of transparency is provenance, which has been shown to be a crucial area where Blockchain may address the issue of not knowing the origins of the raw materials or products across supply chain. Kim, Laskowski and Nan, (2018) added that provenance is "source or origin, or the history of ownership of a valued object or work of art or literature". Further, Montecchi, Plangger, and Etter, (2019) and Cheney, Chong, Foster, Seltzer and Vansummeren, (2009) describe provenance as information about creation, chain of custody, modification, or influence pertaining to an artefact. However, provenance was traced back 300 years with original definition in the works of arts as the chronology of a historical object (Zhanf et al 2010), more recently the concept of data provenance emerged as the data lineage which refers to lifecycle including the origins, activities, and its movement.

Literature in supply chain has described the importance of provenance in supply chains—particularly food product or high-cost products like gold and diamonds. Linking provenance to the Blockchain technology is an interest area within the supply chain. Montecchi, Plangger and Etter, (2019) proposed a framework to address the lack of awareness of Blockchain use to increase customers' knowledge of products' provenance. The framework covers the provenance knowledge and demonstrates how Blockchain may improve assurances and reduce risks, and guidance on how to use Blockchain to establish provenance. Another interesting aspect is the integration and compatibility of Blockchain technology as a model that can enhance transparency and collaboration. It was found that a Blockchain-based system can integrate with all innovative technologies like internet of things and radio frequency identification to ensure digital records are kept in a tamperproof system. In essence, this reduces or eliminates conflict among supply chains (Lo, Xu, Chiam, and Lu, 2018).

The integration of Blockchain with other technologies to provide transparency captures the attention of many researcher, for example, the internet of things emerges as set of technology powered by the wireless sensors network to the radio rrequency identification that has the capabilities to sense and communicate through the internet (Figorilli *et al.*, 2015). In a modern supply chain systems, there are significant improvement with a predictive applicable device

between 20-50 billion in the year 2020 (Díaz, Martín, and Rubio, 2016). This, however, makes it strong smarter technology and autonomous to use in transforming and optimizing process to record information (Díaz et al., 2016). IoT technology can increase the transparency along the supply chain process. However, traceability of IoT data and information have been recognised as having limitations and challenges for trust in the data generated (Díaz et al., 2016). Blockchain and IoT enable an immutable record of all transactions, traceable and auditable (Kumar, and Mallick, 2018). For example on how material could be traced through technologies that support Blockchain system, such as the internet of things integrated with Blockchain promises to offer provenance even in a complex supply chain system (Arumugam et al., 2018). The reviewed articles show practical solutions that offer provenance with the integration of IoT and Blockchain-enabled system (Mathijsen and Sadouskaya, 2017; Kim *et al.*, 2018; Vinay Reddy, 2019). The perspective of the integration of Blockchain with ERP, is among the most interesting system based integration that highlights the potential of Blockchain technology-based system because of its wider adoption in supply chain (Banerjee, 2018). Therefore, the possibility of integrating ERP is recognised in the literature as having the most important impact in supply chain. The system transformed how organisations interconnect with different department, unit, and functions both internally and externally through proving a common platform for material, operations and inventory as well as finance (Marshall, 2005; Banerjee, 2018). Furthermore, Banerjee, (2018) added that in his work on the Blockchain technology and supply chain insights from ERP, the capabilities of the Blockchain can be extended to connect with ERP system; it will enable automatic verification, particularly in an open system. Stating that the integration of ERP and Blockchain will help in stakeholders management and increases data sharing integrity. For example, an ERP system across the supply chain enterprises possesses functionalities that maintains records and exchanges information between different parties, however the data only exhibit in different system independently. Additionally, (Banerjee, 2018) found some challenges of ERP solution and recommended the possibility of the integration of Blockchain based system. Thus, concerns are as follows.

- Data setup: data must be set up across places, since access to data is privileged and is not openly available, it must be provided by the supply chain transaction entity for setup. This is a time-consuming and effort-laden procedure.
- Data maintenance: data must be maintained well in the enterprise system and changes must be updated regularly to prevent asynchrony as out-of-sync data can negatively affect supply transactions.

- Data standardisation: From the time when data is independently set up in every enterprise, it lacks standardisation. It leads to maintenance issues, process slowdown and transaction failure. Unstructured and inconsistent data can negatively affect supply chain transactions.
- Multisystem architecture: The data depends on enterprise systems and this architecture must be integrated across multiple systems, which is challenging and tedious with high running cost.

According to the perspectives presented above, the possibility of using Blockchain as a solution could result in a decentralised system that serves as a central repository for all data. At the moment, Blockchain technology has the potential to communicate with multiple parties while maintaining trust and transparency. It is still too early to tell how the technology will be used in future applications based on its performance and adaptability as the literature has not provided that. Based on the findings so far, Blockchain technology is a technology that makes the supply chain more transparent when combined with other technologies such as IoT and ERP, the benefits may be significant. However, the review does not provide real-world evidence to back up these claims, and many of the assertions are based on theoretical models or framework development that will guide the technology's application.

2.2.7 The level of adoption of Blockchain in supply chain

While many studies in the literature have focused on highlighting the benefits and value derived by the organisations through Blockchain implementation, very few studies have analysed the Blockchain adoption and how it affects the value drive from the technology and the organisations. The Blockchain literature is still growing at a slow pace particularly that of adoption is at the early stage with few cases to validate as well as assessment of the impact of the adoption on the specific areas of supply chains.

According to Dobrovnik *et al.*, (2018) despite the assertions that Blockchain will transform supply chain and redefine logistics, we found that existing research are limited concerning contexts that classify Blockchain application potentials and their implications for adoption. They further developed a framework based on Rogers' (2003) 'attributes of innovation framework' that identifies the potential Blockchain applications in supply chain and presented a framework explaining four transformation phases categorised based on identified areas of application according to their effects on organisational structures and processes. The finding of the work recommended the use of Blockchain only when customers have intermediate concerns for trust among product in the market. Instead they suggested how Blockchain can be more effective in

eliminating the post-purchase regret and improving social welfare, the research lack methodological approach beyond the technological aspects.

Conversely, Koens and Poll, (2019) stated that in adopting Blockchain there are non-technological aspects that are key to the decision makers such as philosophical beliefs, network effects, and economic incentives. These non-technical drivers may explain the rationality behind the choice for Blockchain adoption which companies should explore in understanding the effects on the adoption. In that case, despite several advantages of the technology, the research found that practical challenges do exist at the moment, firm's lack of an organised ecosystem to increase the scale of this technology, training to employees, governance, privacy and a high cost of implementation.

To some extent the literature discusses that managers are not fully aware of the impact and benefits of Blockchain which can give a competitive advantage to their supply chain and to the firm (Huckle et al., 2016). Hence, poor understanding of Blockchain is also a reason for lower adoption rate (Mthethwa, 2016). Again, another reason is that most of existing literature on Blockchain is based on conceptual exposition, there is lack of empirical evidence (Ying et al., 2018). The research noted that despite increasing concern toward scaling Blockchain technology in complex logistics and supply chain scenarios. Kamble et al., (2019) investigated the behavioural intention of Blockchain adoption, and found that sector wide Blockchain applications are required to be developed by the vendors to improve the utility of Blockchain. More specifically, research on the actual adoption of Blockchain by logistics and supply chain management practitioners is still in its nascent stage and there is a need for conducting more sector specific Blockchain adoption studies postulating the relationships between the various enablers and barriers of Blockchain adoption. The outcomes of such studies will help practitioners to better understand the issues and challenges involved in Blockchain adoption and formulate strategies to overcome them.

The perspective of value driver for the adoption of Blockchain technology is the feasibility and viability offer by the technology, although the practical applications of Blockchain are still developing the only areas that is receiving attention is the potential of the technology particularly in supply chain. Hence emphasis should not be given to the technology alone, but issues surrounding selection of appropriate technology and the adoption process (Angelis, and da Silva, 2019). Further, Gurtu and Johny, (2019) stated that the main determinants of adoption of Blockchain in supply chain is the diverse stakeholder in the supply chain, due to the constraints that every player has some level of capability that can affect competitiveness of one another. Blockchain technology system has the potential if adopted to bring all relevant parties together, which can sometimes be a difficult task, and may eliminate the need for some of the players in a

chain, thus making supply chains more efficient, it is interesting the research has not covered such aspect in adoption.

It was found that the Blockchain is adoptable due to the potential it has on supply chain efficiency and reduce fraudulent and manipulative activities. Some of the advantages of using Blockchain are data security. At the moment many projects are emerging to be adopted for different purposes in the supply chains, for example in the USA, a logistics operator is leveraging Blockchain to increase supply chain transparency and digitalisation of operations. Blockchain in Transport alliance project started in 2017 and has an annual turnover of more than $1 trillion, it focuses on knowledge of the technology adoption and use of different solution, and it has membership of more than 25 nationalities and 500 plus members (Werbach, 2018). Gurtu, and Johny (2019) further emphasis that the application of Blockchain technology in SCM is limited so far and makes it less to realise the value it has on supply chains.

In addition, Heidari, (2019) investigated the drivers that affect the customer's behavioural intention to use Blockchain capabilities in the financial sector as an instrument using several combined technology acceptance models, in his case found that personal propensity of trust and structural assurance beliefs directly affect behavioural intention. The finding further stated that intention to use the Blockchain was as a result of social need despite many limitations of the technology. Sheel, Nath and Ashutosh, (2019) position was that supply chain practitioners are confident that Blockchain technology will help improve supply chain parameters and helps in creating a competitive advantage even though they have not used the technology. The assertion was based on the knowledge about supply chain and Blockchain, which they acquired from published sources on the potential of Blockchain adoption in supply chain.

Queiroz and Fosso Wamba, (2019) identified Blockchain–supply chain relationships within well-established supply chain areas of distribution, product traceability, intelligent transportation systems, and anti-counterfeiting efforts. Although the research found that the above relationship is based on understanding of the potential of the emerging technology, supply chain stakeholders will be challenged to reconsideration strategies to integrate Blockchains in supply chains. However, Kamble, Gunasekaran and Sharma, (2020) investigated Blockchain technology adoption in supply chains-Indian context with the aim to advance the literature on Blockchain and its adoption in the supply chain through developing, and statistically validating a model for understanding the user perceptions. Their model was based on Technology Adoption Model (TAM). The research was the first of its kind to employ a survey of supply chain practitioners on perceive Blockchain technology adoption.

Most recent studies have shown for example by Li and Chen (2022) discussed the challenges, opportunities, and prospects of blockchain technology implementation in order to investigate its potential to improve supply chains. They also provide case studies of successful blockchain applications in supply chain management. Liu, Si, and Kang (2022) conducted a literature review of blockchain-based supply chain management applications and identified key challenges and opportunities associated with their implementation. While, Olak (2022) proposes a model for investigating and comprehending blockchain technology acceptance in supply chains, drawing on literature on technology acceptance, innovation diffusion, blockchain, and supply chain.

Chen, Y. (2023) on a systematic review and case studies of how blockchain adoption affects supply chain sustainability in the fashion industry shows the impact of blockchain on the fashion supply chain through a systematic review and case studies. While G. Casella, B. Bigliardi, S. Filippelli, and E. Bottani (2023). A review of the literature on blockchain applications in the supply chain through assessing the evolution of research in this area and identified the benefits of using blockchain in the supply chain Dutta, R. Chavhan, Gowtham, and Thakur (2023) studied the impact of Blockchain and IoT on sustainable supply chains. An International Journal of Supply Chain Forum. However, Kafeel, Kumar, and Duong (2023). Blockchain in Supply Chain Management: a manager's guide to the barriers and enablers and summarises the challenges and opportunities for blockchain adoption in supply chain management. It focuses on managers' perspectives and provides insights into how they can overcome barriers and leverage enablers to implement blockchain in their supply chains. Risso, Ganga, Godinho Filho, and Ferreira (2023) outlined the barriers to blockchain adoption in the supply chain. It investigates the challenges that organisations face when implementing blockchain in their supply chains and offers suggestions for how to overcome these obstacles. Blockchain adoption and use in the context supply chain is relatively sparse in academic literature, (Batubara, et al., 2018) even in other aspect Blockchain adoption in many contexts are very limited with lack of empirical evidence. Further the main challenges faced in Blockchain adoption are predominantly technological, such as security, scalability and flexibility, the organisational point of view, the issues of acceptability and the need of new governance models are the main barriers to adoption.

2.2.8 Challenges of Blockchain technology adoption

Despite the recognised potential for Blockchain technology in supply chain, the research has found fundamental challenges that need to be addressed. The literature highlighted the technological aspect of the Blockchain; such as, security, scalability and flexibility as core challenges of the Blockchain technology (Treiblmaier and Beck, 2019; Baruffaldi and Sternberg, 2018; Queiroz and Fosso Wamba, 2019). Though security itself is one of the strongest selling points of the technology

it is still in question according to some scholars (Baruffaldi and Sternberg, 2018). Gatteschi, (2018) precisely outlined issues of cybersecurity as a key challenge of the Blockchain application. The increasing interest within developers, regulators and general users has raised concern as a trade-off between security and performance (Gatteschi, 2018). For example, Gatteschi *et al.*, (2017) there is possibility of increase attack in a public Blockchain despite the decentralisation, the Blockchain is not invulnerable to data corruption or network attacks, the confirmation is that when participation in a Blockchain is low, a coordinated group of malicious parties can create enough nodes to produce a network majority, forcing mutated data upon the rest of the benign nodes (Takahashi, 2017).

That means a public blockchain attacks may compromise supply chain security. A coordinated group of malicious parties can manipulate or corrupt public blockchain data, affecting supply chain integrity. This can introduce fake products or tampered information into the supply chain, which can harm businesses and consumers. This was attributed to technical complexity of the workings of the Blockchain in supply chain as challenges even at the initial stage of building confidence of the participants. The above is consistent with (Gatteschi, Lamberti, Demartini, Pranteda, and Santamaria, 2018) based on the Gartner's hype cycle, Blockchain is at the peak of inflated anticipations, the collective concern is that the technology is considered not fully mature and overhyped by its enthusiast. The biggest challenge of this assertion is that those committed to the technology make less objective judgement on the true benefit that organisations can drive that other technologies cannot offer because of some challenges associated with Blockchain technology, application or perceptions.

Other challenges of the Blockchain are the cultural resistance based on existing business process, models and constant attitude of people toward technological changes (Patel et al., 2017; Wang et al., 2017). According to Michelman, (2017) the biggest resistance is that of the business leaders, they anticipated lost revenue by current economic winners in the spectrum financial of transaction within the Blockchain space, in essence Blockchain can disrupt their business model. For example, intermediaries in any supply chain risk elimination by a Blockchain based system, the problem is they may be reluctant to integrate into Blockchain for competitive advantage or even to stay in business, (Zhao, Fan, and Yan, 2016). The role of actors in adoption of the technology is key to the success of its use, but for a Blockchain to work in the supply chain environment, the whole network of supply chain actors should be committed (Kshetri, 2018). For instance, global supply chains operate in a complex environment that requires various parties to comply with diverse laws, regulations and institutions and work toward achieving the overall business value. Effecting the use of Blockchain in such an atmosphere is an extremely complex task (Casey and Wong, 2017). In such scenarios, undue advantage always takes place, accidental errors, conflicts of interests,

corruptions and malicious attacks could bring down the trust element of the solution (Boucher et al., 2017; Kshetri, 2018; Chen et al. 2017). However, the potential of making the supply chain transparent to the whole network of supply chain actors, should sufficiently benefit them: what others see is that it can be resisted by the actors, for simple reason that they may not want high level of transparency (Fawcett et al. 2007). Kembro et al., (2014) confirmed that lack of openness to share valuable information by actors in supply chain as a barrier to effective supply chain efficiency.

Patel et al., (2017) and Wang et al., (2017) outlined the cost of implementing and participating in Blockchain based solution as part of the adoption challenges, the technical and specialised expertise required for participation will come with huge financial burden. Some supply chain networks will take longer to realise the value drive, even if the technology offers unique advantage, but the cost will remain a barrier to them (Hoy, 2017). The point of concern is the operations and environment factors that Blockchain technology requires such as high level of energy consumption to maintain the network and enforcement (Hoy, 2017; Kshetri, 2017). This review has identified the critical challenges that are associated with the adoption of Blockchain technology within the literature. Despite this, there are gaps in the literature that are found to be relevant to the adoption of Blockchain technology in supply chain. The implication of the gaps will provide direction to the extent of Blockchain adoption in supply chain and the areas that fit within the context of this research.

2.2.9 The gaps in the Blockchain and supply chain literature

The objective of the systematic literature review is to identify the gaps in the literature and outline the implications of the gaps and how the research will align to the existing body of knowledge. The gaps identified are summarised into Blockchain and supply chain from the conceptual and empirical research evidences. The major shortcoming in the literature is a lack of empirical studies particularly on implementation, challenges and drivers for the adoption of the Blockchain in supply chain. Most particularly the emerging markets are underrepresented in the literature (Queiroz, Telles and Bonilla, 2019). The literature has not captured the assessment of the potentials and limitations of the technology from a theory based approach (Treiblmaier, 2018). The lack of theory to analyse, explain, predict and design action that can lead to research question that will help answer some of the concerns of the industry as well as smooth the adoption of Blockchain technology for the wider supply chains (Treiblmaier, 2018). Treiblmaier, (2018) provided a step to develop the knowledge that would enable a better understanding, predict, and if needed, design Blockchain solutions that benefit the industry. There are various methodological approaches, such as generalizable empirical studies, that can be used to gain a better understanding and identify the

most important problems for the industry, a close cooperation between academics and practitioners will best yield such results for mutual benefit in this novel research area.

Another important gap is the lack of theory and methodological pluralism populated research on this subject, more need to be done in exploring and aligning theories that can help in investigating Blockchain and supply chain phenomena (Y. Wang, Han, *et al*, 2019)**.** For these reasons, research employing the use of theory is indispensable as a vital part of technological innovation and adoption of Blockchain in supply chain. There is lack of research that focusses on building theoretical lenses and multi-methodological approaches to understanding the Blockchain phenomenon, particularly diffusion within the supply chain (Y. Wang, Singgih, et al., 2019).

There is a gap in knowledge in relation addressing how the implementation of Blockchain can be benchmarked in an organisation empirically (Queiroz et al., 2019). No research has provided insight into the capabilities required by companies to implement and utilise Blockchain in supply chain operation from an integrated approach covering all aspect of implementation. Corruption can still be embedded as a culture of practice: exploring how Blockchain eliminates corruption in the supply chain particularly in developing countries where this problem prevails is a future research agenda that need to be carried out (Wang et al, 2019). Queiroz, M.M., Telles, R. and Bonilla, S.H., (2019) recommended examining the maturity of Blockchain in emerging economics with the view to diffuse the innovation. The proposed recommendation would help with perspectives to the adoption and be compared with developed countries. There are more calls for theoretical insight to better understand the motivating and/or discouraging factors on companies to adopt and implement Blockchain in supply chain. Alternatively, picking other theories from wide range of subject areas will help research in the field to conceptualise the Blockchain into several academic disciplines therefore fostering interdisciplinary studies.

Blockchain has implication according to industrial context in supply chain due to the differences across supply chains, there is a gap on the potential impact of the Blockchain based on industry trends, peer pressure, government intervention and to what extent top management support organisational support of adoption decision. Another gap that was identified was from the work of (Min, 2019) that proposed the need to explore the synergy between stakeholders in building successful Blockchain solutions for supply chain, and the concerns of participation of diverse supply chain members in order to realise the full potential of the technology, this topic has not gained any research interest.

The overall gaps were concentrated around the sparsity of literature in exploring beyond the technical capabilities of the technology, understanding the management implication, adoption behaviours beyond the technological constructs, workability of the system as well as the

requirement needed for companies to successfully benefit from the Blockchain technology adoption. The theoretical alignment in the literature and the approach to building the technology to meet the technical requirements, system configuration and operations is lacking within the literature. It has less to do with user experience and working culture within the organisation, but emphasis was given to the technology.

Future recommendation and findings from the literature could be used as a basis and additional insight when developing the aim of the research. Building from the existing body of knowledge is a critical way of validating the outcome or otherwise of this research. On this basis, therefore, theory is the breach of any field of knowledge, and so in Blockchain technology phenomenon. There is a clear lack of theory to support the understanding, examination, and methodological approach to solving Blockchain in supply chain problems (Y. Wang, Han, Beynon-davies, et al., 2019). A large majority of papers were either conceptual or technical in nature. The main characteristics could be derived from the literature review, there are too few empirically investigated indicators in this area that could validate a possible Blockchain use case that will benefit complex supply chain and influences adoption.

Many companies and researchers are attempting to engage with the trend of Blockchain adoption based on their business objectives, but the effects of Blockchain on the supply chain are yet to be systematically assessed. There are open questions about Blockchain that remain unanswered in the research field. As a result, the purpose of this research is to demonstrate the impact of Blockchain in the supply chain and how Nigerian oil and gas can adopt Blockchain and deliver value that will address supply chain challenges of lack of transparency, accountability, efficiency, and trust among stakeholders. As a result, this study acknowledged the gaps in the systematic literature reviewed by investigating stakeholders' perceptions of factors influencing Blockchain adoption in the Nigerian oil and gas supply chain.

2.3 Summary

Blockchain technology is still in its infancy; its application in supply chain is still in its early stages, with few use-cases. The technology has proven to increase transparency, provenance, efficiency, and visibility in the supply chain despite its limited use. The literature has not demonstrated how supply chain actors' behaviours affects Blockchain adoption, or the role of the actors in its adoption. Despite the growing interest in leveraging the potential of Blockchain in the supply chain, only a few studies have been conducted to date to investigate adoption from the stakeholder's perspective, and those studies have not used an empirical approach, and are instead based on a conceptual approach.

The motivation for investigating Blockchain adoption in supply chain was necessitated by a lack of empirical insight into the perceived factors for companies to accept and use Blockchain technology in supply chain beyond technological factor. As the potential of Blockchain continues to be realised, organisations must better understand, predict, and, if necessary, design Blockchain solutions that benefit their supply chains at the enterprise level. The knowledge gathered and gaps identified in the systematic literature review provided knowledge of what has been done and what needs to be done in Blockchain ad supply chain, particularly given the scarcity of empirical research. However, the purpose of this research is to investigate the perceptions of Blockchain technology adoption in the Nigerian oil and gas supply chain. The questions of how and what stakeholder's perceptions are regarding technology adoption, and how the use of theory will explain the Blockchain technology adoption. Based on the above review and the gaps identified, the rational for the investigation to be carried in the context of the Nigeria oil and gas supply chain cannot be overemphasised. The next chapter will present the context of the research which is the Nigeria oil and gas supply chain.

3 The Nigerian oil and gas supply chain

This chapter describes the research context using published literature as well as industrial reports of supply chain operations within Nigeria's oil and gas industry. The last chapter set out the systematic literature review, and presented the critical analysis of the subject areas, identified the knowledge gap, and set the agenda for the research. Consequently, the aim of this chapter is to link the literature review within the context of the investigation (the Nigerian oil and gas industry), and highlight the structure, challenges, and state of adoption of Blockchain technology in this industry.

It is important to note that oil and gas was discovered in commercial quantity in early 1956 in a remote village called Oloibiri in Bayelsa state in Nigeria. Since then, oil and gas exploration has continued to attract foreign and local investments into the sector (*The World Factbook*, 2021). The Nigerian economy depends on revenue from the oil and gas industry and has become the major critical national sector that drives the nation's Gross Domestic Product (GDP). As a producer of oil in large quantities, recent data shows Nigeria has a total oil reserve per barrel of 36,910 million barrels and is ranked 10th globally with a production per day of 1,493,300 ("OPEC : Nigeria," 2021).

The chapter starts with the discussion of the supply chain in the oil and gas industry, the structure of the industry in Nigeria, oil and gas contractual models, then a section on supply chain challenges with the industry. In addition, the chapter discusses Blockchain technology use in Nigeria and Blockchain development in the Nigeria oil and gas industry as well as the summary of the chapter.

3.1 Supply chain in the oil and gas industry

Like many supply chains, the oil and gas supply chain comprises the key fundamentals of managing the flow of information, material, and finance (Amu and Ozuru, 2014). The concept of the supply chain has continued to grow and change dimensions from transactional non-strategic function to logistics management, and now network management end to end. As a result, organisations are now leveraging the supply chain to achieve a competitive advantage through effective management of resources, planning to lower production costs and relationship management to increase sales and long term gains (Barney, 2012).

The oil and gas supply chain encompasses three different stages: upstream that deals with the business of exploration and production, midstream manages the transportation of crude and storage, and downstream handles the refining, marketing and retailing of the finished products. They are all interconnected and the activities in every segment add value to the operations. Figure 3-1 illustrates

the three streams, the nature of operations and activities at every point, and how they are linked together (Joshi, Haghnegahdar, Anika, and Singh, 2017).

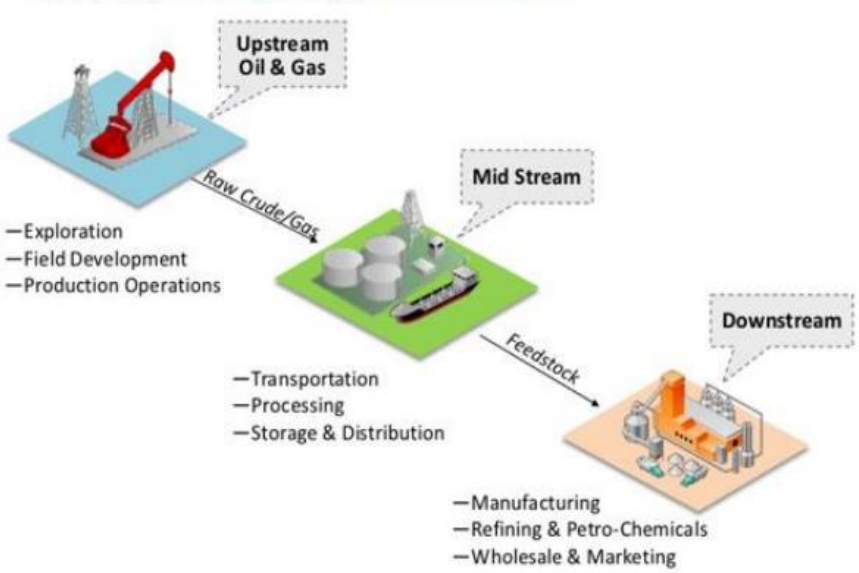

Figure 3-1 The oil and gas industry (Joshi et al., 2017).

From the above figure, the illustration shows how the typical oil and gas supply chain operates and is interlinked within the industry, this linkage provides the transfer of the products, information and finance from multiple functions, business and services for the supply chain to function. However, depending on the operational environment, different structures work within the sectors in the industry. The structures show the operational framework, the nature of companies and the policy that drives the industry. For example, a part of the participation of the government, the companies that operate across all streams of the industry are called integrated oil companies (having operational presence in more than one stream). While there are companies that only operate in one or two segments of the industry. They all play a crucial role in the effective operation and supply chain within the industry.

In Nigeria, the oil and gas supply chain has been described as being complex associated with regulation, operations, legal requirements and due to the specific nature of the operations (Donwa, Mgbame, and Julius, 2015). The international oil companies are the major players in the upstream stage, whilst the government-owned Nigeria National Petroleum Corporation plays a significant role as an integrated oil and gas company (Oguine, 2015).

Constitutionally, the vast oil and gas resources are owned by the government of the federation. The law that governs Nigeria's oil and gas industry includes the Petroleum Act 1969 as the principal legislation, the national Oil Spill Detection and Response Agency (Establishment) Act 2006 as the regulatory body with the responsibility of surveillance and monitoring oil spill in Nigeria. Others

include the Nigerian oil and gas industry content development Act (Local content Act) 2010 for the promotion of the participation of Nigerians in the oil and gas industry. The Niger delta development commission (establishment) Act 2000 for the payment of commission by oil and gas companies of 3% of their annual budgets, for the development of the oil and gas zones. And the oil pipelines Act 1956 as the provision for the granting of license and permits for the laying of pipelines, these law as form the operational and legal framework (Oguine, 2015). The laws affect the operations of any entity within the different streams of the industry. The government of Nigeria controls the operational framework, regulatory standard, and revenue sources, which account for more than 60% of the government sources of revenue.

3.2 Structure of the industry

The Nigeria oil and gas industry has a structure that covers all three streams and across the value chain as illustrated in Figure 3-2. The structure varies from the policymakers, regulators, operations (international oil companies and local), service providers, and other relevant authorities outside the specific industry.

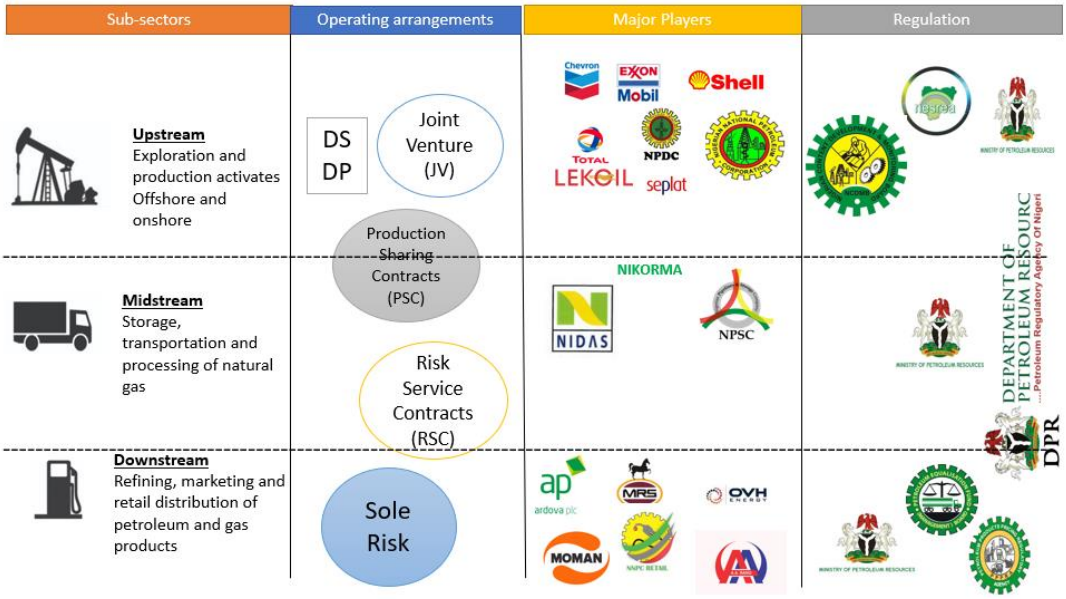

Figure 3-2 The Structure of the Nigerian Oil and gas Industry (NNPC, 2019).

The structure of the oil and gas industry in Nigeria illustrated above highlights the complexity of the sector, involving different stakeholders across the supply chain. In order to discuss the critical stakeholders, the following parties are considered as representing the key stakeholders within the industry and across the supply chain.

1. **Ministry of Petroleum Resources (MPR)** – is part of the Federal Ministries in Nigeria responsible for policy development and supervision of the industry. The Ministry coordinates all policy and top-level government initiatives in the industry.
2. **Nigeria National Petroleum Corporation (NNPC*)*** – is an integrated National oil and gas Company owned by the government and is responsible for harnessing Nigeria's oil and gas reserves for sustainable national development. It is also involved in petrochemicals and gas development, oil and gas engineering, the supervision of government investments in the upstream sector, and the marketing of Nigeria's accruable crude. The NNPC has several sub-business units, companies, and subsidiaries across all the industry sectors, i.e., Nigeria National Petroleum Investment Management Services NAPIMS, Nigerian Petroleum Development Company NPDC, NIKOMA, NNPC Retail LTD, and the NNPC Refineries.
3. **Department of Petroleum Resources (DPR)** – is a government department under the supervision of the MPR responsible for enforcing policies of the petroleum sector. The department is also responsible for granting licences and permits to operators. As part of the key strategic players, the department has a presence in all industry sectors.
4. **Midstream and Downstream Regulatory Agencies** – the industry has some essential government-owned organisations that also play regulators' roles. They handle the pricing and bridging cost from the midstream to downstream. The agencies are the Petroleum Product Pricing Regulatory Commission (PPPRA), and the Petroleum Equalisation Trust (Management) Board (PEF).
5. **Nigerian Content Development and Monitoring Board (NCDMB)** – was established by the Nigeria Oil and Gas Content Development Act 2010 (NOGICD). The Board is responsible for enabling local content participation through providing guidance, coordination, and implementation of the NOGICD Act. The overall objective of the Board is the local participation in the social, economic, and environmental aspects of the oil and gas industry.
6. **International Oil Companies** – the international oil companies have the largest participation in the upstream of the Nigeria oil and gas industry. Some of which still operate within the downstream. The companies are Royal Dutch Shell Nigeria, ExxonMobil, Chevron, Total, and Nigeria AGIP. At the strategic value chain in the industry, they are responsible for the exploration and production of oil and gas.
7. **Indigenous companies** – the oil and gas industry are locally owned oil and gas companies that operate within the streams. The increasing local content participation has created an opportunity for indigenous participation due to the laws. As a result, the companies under this umbrella have continued to grow, particularly with Marginal fields' allocation. Some

indigenous companies are Addax Petroleum, Seplat Petroleum, Sahara Energy, Rahamaniya, and Forte Oil.

In addition to the stakeholders described above, government establishments and organisations, the industry has other relevant stakeholders due to the importance of its activities and the revenue source to the country. These include: the Ministry of Finance; The National Treasury - office of the Accountant General of the Federation; the National Assembly; Federal Inland Revenue Services; The Ministry of Environment; National Oil Spill Detection and Response Agency; the National Environmental Standard, the Regulation Enforcement Agency, and the Independent Petroleum Marketers Association of Nigeria Major Petroleum Marketers Association.

The complexity of the operation of the industry has resulted with a lack of transparency due to the inability to open information to the public as demanded by many stakeholders and resulted with large amounts of corruption as several officials have been charged with oil and gas related fraud and misappropriation of funds. For example, a *Financial Times*, (2018) report has shown that the current administration has an agenda to fight corruption and increase transparency in the industry. Some of the policies that have shaped the future of the industry on transparency are the Nigeria Extractive Industries Transparency Initiative (2007) responsible for reporting the financial transaction in the extractive industries as a global standard, the Freedom of Information Act (2011) responsible for providing information by public officials to the general public, and the proposed Nigeria Industry Act is adjourning for over two decades, the law is deigned to restructure the oil and gas industry in line with international best practices (Oyewunmi and Olujobi, 2015).

3.3 Oil and gas contractual models

Contracts legal and management are integral to any successful supply chain management. The oil and gas industry has a unique approach to contract arrangement, particularly in the upstream sector. The importance of contractual arrangements in the industry's supply chain cannot be ignored. The review of the contractual arrangement provides insight into some of the areas that are lacking in transparency and accountability.

Concession contracts

The concession contracts is a systematic process of granting companies the exclusive right to engage in exploration, production and marketing of oil, gas and petroleum products in return for royalties and taxes (Al-Attar and Alomair, 2005). Although before the establishment of an agency to manage concessions, there was no organisation responsible for concession contracts except recently when the Infrastructure Concession Regulatory Commission (ICRC) was established in 2007.

Joint Venture Contracts

The Joint Venture Contract (JVC) is one of the major fiscal arrangements in Nigeria's oil and gas industry. In this type of contractual arrangement, the government engages with the IOCs and acquires some participatory interest as a concession, with business is conducted with the national oil company (NNPC). The contract is jointly between the parties through 'cash calls' a form of agreement and payment of dues based on the stakes of the parties and is the commonly known means of a contract with the IOC. The Nigeria Petroleum Development Company (NPDC) manages the operation on behalf of the Nigeria government. However, it has been identified that historically, the government was not fulfilling its part of the cash calls obligations in this contract form. Hence, the introduction focuses on the production sharing contracts (Chukwuemerie, 2003; Jackson, 2003; Itsueli, 1993).

Production Sharing Contracts

Like the JVC, the Production Sharing Contract (PSC) is broadly the most accepted form of agreement that the industry is currently engaging IOC and some Major Oil Companies (MOC) upstream. The difference between JVC and PSC has arisen as a result of the challenges of the NNPC and the government to pay its cash calls. The PSC was adopted as an option that gives the contractor (oil companies) to carry out exploration, production and marketing fully funded (Mmakwe and Ajienka, 2009). The contracts bear the risk and recover costs when oil is received commercially. If there is no oil at all, there is no compensation or risk associated with the government. Under the PSC, the contract has the right to oil cost, and equity cost based on a guaranteed return on investment shared between the parties (profit oil). All current deep-water investments in exploration and productions are conducted through this form of contract (Al-Attar and Alomair, 2005; Adepetun, 2015; Kellas, Hodgshon and Member, 1994).

Financial and Technical Service Agreement

The contract model invites technical and financial partners to engage in the development and exploration of the field, and the government, through NNPC, get an income after recovering the cost through royalties and taxes (NNPC, 2019; *Vanguard News*, 2019). When considering the risk and huge commitment required in production sharing contracts, the NNPC developed another contract model called the Financial and Technical Service Agreement (FTSA). The Group Managing Director (GMD) of the NNPC described it as a new financing model to the industry's project financing. In the quest to increase Nigeria’s oil daily production, Oil Mining License OML13 is owned by NPDC 100%. Currently, this model has attracted two major field developments between 2019-date.

Direct Sales Direct Purchases

The concept of direct sales direct purchases was for the NNPC to manage the crude oil value chain whilst sourcing for the refined petroleum products for national consumption. The contract and business process involves the NNPC to allocate the crude oil and product supply as a strategic plan and commitment to create a flexible and workable initiative in the downstream, involving products supply and distribution. This model was introduced by the current administration to tackle corruption in the supply and payment of subsidy in the downstream. The plan is warranted to provide security of the product supply in unforeseen disruptions like shortage of supply, diversion of products and high cost of sales per litre (*Ibrahim S*, 2019). The process is open to companies to express interest and bid of which the NNPC finalise the award for one year (*NNPC 2020/2021);*

The above contracts arrangement has had a significant impact on the industries supply chain. The critical stakeholders are often determined to maximise the value chain and create an efficient flow of resources (petroleum product, kerosene, and other components from the oil). Notably, the revenue is expected to improve the cash flow of the government and make the economy functions. However, the current DSDP, which effectively provides the country with petroleum products, has been under investigation for the lack of the NNPC to account for 5.3 million barrels allocated in 2018 – 2019 (*Tribune Online*, 2021). Some stakeholders have challenged the process of DSPD itself as it is still OIL SWAP (a form of contracts where crude oil was swapped with supply of refined products) condemned by corruption and waste of countries resources (*NNPC aims to end product swaps in 2023 - News for the Energy Sector*, 2019). Another report by Business Day described that the DSDP represents the same outcome as oil swapped due to corruption of allocating Nigeria's crude through middlemen for cheap fuel. In practice, the middlemen buy the product from NNPC and sell through other means and buy from refineries to import to Nigeria (*Businessday NG*, 2021).

Another concern on the contractual transaction is the lack of transparency in the selection process from NNPC to the winners, for example, according to the NRGI:

> *"In its 2015 study on NNPC oil sales, NRGI stated that between 2010 and 2015, the management of NNPC's oil sales had worsened, becoming 'overly discretionary and complex, as political and patronage agendas surpassed the importance of maximising returns."* - (*Natural Resource Governance Institute*, 2015: pg. 39)

The amount of money lost to corruption in NNPC sales has been estimated to be N6.4 trillion over the last 2011- 2015 (Premium Times Nigeria, 2015). According to a deeper analysis of NNPC's crude oil sales and discretionary spending from the domestic crude oil, sales skyrocketed to $6

billion years from 2011 to 2015. They found that the national oil company's discretionary spending from domestic crude oil sale revenues has skyrocketed, exceeding $6 billion a year for 2011 to 2013 (i.e., over $18 billion in three years) and no public accounting was provided on how the decade's worth of revenue transaction on behalf of the federation was conducted. For instance, it was gathered that a single offshore processing agreement cost $381 million in a 12 calendar month period (*Natural Resource Governance Institute*, 2015). As a result, contractual models in the oil and gas industry play a significant role in how the supply chain functions. When the contractual models are examined, the areas where transparency is required, the aspects that need to be automated, and where processes need to be improved can be seen.

3.4 Supply chain challenges within the industry

Over the years, the oil and gas supply chain challenges have been identified as a weak link, particularly the interconnectivity and collaboration between the players, the complexity within the processes, and the lack of visibility and transparency (Akpomera, 2015). Oil theft has continued to significantly limit the ability of the government to generate more revenue for developmental projects. The relevant authorities' inability to protect the industry's integrity, like the Nigeria Navy the military arm that is responsible for the protection of waterways and offshore facilities where oil theft happens, is in fact manifested by not deploying the right technology to fight theft (Akpomera, 2015). In addition, (Sakib et al, 2021) pointed out that the lack of technology deployment to track and trace a transaction from production to consumption represented one of the industry's most considerable supply chain risks. Like many industries, the oil and gas supply chain face significant challenges across all the streams. Some of the evident challenges include the flow of information, finance, and material distribution. Nigeria faces significant disruption resulting from these challenges. The disruption to the supply chain has increasingly affected operations, revenue efficiency, and dynamic investment growth. Some of the most specific aspects that affect the supply chain are described in the following sub-section.

According to Olusola (2020), the security of contracts administration, ongoing instability in policies, and overriding powers from the Petroleum Ministry have affected the integrity of the oil and gas contracts. Olusola (2020) further outlined challenges in the oil and gas contracts: the lack of leadership to take consistent policy changes has affected investments in the industry; the Clandestine nature of oil and gas contracts has affected the government to keep records and published revenues that are accrued from the sector; the transparency in the contracts is mainly neglected due to the inability to insert a clause that will make all parties open to the public; and, the national oil company represents the country. The lack of transparency has not availed the NNPC with the integrity to strengthen internal cost control, regular audit, and accounting records

accessible at any point in time. Figure 3-3 illustrates interconnections of the different parts of the supply chain and the actives that affect supply chain management. The figure provides insights into the industry's challenges that have implications for the supply chain that are described in the following sections.

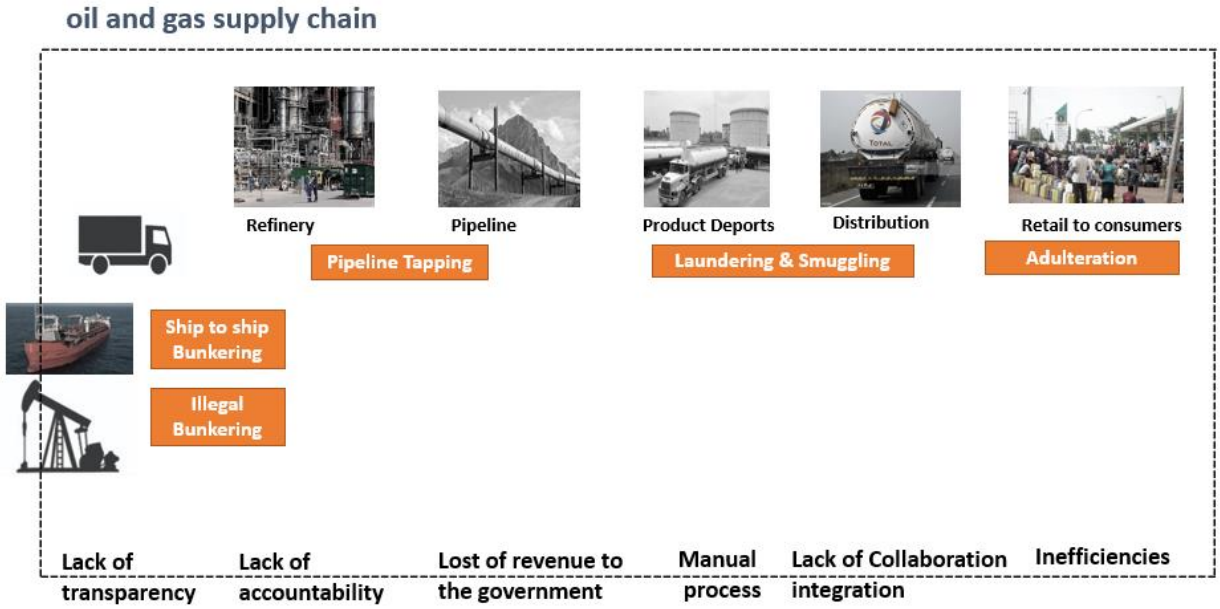

Figure 3-3 The oil and gas supply chain challenges in Nigeria Adapted (NNPC, 2019)

The diagram above depicts the interaction along Nigeria's oil and gas supply chain. The nature of the industry and its participants has a significant impact on the fundamentals of supply chain management of information, material, and finance flow. The following Table 3-1 summarises the challenges and how it affects supply chain.

Table 3-1 Summary of supply chain challenges in the Nigeria oil and gas industry

Challenges	How it affects supply chain
Lack of transparency	This involves the lack of transparency in the flow of information, crude oil trading, refined petroleum products and the flow of finance from traded products, payment of subsidy and revenue remittances
Lack of accountability	This involves the practices across the entire supply chain due to manual process, lack of controls and central data responsibility and strong regulations. This has affected revenue from sales of crude oil and investment from foreign direct partner.
Lost of revenue to the government	The oil and gas industry has significant impact to Nigeria. The lack of accountability and transparency in the operations has triggered lost of revenue amounting to billions of naira.
Manual process	The nature of the operational actives of the oil and gas has been criticised by lack of digital transformation across the supply chain. The manual process is filled with inefficiencies and lack of transparency and

Challenges	How it affects supply chain
	accountability. This challenge is affecting all aspect of information, material and finance.
Sources	Olusola (2020), Sakib et al, (2021) and Agbu, O. and Nzeribe, S.A., (2023)

3.4.1 Lack of transparency and accountability

Referring to Figure 3-3 above, the lack of transparency and accountability is a dominant factor across the industry. There is no sector within the industry that performs well with respect to transparency and accountability. The oil and gas industry has witnessed some improvement from inception to the present date. The introduction of new legislative acts like the Nigeria Extractive Industries Transparency Initiative (NEITI), Freedom of Information Act (FOI) and the Public Procurement Act (PPA) (2007) has centred on transparency and driving information from the industry for public use. Despite that, and several anti-corruption agencies, Economic and Financial Crime Commission EFCC and Independent Corrupt and Practice Commission (ICPC), the enforcement of the law across the industry to promote transparency is very low (San, 2014). The lack of transparency has continuously affected the confidence of the public and investors; for example, income through royalties paid to the government remain undisclosed for unjustifiable reasons. Details of transactions are not in public domain, making it extremely difficult for an interested stakeholder to have visibility on every aspect of the industries transaction--royalties, taxes, and fees paid under the government's watch (Menhat and Yusuf, 2016; Oyewunmi and Oyewunmi, 2016). Recently, the new head of the National Oil Company emphasised that transparency and accountability of the National Oil Company and its activities will be the cardinal pillars of the new management and introduced an initiative, 'Transparency and Accountability Performance Excellence' (TAPE) that has since been implemented by the new management (*The Cable*, 2021). The National Oil Company's 2018 and 2019 financial audit and its 19 subsidies were published to ensure the transparency drive tracked performance. The publication has triggered public debate due to an important revelation on how the NNPC has incurred losses in its businesses (Ogbuigwe, 2018; Omozue, 2022).

3.4.2 Revenue leakages

The oil and gas industry has been the revenue driver that finances Nigeria's critical national projects and infrastructural development. However, an average of 100,000 barrels of oil per day was vanished and cannot be accounted (Boris, 2015). In addition, the amount of oil and gas lost on transit cannot be accounted for during exportation, due to poor or manual measurement practices, and oil spilling equates to nearly 300,000 barrels per day (Chatham House 2014). BBC reported that $29 billion (£18 billion) was lost in the last decade with about $6 billion to oil theft (*BBC*

News, 2012) and this figures continue to grow exponentially. Oil is stolen at an industrial scale, with collaboration between political and security officials, with the practice achieved through pipeline vandalism and sabotage. According to the former Minister of Finance Dr Ngozi – Iweala, illegal bunkering has reached 400,000 barrels per day, and the figure differing from JVC partners also known as multinational operators to around 150,000 and 180,000 barrels per day. The revenue loss from the oil and gas industry was estimated to be $40M (about N6 billion) per day at a flat price of $100 per barrel of crude oil (Bello, 2017; Okwelum, 2021).

In 2013, the National Oil Company reported a loss of revenue amounting to $1.1 billion (N.1.72 billion). The NNPC also disclosed that the federal government lost $1.1 billion citing pipeline vandalism and oil theft in the Niger delta (Obiene, 2017). More recently, the NEITI report revealed numerous irregularities in the management and administration of oil revenues by the National Oil Company. For example, the report cited that from 1999 and 2011, there was under-assessment of taxes, rents, royalties and other processes to revenue losses of $98B and $11.6B non-remittances from Nigeria Liquefied Natural Gas (NLNG) to the Nigerian government *(Extractive Industries Transparency Initiative*, 2021). In 2021, a report also indicated that the 150,000 barrel daily production per day losses in revenue would be recovered through an initiative called the Wide Oil Revenue Recovery Initiative (*Voice of America*, 2021).

3.4.3 Manual process and operational inefficiencies

The Nigerian oil and gas industry is complex and requires expertise in various areas, technical disciplines, and technological enhancement. For example, there is a lack of an integrated system that will enable end to end processing, evaluation and tracking of operational and transaction processes (Denni-Fiberesima, Shima, and Rani, 2011). Agencies across the industry are developing solutions to automate their processes, but integration has always become a problem. The Petroleum Equalization Fund Management Board PEF(M)B has introduced Aquila, a platform that mainly extracts data from loading and discharging petroleum products from depots, and then uses the data to process payment to marketers (Abubakar. *et al.*, 2016).

The NEITI (2014) report has highlighted the lack of integrated systems for monitoring, reconciliation, and tracking information and material across the industry. Lack of integrated systems to enable end to end monitoring, reconciliation and tracking of transactions affect supply chain visibility and tackled inefficiencies and improvements in the way data is exchanged. The industry has not invested in digital technologies compared to telecommunication and banking *(Blueprint Newspapers* 2021). However, the ability to deploy technology will create operational excellence.

The lack of efficiency in the industry has made some stakeholders call for the national oil company to be denationalised (Adamu, 2019). The DPR, NNPC, and the government capacity and adequate operational excellence have questioned the management and administrative functions. The major shortcomings in governance were due to the intrusion of the national oil company into regulatory and policy marking functions, which has created operational inefficiencies (Gilles, 2009; Akanji, 2010). Due to the nature of the industries operation, inefficient responsiveness has led to delays in supply chain management to deliver the expected outcome at exploration, production and distribution. Furthermore, even the DSDP is full of manual processes; in essence, this has resulted in significant losses to the industry which was meant to improve on the previous commercial and contractual modes (Sakib *et al.*, 2021; Suleiman, 2020).

3.4.4 Downstream and subsidy regime

Despite Nigeria's enormous oil and gas resources, the country is importing petroleum products for national consumption. Nigeria has four refines, all built in the 1970 and 80s. However, the refineries do not produce more than 10-15% of the demanded products for the country's domestic consumption (Ogbuigwe, 2018). Hence, 90% is imported (through the DSDP contracts discussed above). Zaccheus, (2013) posited that the imported petroleum products, especial Premium Motor Spirit (PMS), must include subsidies by the government through a programme called 'Subsidy'. The subsidy regime was designed to target the adverse effects of escalation in the process of the PMS, but the process persists, owning to corruption (Olusola, 2021).

Efforts were made to deregulate the sector and remove subsidy. Still, it failed due to institutional forces benefiting from the industry's shortcomings through subsidy fraud and corruption (Abdul-Baki, Uthman, and Kasum, 2021). The subsidy regime has contributed to the lack of value chain optimisation and investment downstream, and has aided corruption at the institutional level (Akinola, 2018). At some point, the government of Nigeria attempted to remove subsidy but instead, the efforts were resisted by many Nigerians (Akinola, 2018). The argument was centred around a lack of policies, facilities, and infrastructure to ameliorate the removal effect (Akinola, 2018). Alternatively, the lack of refining capacity, inadequate pipeline infrastructure, supply chain architecture and payment of bridging cost (another form of subsidy) has resulted in petroleum product shortage over the years (Itsekor, 2020; Adeleke, Igboanugo and Chime, 2019).

The above dimensions to the challenges that affect the oil and gas industry's operational, commercial, and administrative aspects have a significant impact on the supply chain. Supply chain failures are attributed to the lack of transparency and accountability, revenue leakages, manual processes, operational inefficiency, and downstream and subsidy regime. As a result, Nigeria's oil

and gas industry has been viewed globally as corrupt and lacks transparency, which has crippled the development of the industry and afforded Nigerians the desired benefits for socio-economic development.

3.5 Blockchain technology in Nigeria

Blockchain technology is an emerging technology that Nigeria is still exploring to exploit its potential. In a more recent development, the government was keen to explore the adoption of Blockchain technology for a critical aspect of the economy. The Chief Information officer of Nigeria in 2019 stated:

> "*There are still many myths and inflated expectations surrounding Blockchain technology in the country. In view of this, NITDA has commenced work on the development of standards and guidelines for adopting the technology generally in Nigeria. This is to complement ongoing work by financial regulators on how Nigeria can maximally benefit from the use of cryptocurrencies and digital assets*" (Pantami, 2019).

Since then, the evolution of Blockchain technology in Nigeria has continued to gain interest. The National Information Technology Development Agency (NITDA) has taken steps to develop a framework across various sectors and the projection that adoption will generate $10B in revenue by 2030 *(*Emmanuel, 2020). NITDA is the ICT regulatory agency in Nigeria that has the mandate to regulate and develop ICT in Nigeria (NITDA 2021). Moreover, in an unexpected move, the government banned cryptocurrency trading and use in Nigeria; this was announced by the Central Bank of Nigeria (Al Jazeera, 2021). This was following a report by UsefulTulips, (2021) that Nigeria is Africa's most significant Bitcoin market by trading volume. Since the inception of NITDA, the agency has created a working group and committee to explore the potential of Blockchain technology in Nigeria. NITDA proposed a draft National Blockchain Adoption Strategy with a clear vision of using Blockchain as a technology for the transition to a digital economy. The mission is to drive adoption of Blockchain technology in public administration leading to improved efficiency, transparency, and accountability in governance and to open job creation opportunities in the transformation agenda of a digital economy.

According to (NITDA, 2020), to build a solid basis to achieve the mission of the national Blockchain adoption strategy, the strategic framework was designed in three major themes as follows:

1. Initiatives: Under the initiatives, the NBAS focus on six initiatives: the Nigeria Blockchain consortium; regulation, and legal framework; Blockchain business incentive initiatives;

national digital identify; Blockchain digital literacy; and awareness and Blockchain sandbox.

2. Strategic objectives: In this part, the focus is on regulatory oversight; stimulating innovation and entrepreneurship; security, trust and transparency in the value chain; investments opportunities; and job creation and governance.
3. Government policies and regulatory frameworks, the NBAS strategic frameworks number 3 captures the role of the National digital economy policy and strategy 2020-2021, e-government master plan, the Nigeria Data Protection and regulation 2019, National ICT Policy 2012, the National Broadband Plan 2020-2025 as the key drivers of the government policies and regulatory framework to achieving the national Blockchain adoption and strategy. These policies were aligned to the Blockchain adoption strategy.

In summary, the draft document calls for the stakeholders in the domain to come together to further review the document and make it a government policy. However, some stakeholders have found fault with the document, and criticised the expulsion of some critical stakeholders like industry representatives and technical self-regulatory bodies. But the overall goal of the NITDA's NBAS is to increase ICT contribution to Gross Domestic Product (GDP).

3.6 Blockchain development in the Nigerian oil and gas industry

The oil and gas industry has attracted attention to Blockchain technology due to the nature of the industry's activities. Blockchain technology within the Nigerian oil and gas industry is still a concept that is yet to cross the awareness stage. A Gartner report has put Blockchain into the hype cycle at the peak inflated expectations, and the potential has been overestimated (Gartner, 2018). Blockchain has however been identified as means to make the industry highly efficient, transparent and streamlined traditional operational models (Lakhanpal and Samuel, 2018b). As a result, the supply chain and crude oil and gas trading have higher chances of creating immediate use cases for the industry (Conley and Johnson, 2016).

Deloitte put together a report on the Blockchain future in the oil and gas transformative or transient, perceives Blockchain adoption as a crucial tool to data transparency, accountability and efficiency (K. Mark, Shrier, and Morgan, 2017). In Nigeria, the president of the Chartered Institute of Bankers of Nigeria (CIBN) stated.

> "A lot of issues that bother on transparency and accuracy of records, issues on honesty and sincerity in terms keeping records and open disclosure of what is happening in the oil and gas in Nigeria. Operators and regulators may not feel comfortable with the openness the

technology will introduce. But it will override the interest of an individual." *How the Blockchain Can Disrupt Nigeria's Oil And Gas Sector* (Willington, 2018)

Although, there is a lack of proven projects within the industry that utilise Blockchain technology in Nigeria, industry leaders and organisations continue to recommend exploring and adopting Blockchain technology in the Nigerian scenario where transparency, accountability and efficiency are reportedly lacking. The experts have called for frameworks that will enable Nigeria's oil and gas sector to benefit from the innovation, particularly the digital ledger system that could lead to an increasing database and trading efficiency, improving transparency and compliance, addressing cyber threats and even improving the supply chain through more seamless contract management *(The Guardian Nigeria News,* 2018). Another report stated that Blockchain would improve the NNPC's entire supply chain if adopted and used by all stakeholders (*Businessday NG*, no 2020). In 2019, a consortium of seven big companies came together to form a Blockchain project targeting the exploration of the potential within the energy sector. Some companies have a presence in Nigeria's upstream sector (*Oil International Organization*, 2019). It has indicated that Oil and Gas Blockchain Consortium is a significant step toward establishing essential Blockchain standards, frameworks and capabilities for the oil and gas industry that the Nigeria oil and gas industry can benefit from the full-scale benefits of the technology.

3.7 Summary

In summary, this chapter has presented a broader overview of Nigeria's oil and gas industry, highlighting the industry's nature with a focus on the unique structure of operations and supply chain across all sectors. The challenges facing the industry that can be viewed from the supply chain has also been discussed and identified the effect they have on the supply chain. Furthermore, the overview of the Nigeria Blockchain technology has given an understanding of the development of the technology in the Nigerian space. More specifically, the aspect of Blockchain within oil and gas has also been discussed. Finally, this section has set the scene by examining the context of the study and how that aligned with the overall aim of the research. The next chapter is the theoretical framework for the investigation, which outlines and discusses the theory and the justification for the choice of unified theory of acceptance and use of technology (UTAUT) to conduct the study.

4 The theoretical research framework

The previous chapter discussed the Nigerian oil and gas industry as the research context. This is significant as the gap identified in the literature review chapter was aligned to the context of the Nigerian oil and gas supply chain. This research investigates the perceptions of Blockchain technology adoption in the Nigeria's oil and gas supply chain. In order to conduct the investigation, the use of theory is an important aspect that allows the research to view the problem from the lens of the theory. Therefore, this chapter presents the theoretical framework. It starts with an overview of a theoretical framework, a discussion of the technology adoption theories and a comprehensive review of the UTAUT model. The chapter further reviewed the use of the UTAUT model to predict technology acceptance and use and the UTAUT model's applicability in Blockchain technology research. The chapter ends with a justification for the UTAUT model as the theory and unit of analysis for this thesis.

4.1 Theory in research

There is no definitive consensus on the definition of theory or an agreement on the borders and relationships between theories and a non-theory in any form of research (Mintzberg, 2017). There is no universal standard or strategy to determine the theory choice in the study due to the justification if a theory should be built or adopted (Eisenhardt and Graebner, 2007). However, Abend, (2008) stated the significance of theory and defined it as a general viewpoint from which one observes and interprets the world. Theories are concerned with how to view, comprehend, and portray the social reality; what can be recognised, what is worth knowing, what kind of questions may be enquired, what constitutes good evidence, who are we talking to, what the social world is comprised of, what attributes these things can have, how they fit together, and so on. Abend posited that a theoretical framework is determined by how it aligns with the "ontological and epistemological plurality" (Abend, 2008). Hence, the theory involves any theoretical construct, conceptual framework, analytical tool, experiential device, analytical framework, concept, and model.

The theoretical framework is the application of a theory, or set of concepts from an individual theory or many theories, to offer an explanation of an event or research problem (Imenda, 2017a). The theoretical framework functions as the blueprint for the entire knowledge investigation, with the supporting guide for the research relying on the theory (Imenda, 2017). The theoretical framework contributes to two purposes: demonstrating how the research fits into what is known; and, demonstrating how the research will benefit the wider school of thought around the research

field (Lederman and Lederman, 2017). Furthermore, a theoretical framework synthesises existing theories. It relates them to the concepts and empirical findings to develop a strong foundation for new theory development, also regarded as the unit of analysis. In this research, the theoretical framework is the baseline of the research that will help uncover the conduct and outcome of the research.

4.2 Technology adoption theories

The decision as to whether or not an individual would embrace a specific technology, and the period related to that decision, has long been a topic of research across different disciplines (Straub, 2009). Those decisions within information system research have received researchers' attention. However, the research areas continue to grow beyond the field of information systems to other related fields.

In order to identify the appropriate theoretical framework for this research, the theories identified that are relevant in the literature and the most widely used theories that support research in technology adoption were reviewed. In order to provide a requisite background and knowledge of these theories and the relevance they hold in the areas of technology adoption research. This covers a brief overview of the meaning of the individual theories, the constructs that formulated the theories and their applicability to the adoption of technology research and limitations.

Firstly, the Diffusion of Innovation (DIT) theory emerged from multiple conceptual and research practices over the last fifty years. DIT is an extensive social and psychological theory designed to predict how individuals make innovation adoption decisions by finding their adoption patterns and understanding its structure (Rogers, 1995). The theory was initially established as a foundation for conducting research on innovation acceptance and technology. Research on innovation diffusion synthesised more than 508 diffusion studies, which allowed the formulation of DIT for the adoption of innovation amongst individuals and originations (Miller, 2015). Rogers, (1995) stated that "diffusion of innovation theory is communication, or the process by which people develop and share information with each other to achieve common understanding". That means in diffusion theory, the communication process requires an innovation, an adopter (person or organisation) who knows and has utilised the innovation, and additional adopters who have not yet experienced it. DIT applications are considered to be relevant to research that extend beyond the field the innovation and information systems (Sonnenwald, Maglaughlin, and Whitton, 2001) such as programme evaluation (Willian and Lorilee, 2007).

Rogers' diffusion of innovations theory is appropriate for investigating technology adoption in a chosen environment (Medlin, 2001; Parisot, 1995), considering that diffusion research involves technological innovations. Moreover, to further the applicability of the theory to technology

innovation, Rogers (2003) consistently used the words technology and innovation synonymously, which supports the use of this theory to investigate technology adoption research (Aang *et al.*, 2019).

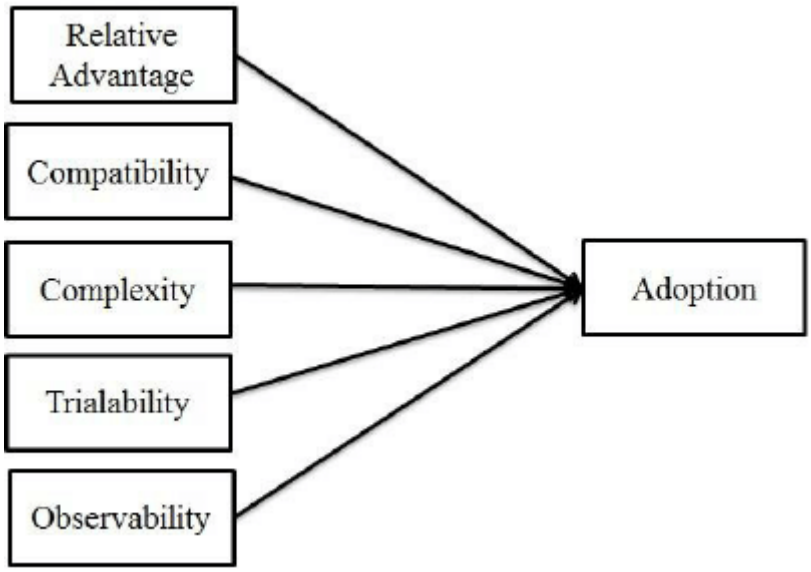

Figure 4-1 Diffusion of innovation theory

As illustrated in Figure 4-1 the proposed model by Rogers has the five stages in the innovation-decision process, which describe the different stages an individual or other decision-making unit must go through in adopting or rejecting an innovation (Rogers, 1995; Ahmad Wani and Wajid Ali, 2015):

- Relative advantage: if a user considers an invention more beneficial than the previous one, they will embrace it. The more beneficial a new idea, the faster it will spread. The extent of relative benefit is typically described by sub aspects (economic viability, low beginning expenses, decreased pain, social prestige, time and effort savings, immediate returns).
- Compatibility: it is how well an invention fits customer demands, attitudes, beliefs, ideas, and experiences. It helps explain and familiarise the new notion.
- Complexity: it is the extent to which innovation is perceived as relatively difficult to understand and use contrary to other qualities, this one slows innovation uptake. Simpler innovations are more widely adopted.
- Observability: it is how easy it is not only to see the results of an innovation but to ask the potential users about them. The faster a new idea spreads, the better a communication system can share the results of an innovation.

- Trialability: it is the extent an innovation gets tested before being adopted. This provides perspective to decide whether people accept an invention.

Despite the theory's contribution to the academic environment and practises, numerous scholars have discussed its limitations. The central argument here was that (Winter , 2003) stated that DIT theory is at best descriptive and does not allow for a detailed exploration of critical decisions that determine the acceptability of new technology and innovation. Some scholars have criticised DIT because it does not relate attitude to innovation adoption or rejection, and the selection process and innovation traits are also unclear (Kiwanuka, 2015). Contrary to popular belief, complex technologies do not always spread in a linear fashion. DIT dimensions may not be good predictors in a complex organisational context.

As a result, DIT has been criticised for having elements that are not applicable in a specific context outside of the theory's original context (MacVaugh and Schiavone, 2010). The limitations of the theory and its inability to predict the adoption of new technology, therefore this research focuses on the prediction of adoption of Blockchain technology in the oil and gas supply chain, hence, the shortcomings identified could be attributed to the theory not fitting within the research context.

Secondly, the Theory of Reasoned Action (TRA) has been designed to explain individual behaviours and how the behaviours affect certain actions. Fishbein and Ajzen (1975) proposed the model as representative of an individual’s behaviour intentions that subsequently determine actual behaviours. The individuals equally determine the behaviour intention attitude toward their behaviours and subjective norms in relation to the performance of their behaviours. The theory was built on the assumption that individuals are rational decision-makers, who constantly calculate and evaluate certain behaviours and beliefs in forming their attitude towards the behaviour. The relationship between intention and behaviour is determined by the measure of intention must correspond to the behavioural criterion in action, target, context, and time and intention does not alter before the behaviour is seen (Yousafzai, Foxall, and Pallister, 2010).

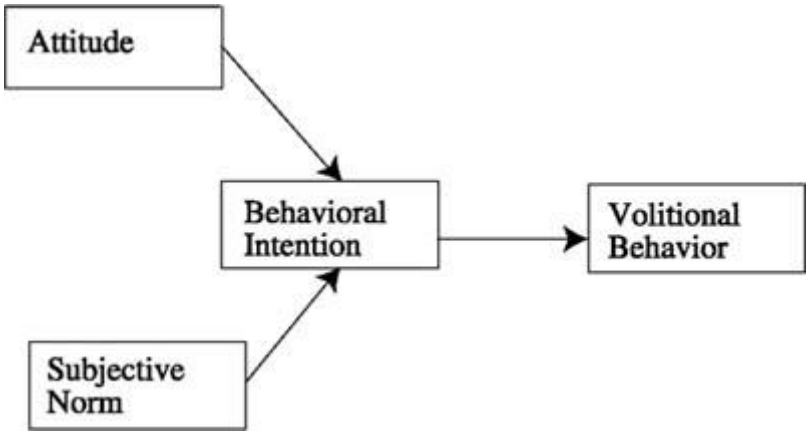

Figure 4-2 Theory of reasoned action

Figure 4-2 illustrated the constructs of the theory of reasoned action. For example, an individual's intention to perform a specific act with respect to a given stimulus object is as a result of the following (Fishbein and Ajzen 1975):

- Attitude - is the individuals belie about the consequences of performing a particular behaviour that is the probability that the behaviours will lead to some consequences.
- Subjective norm – the individual's evaluations of those beliefs that is the person's evaluation of multiple consequences.
- Behavioural intention - belief is what the person believes others think they should do in this situation.
- Volitional behaviour - the individual's motivation to comply with what others think should be done.

Although theory can be utilised to examine behaviours of an individual based on certain beliefs, particularly when it relates to decision making, the general criticism of the theory is that it is common and does not consider factors outside the individual's intention or attitude (Budd, 1987). For example, it does not consider certain circumstances that constrain the efficacy of the theory to explain certain scenarios like factors that will predict adoption of technology beyond individual's intention or beliefs but captures cross organisational considerations. In the case of this research, the theory of reasoned action could not be elaborated to capture the entirety of the aim and research context: the research context is particular to the Blockchain and supply chain and the oil and gas in a developing country. Investigating the adoption of Blockchain technology in the oil and gas supply chain requires the model that will predict the technology adoption across organisations and leading to the discovery of the reasons, influence and factors for the adoption.

Lastly, the Technology Acceptance Model (TAM); during the 1970s, there was a persistent growth of technology, along with an increase in failures of the adoption by the organisations. Researchers developed an interest in predicting system use and behaviours associated with the use of technologies, and built on the existing theory of reasoned action (Fishbein and Ajzen 1975). Chen, Li and Li, (2011) postulated that studies conducted over the subsequent period have failed to produce reliable measurements to explain system acceptance or rejection of technology (Davis, 1989). Technology Acceptance Model (TAM) posits that system use is a response that can be explained or predicted by the external stimulus of actual system features and capabilities.

TAM is a theoretical model for understanding and explaining usage behaviour in technology and systems development. It has been widely applied in the literature and empirically tested the effect of supply chain and technology. For example, the effect of technological turbulence and breadth on supply chain technology acceptance and adoption, extend TAM to incorporate the state of environment to the adoption (Autry, Grawe, Daugherty, and Richey, 2010). Unlike DIT and TRA, TAM's main purpose is to explain the decision for the acceptance of computers and later extended with the determinants of behaviours of acceptance of technology (Venkatesh and Davis, 2000).

TAM has received attention from the literature due to its applicability in different context to examine and analyse technology adoption (Y. Lee, Kozar, and Larsen, 2003). The constructs used within the model are considered to be of high significance in predicting its use and produced statistical accuracy of findings (Marangunić and Granić, 2015). TAM constructs determine the effect of external variables that helps develop perceived usefulness and perceived ease of use. Thus, the perceived usefulness and perceived ease of use of a technology helps develop attitude toward use and the eventually behavioural intention. There are two main constructs in the model.

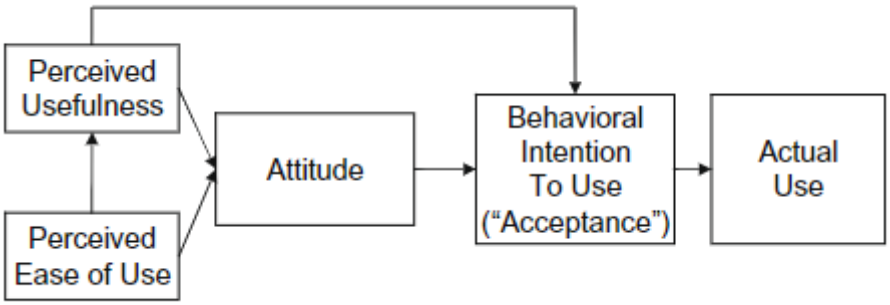

Figure 4-3 Technology acceptance model

Perceived Usefulness - this is the user's assessment of how much using the technology will enhance their ability to perform their job or simplify their lives.

Perceived Ease of Use - this refers to the user's perception of how easy it is to use a particular piece of technology and how little effort is required on their part to do so.

Users' attitudes towards using technology and their intention to do so are thought to be directly influenced by these two constructs. External influences can also affect a user's intention to use technology, including perceived behavioural control and subjective norms, which refer to the user's confidence in their ability to use the technology and the influence of others on their decision to do so, respectively. Therefore, the arrows pointing in the direction of the user's attitudes and behavioural intentions towards using the technology, which in turn influence actual technology adoption, a typical figure of the Technology Acceptance Model includes the two main constructs, perceived usefulness and perceived ease of use.

Based on TAM, the initial proposition by Davis in 1985 incorporated the user's motivation as a construct to explain the three factors of perceived ease of use, perceived usefulness and attitude toward using the systems (Chuttur, 2009a). TAM has evolved over the years and its included behavioural intention as a new variable directly influenced by the perceived usefulness of the system (Davis, Bagozzi and Warshwa 1989). Davis, et al. (1989) further suggested that in some instances, for a system that was perceived useful, an individual might form a behavioural intention to use it without any attitude formation.

Similarly, like other technology adoption models, TAM has limitations which are associated with its application and outcome, these have resulted in the extension to Technology Acceptance Model 2 (TAM2). One comprehensive analysis of TAM was the review of the model from over 700 citations (Venkatesh and Davis, 2000). A meta-analysis of 140 published articles on the TAM provided the basis for the assessment of its usefulness in conducting a technology adoption study.

Despite the increases in accuracy of the Technology Acceptance Model 2, the limitation of the original model, due to its inability to fit into an organisational context, is still considered as a weakness to evaluate technology adoption (Malatji, Eck and Zuva, 2020). TAM has implications when considering merging research areas because it fails to differentiate and evolve with practical and real-life applications (Ajibade, 2019).

Specifically, Tam model's emphasis on individual factors highlights its significant limitations, as it disregards the impact of external factors such as organisational culture, which would have significant impact in determining technology acceptance. The confined concentration on individual factors can make it challenging to comprehend the complexity of the technology adoption process within organisations just like the complexity of the oil and gas supply chain in Nigeria and the

multi-organisational level adoption of Blockchain technology. The assumption that perceived usefulness and perceived ease of use are the only factors that influence technology acceptance is deemed a limitation of the model (Ajibade, 2019). TAM's failure to account for negative effects of technology was perceived as a significant limitation, as it overlooks the potential downsides of technology adoption, which can lead to a skewed view of the overall impact of technology on the adopters (S. Singh, Sahni, and Kovid, 2020).

The research also examines the unified theory of acceptance and use of technology, which predicts and evaluates the acceptance and use of new technologies such as Blockchain technology. The model's ability to extend beyond the existing model's limited application demonstrates its utility for predicting the perception of new technology adoption, considering it most suitability to the research, the next section presents a review of the UTAUT.

4.2.1 Unified Theory of Acceptance and Use of Technology

The difficulty in determining and predicting an individual's behaviour has been a concern in technology adoption research (Venkatesh and Zhang, 2010). The techniques and theories that have been developed to explain patterns of technology adoption in a particular setting are well established. However the pace of emerging technology has an influence on the context particularly in relation to the perception about the advancement of a specific technology being considered to be disruptive to the existing ways of doing things (Kazancoglu and Aydin, 2018). Considering that technology adoption research is a widely utilised field of research that attracts much attention. The review of initial theories in Section 4.2, used with the academic community to understand the phenomenon of technology adoption, has set the scene to identify the best fit theory for this research. However, considering the limitation discussed in each theory has provided the basis of the inapplicability of the theories to conduct this research.

Venkatesh and Davis, (2000) provided a solution to the limitations of the various technology adoption theories in his study that extended TAM to TAM2 with combined multiple theories to come up with the Unified Theory of Acceptance and Use of Technology (UTAUT) as a new model to further the academic discussion on technology adoption. According to Venkatesh et al. (2003), the unified theory has four recognised constructs and progressively modifies effect, moderating constructs, and many other extensions. The UTAUT model was developed based on conceptual similarities among eight prominent models: the theory of reasoned action; the technology acceptance model, the motivational model; the theory of planned behaviour; the model combining the technology acceptance and the theory of planned behaviour; the model of PC utilisation; the

innovation diffusion theory; and, the social cognitive theory (Venkatesh, Thong, and Xu, 2016a) (J. M. Lee, Lee, and Rha, 2019). Figure 4-4 illustrates the components of the UTAUT model.

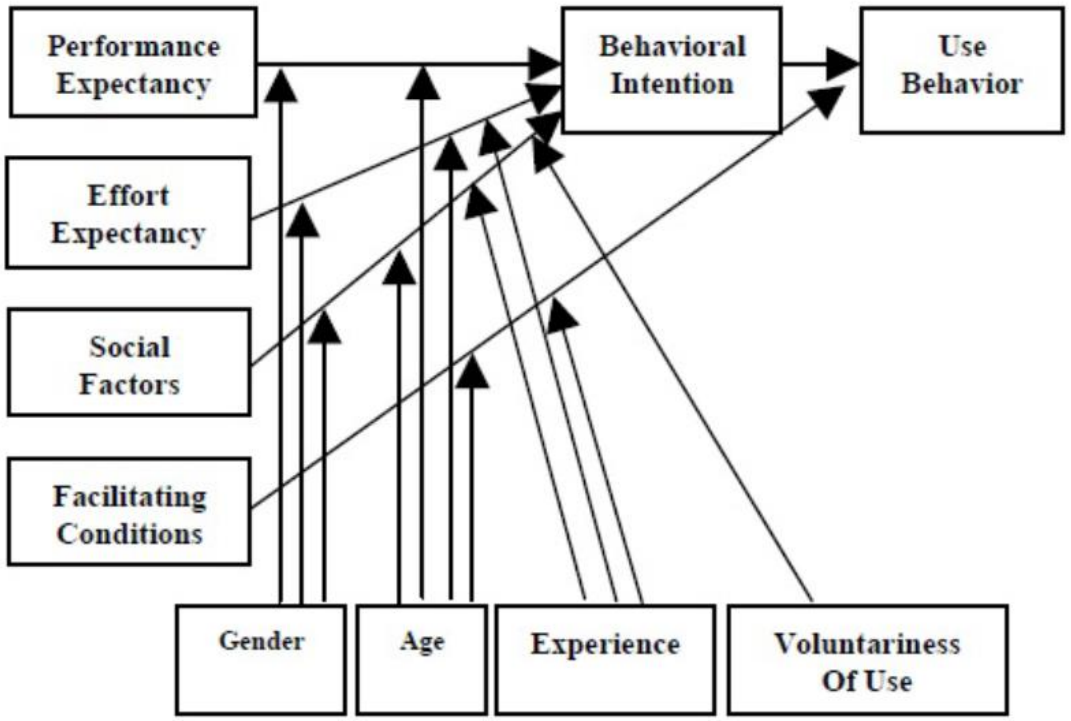

Figure 4-4 UTAUT Model and its constructs (Venkatesh and Davis, 2000).

(Venkatesh, Thong, and Xu, 2016b) stated that the unified model is a definitive model that consolidates what was known and advanced cumulative theory, while maintaining a simple structure. UTAUT has four constructs that are direct determinants of acceptance and use of any technology:

Performance Expectancy

Performance expectancy, as defined by Venkatesh and Davis, (2000), is the degree to which an individual has confidence in that using the technology will help accomplish gains in a job. Performance expectancy was interpreted as a critical constructs to predict the intention to accept technology. Studies have shown the effect of the performance expectancy on the intention to use the system in different technologies and systems (Al Mansoori, 2017). Performance expectancy was developed as a synthesis of the features extracted from the combinations of the following constructs (Rempel and Mellinger, 2015;Wong *et al.*, 2020b):

- Perceived usefulness was used in TAM and Tam2 based on the prospective user's subjectivity as a result of the probability of using a specific system that influences their job performance.

- Extrinsic motivation was used from the Motivational Model (MM) as the perception that a user of technology or system will perform and achieve their outcome due to the perception that it is instrumental in attaining value.
- Job fit was used from the Model of PC Utilisation (MPCU) as the extent to which an individual is satisfied that using a system can enhance their job performance.
- The relative advantage was used from the Innovation Diffusion Theory (IDT) and is the extent to which an innovation is regarded as better than the precursor.
- Outcome expectancy was used from the Social Cognitive Theory (SCT) and is the perceived likelihood of consequences as a result of using a system.

Effort Expectancy

Effort expectancy was defined by Venkatesh and Davis, (2000) as the degree of ease associated with the use of the system, and was derived as a factor from TAM's perceived ease of use. Any system or application perceived by an individual to be easy, has greater likelihood of being accepted. Performance expectancy and effort expectancy have proven to be influential factors in accepting and using new technology and system (Thongsri, Shen, Bao, and Alharbi, 2018). The effort expectancy was derived from the following constructs:

- Perceive ease of use was used from the Technology Acceptance Model, and it is the extent to which potential users expect the target system to be less of an effort.
- Complexity was used from the Innovation Diffusion Theory and the Model of PC Utilisation (MPCU) and is defined as the extent to which an innovation is perceived as relatively difficult to understand and use.
- Ease of Use was derived from the Innovation Diffusion Theory and is the extent to which an innovation is perceived as being easy to use.

Social Influence

According to Venkatesh and Davis, (2000), social influence is the extent to which an individual belief that significant others will influence their decision to use new technology. Therefore, social influence is considered similar to the construct of subjective norms in TAM2. As further clarified by Venkatesh and Davis, (2003), subjective norms significantly influences perceived usefulness via internalisation. This enables people to incorporate social influences on usefulness perceptions and the ability to use a system because it improves their job performance. It was also derived from the following theories:

- Subjective norm was used from the theory of reason action, TAM (2), and TPB. It is regarded as the individual's acceptance of the reference group's subjective cultures and

specific interpersonal agreements that the individual has made with others in a given situation.

- Image was used from the diffusion of innovation model and is regarded as the use of innovation to enhance one's image or status in one's social norms.
- Social factor was used from the Model of PC Utilisation (MPC) and regarded as the individual's internalisation of the reference group's subjective culture and specific relational agreements that an individual has made with others in a particular social condition.

Facilitating Condition

According to Venkatesh and Davis, (2000) facilitating condition is the extent to which an individual believes both technical and infrastructure exist within the organisation to support a system or application. Generally, this was regarded as similar to the mode of personal computer utilisation (Thompson et al. 1991). Technological, organisational, and environmental factors that enable the system and eliminate barriers can be put together under the facilitating condition. The facilitating condition construct is derived from the following:

- Perceived behavioural control was used from the Theory of Planned Behaviours (TPB), Decomposed Theory of Planned Behaviours (DTPB), and combined TAM and TPB. It is regarded as the individual's perception of the presence or absence of requisite resources and opportunities that are internal or external constraints to use a system.
- Compatibility was used from Innovation Diffusion Theory (IDT) and is regarded as the extent to which an innovation is perceived as coherent with the current values, needs, and past experiences of a potential system user.
- Facilitating condition was used from the Model of PC utilisation and is regarded as the factual factors in an environment that observes and makes an act easy to accomplish.

From the perspective of this research, the four constructs are considered to be relevant to investigating the adoption of Blockchain technology in the oil and gas supply chain, principally due to the appropriateness of the constructs to predict the behaviours of any technology acceptance and use (Queiroz et al., 2020a). This is evident from the wider applications of the model to test and examine technology adoption in different circumstances (Mustafa et al., 2022). It is therefore proposed that Blockchain technology acceptance and use can be investigated through the use of the above constructs as determining factors.

Behavioural Intention

Venkatesh and Davis, (2000) asserted that behavioural intention directly impacts an individual's actual use of technology and is a significant determinant of the actual usage behaviour. The behaviour intention here is presumed to be measured based on predicting behavioural intention. Behavioural intention is mainly dependent on performance expectancy, effort expectancy, and social influence, whilst facilitating condition directly affects the intention to use (Venkatesh et al., 2016b).

Moderators

The moderators of the UTAUT model are the demographic factors of age, gender and experience, and voluntariness of use, and are regarded as the capability to differentiate certain intention differences for the behaviours to adopt the technology. As a result, these are included as control variables that support the examination of the impact. For example, older people are thought to be less sensitive to social pressure (S. Singh et al., 2020). Additionally, greater knowledge and expertise with technology encourage users in forming their opinions and beliefs regarding the usage of technology. As a result, these factors may impact the findings when investigating the influence of antecedents of behavioural intention and actual use. According to Venkatesh et al. (2003), the impact of enabling factors is mitigated by the individual's age and experience. However, Lee, Lee and Rha, (2019) analysed the moderating effect and noted the significance of gender, age and experience and their impact on the decision to adopt technologies. For example, females were more likely to use technology based on their social networks than their male counterparts (Tsourela and Roumeliotis, 2015). However, others argued that there is no gender difference in technology acceptance, which has been demonstrated to be not statistically significant in many studies that predict new technologies (Lian and Yen, 2014).

Several studies insisted on the significance of moderating effects of the moderators (gender, age and experience), a meta-analysis by Dwivedi *et al.*, (2019) critically reviewed and presented a modified model of UTAUT that demonstrated that the original UTAUT moderators may not be applicable in all context, their submission was empirically validated (Möser, Moryson and Moeser, 2016; van Hoek, 2019). From the perspective of this research, the moderators of gender, age and experience may not be determinant of the adoption of Blockchain technology, as the lack of the usage of the technology is evident. Still, more importantly, the expectation of the research is not to test the model but as a guide that underpins the empirical investigation.

4.3 Predicting technology acceptance and use

Since its first publication by (Venkatesh and Davis, 2003), the UTAUT model has been integrated and used to increase its prediction capability in various scenarios. UTAUT extensions fall into four of the model's constructs as discussed in Section 4.2.1. The constructs were integrated with other theoretical models to study technology acceptance and use and related issues (Alrawashdeh, 2011). The UTAUT model have been frequently used and known to have good measurement characteristics and experience associated with users' perceived factors to use technology (Venkatesh et al., 2016b). However, the traditional technology adoption models, such as DIT and TAM, are limited in evidence for the prediction for adoption of an emerging technology such as Blockchain technology (Queiroz and Fosso Wamba, 2019). This is due to the adoption being primarily focussed on the usage of functional technologies and are incapable of completely explaining the complicated acceptance and use of new technology that has not been tested (Tran and Nguyen, 2020).

Despite the above shortcomings, the UTAUT model has been utilised to predict the acceptance of technologies like cloud, mobile systems and management information systems. For example, Hazen, Overstreet and Wang, (2015) have used the technology acceptance model to understand one's intention to adopt bicycle sharing programs. The research surveyed 421 participants and found positive direct relationships between all the constructs and intention. The outcome demonstrated the significant impact that value could have in adopting a system by potential users. Similarly, Magsamen-Conrad *et al.*, (2015) employed UTAUT to predict multi-generational tablet adoption practices through a survey of 899 participants, generating insights that effort expectancy and facilitating conduction are the constructs that only indicated the intention. They also posited that researchers must be careful when adopting the moderators as they do not affect assumptions on unused technologies. Further, Ikumoro and Jawad, (2019) utilised the same UTAUT model to identify the intention to use technologies like Chabot, artificial intelligence and virtual reality among small and medium enterprises. Even though a technology related organisation and environment framework was used, it was found that some parts of the UTAUT model studies had flaws. These flaws included perceived adoption costs, technology security, and the role of the top management as a key driver of technology adoption.

Emerging technologies like Financial Technology (FinTech) have benefited from the application of UTAUT to examine the adoption through the perspective of what drives the decision to use the services offered by FinTech. For example, Singh, Sahni and Kovid, (2020) conducted a study with an iterative discussion with experts using a survey, and found that perceived usefulness and social influence are the critical determinants of the behaviours to use FinTech services. However, the

findings confirmed that technological attributes and digital behaviours led to significant acceptance of using the benefits but are not the only factors determining the acceptance of the financial technologies. However, an interesting scenario revealed that manager's attitudes to adopt and use emerging technologies had been identified as lacking research; recent research proposed an integrated AI acceptance and avoidance model that enables the identification of both negative and positive factors using AI as the enabling technology (Cao, Duan, Edwards, and Dwivedi, 2021). The model developed was tested using a survey of 269 UK business managers, and revealed how attitude can be predicted through the UTAUT model by going beyond the functional technological capabilities.

With respect to the current research, the line of argument is the limitation of the use of the UTAUT model to predict acceptance and the use of technologies to only confirm the applicability of the constructs of UTAUT in predicting the use behaviour in a specific context (Magsamen-Conrad *et al.*, 2015; Tarhini *et al.*, 2016; Wang, 2018; Alabdullah *et al.*, 2020). The use of UTAUT to explore and predict the adoption, acceptance and use beyond the testing of the model was limited in the literature. Instead, few researchers have attempted to explore other factors beyond the construct and test the construct by integrating other presumed perceived factors (Balasubramanian *et al.*, 2015; Barrane, Karuranga and Poulin, 2018). For example, the UTAUT model was used to explore the consumer's purchasing intention with a focus group. This approach underpins price and habit as the major influential factors (Kazancoglu and Aydin, 2018).

Similarly, an approach was employed to explore factors outside the UTAUT model to understand the adoption of knowledge management system. The research found that organising structure, available time, time allocated, and incentives contribute to the acceptance of the knowledge management system. The findings were used to incorporate and validate and revise the UTAUT model (Isabelle and Sandrine, 2009). All of this has shown how the UTAUT model can be used in the literature. It has also shown how the researchers have mostly confirmed the effect of the UTAUT constructs and how te UTAUT can only be seen as a guide for future constructs of a technology adoption that has not been accepted because of things like context, geography, or even government policies.

4.4 Blockchain and the UTAUT model

The discussions in Section 4.2 provided the technology adoption models that may be applicable to the current research. However, the shortcomings of the models were discussed and acknowledged within Section 4.2. The UTAUT is most suitable for this research and herein reviewed from the context of the research focus, which is the application of Blockchain within the oil and gas supply

chain. This is aimed at elaborating how the model has previously been used in Blockchain and supply chain-related research, and the where the gaps in knowledge are.

Blockchain scholars have aligned with many technology adoption researchers on the importance of the UTAUT model as a strategic framework that provides a thorough description of the drivers of new technology adoption like Blockchain (Wong, *Tan, et al*, 2020b). Research in Blockchain technology utilised the UTAUT model to access the adoption, acceptance and use across finance, management, and supply chain management (Hughes, Park, Kietzmann, and Archer-Brown, 2019). For example, the fundamental goal of UTAUT is to forecast users' intentions to embrace and employ technology through understanding the behavioural intention to accept and use the technologies (see Queiroz and Fosso Wamba, 2019; Queiroz *et al.*, 2020a; Wong *et al.*, 2020a; Queiroz *et al.*, 2020b; and Handoko, Lantu and Ester, 2021). The use of UTAUT has crossed disciplines, boundaries and dimensions, i.e., supply chain, country and industries (see Queiroz and Wamba, 2019; Kamble et al., 2019; Venkatesh et al., 2003).

The reason for the analysis of literature on the UTAUT for Blockchain will help identify the applicability of the model and the impacts of the theory on Blockchain adoption research and the contributions of the research across the entire spectrum of technology adoption perspectives. Handoko, Lantu and Ester, (2021) conducted a study that was focused on quantitative analysis of the factors that make auditors want to adopt Blockchain using UTAUT 2. The study's contribution was primary data from administering questionnaires to selected auditors, followed by statistical data to test the hypothesis. Research by Alazab *et al.*, (2021) investigated the elements that either impede or facilitate Blockchain adoption in supply chains. The conceptual model combines UTAUT, Task-Technology Fit (TTF), and Information System Success (ISS) models, along with trust-based information technology innovation adoption constructs. The contribution used structural equation modelling that helped assess the factors affecting supply chain employees' willingness to adopt Blockchain.

Furthermore, (Liang, Kohli, Huang, and Li, 2021) have examined the factors that influence managerial intention to adopt Blockchain technology using the UTAUT model. The contribution was drawn from an empirical study of 242 managers, mostly in medical and financial industries, which tested the UTAUT model. Queiroz *et al*, (2020) investigated Blockchain technology adoption behaviours and the possible barriers in the Brazilian Operations and Supply Chain Management (OSCM) context through developing a model drawing on the UTAUT model. Using partial least squares structural equation modelling, the paper contributed by empirically testing the proposed model using a context of Brazilian operations and supply chain.

Another interesting perspective is the work of Park, (2020) who investigated the factors influencing the adoption of Blockchain technology in the logistics industry and to investigate the consequences of the identified factors in reciprocal to casual relationships. The research focused on the technological and organisational settings of TOE constructs and integrated them with the UTAUT paradigm, eliminating the "external task environmental context. Wong *et al*, (2020) investigated the behavioural intention to embrace Blockchain for supply chain management. The study adopted a framework that address how Performance Expectancy, Effort Expectancy, Facilitating Condition, Technology Readiness, Technology Affinity, and Trust can lead to technology adoption. The theoretical lens employed was the utilisation of the UTAUT on Blockchain adoption intention. The contribution was made by data obtained from 157 firms, which was examined using SPSS version 2 and the measurement's quality was tested.

Finally, Caldarelli *et al.*, (2020) investigated individuals' Blockchain adoption behaviour in an Italian context and collect perceptions from information systems practitioners and entrepreneurs using UTAUT. The contribution was the estimated model that used structural equation modelling and Partial Least Squares Estimation (PLS-SEM). While Wamba and Queiroz, (2019) explored the power of social influence by incorporating workers from Brazilian supply networks. The results demonstrated the predictive efficacy of social influence over other UTAUT characteristics. However, Queiroz and Fosso Wamba, (2019) investigated how to comprehend individual Blockchain adoption behaviour in the logistics and supply chain industries in India and the United States. The study focused on the increasing literature on Blockchain and supply chain and incorporated the technology acceptance model.

All of the listed studies use the UTAUT model as a framework to explain what factors affect how Blockchain technology is used. The UTAUT model proposes that a person's plan to use a technology is affected by four main factors: performance expectations, effort expectations, social influence, and enabling conditions. The studies are different in terms of what they look at and where they look at it. Some studies, for instance, look at auditors Handoko, (Lantu, and Ester, 2021), people who work in the supply chain (Alazab et al., 2021), managers (Liang et al., 2021), or people in certain industries or parts of the world (Handoko, Lantu, and Ester, 2021). Similarly, some studies also use other conceptual models, such as Task-Technology Fit (TTF) and Information System Success (ISS) models, trust-based information technology innovation adoption constructs, and TOE constructs. Some studies have used structural equation modelling (Queiroz *et al.*, 2009; Queiroz, Telles and Bonilla, 2019).

This research considers the discussion based on the evidence provided from the systematic review from the existing body of knowledge on the adoption of Blockchain technology using UTAUT.

The literature review has critically analysed the findings and found that there is the need for additional research across the adoption of technology and in a specific the context to garner more perceptions and build an approach to acceptance and use of the Blockchain technology in specific but also broader perspectives (Magsamen-Conrad et al., 2015). There is even a scholarly call by Queiroz and Fosso Wamba, (2019) based on their work on a proposed model for Blockchain adoption that voiced the urgent need to conduct more studies on Blockchain, and extend the research to many other countries around the world. This is an imperative approach to bridge the gap on the potential and identify the challenges and opportunities associated with its acceptance and use.

4.5 Justification for the theoretical framework

The utilisation of the UTAUT model was critically discussed, highlighting the limitations of other technology adoption models. The UTAUT model was reviewed and a summary of research that employed the model in Blockchain research was systematically reviewed, including their focus and contributions. The review and discussions have availed the gaps of such research and why other technology adoption theories and models are not as comprehensive as the UTAUT model. The theory has also been empirically validated and tested for the technology acceptance, and specifically for Blockchain technology research (Salem and Ali, 2019)

The use of UTAUT model was advocated to be the baseline for future research on the actual use of technology and the future anticipated use of the technology at individual and organisation levels (Venkatesh et al., 2016a). However, the impact of the novel context of the use of technology can be combined alongside the multiple dimensions of contextual elements that have not been addressed in earlier research such as location, organisation, and events. This could include organisational-level elements, such as work system interventions, that may encourage future-level adoption. In order to employ the UTAUT model as the theoretical lens for this research, it is essential to revisit the research focus of "investigating stakeholders' perception on the adoption of Blockchain technology within the oil and gas supply chain in Nigeria". The choice of UTAUT is that Blockchain is a new technology, it is in an early stage of adoption and use within non-financial sectors but has applications, it has been identified as having potential benefit to address some of the challenges within Nigerian oil and gas supply chain, but the level of acceptance and adoption within this industry remains unknown. The capability of UTAUT will help address the gap on the adoption of Blockchain in the Nigeria oil and gas industry.

The choice of application of the theory was motivated by the use of an empirical approach to investigate the perception of Blockchain technology in the oil and gas supply chain in the context

of Nigeria. The literature review found no evidence of research that considered Blockchain adoption in Nigeria's oil and gas supply to date. Evidently, the oil and gas supply chain in Nigeria is facing challenges associated to lack of transparency and accountability, revenue leakages, manual process, operational inefficiencies and subsidy regime. Despite these challenges, Blockchain has the potential to transform the industry and the way things are done.

From the theoretical standpoint, the application of the theory is intended to guide and explain the perceived factors at a multi-organisational level such as the players in the upstream, mid-stream and downstream for the acceptance and use of the technology. The complexity of the industry was discussed in Chapter 3, Section 3.2. These stakeholders' perception could be better understood through the lens of UTAUT model. This will be the first time, UTAUT were used to predict and interpret the outcome of Blockchain adoption factors at multi-organisational level in a complex industry, the benefit of multi-organisational level enable cross level analysis and corroborate findings that represent the views of the industry. Blockchain has huge potential for the oil and gas supply chain, particularly in developing countries where the challenges of supply chain (lack of transparency, efficiency, corruption, and many others) may be addressed with Blockchain technology. The use of the theory will add significant theoretical knowledge by identifying the factors and utilising UTAUT across the stakeholders described in Chapter 3 and as the level of analysis particularly how the perceived factors affect the adoption of Blockchain in the industry affect the adoption of the technology. The research found that UTAUT has the highest potential to explain compared to other relevant models and theories within the context of this research on adoption of Blockchain in the oil and gas supply chain.

4.6 Summary

This chapter has critically reviewed the theoretical framework and theory's importance in underpinning this research. It has also discussed the technology adoption model, of which the four major theories are discussed, and their limitations identified within the technology adoption theories. The choice of the UTAUT model was discussed in detail and the use of the UTAUT model to predict technology adoption was critically evaluated. The UTAUT model has been comprehensively used by researchers as a guide to predict technology acceptance and use. Many attempts centred on testing the efficacy of the theory, and modifications have been empirically evaluated and tested. Limited research utilises the model to predict unknown situations like that of the Blockchain technology acceptance and use as a guiding principle to uncover contextual cross-organisational factors that this research aims to empirically identify.

The chapter has also reviewed the application of the UTAUT model to the research in the Blockchain. Finally, it has justified the choice of UTAUT as the theory that underpins this research, and is considered as the theoretical model, and the unit of analysis for this research is based on the construct of the UTAUT model. The next chapter presents the methodology and methods adopted for the research.

5 Research methodology

This chapter presents the research methodology, method, and justification for selecting the appropriate method. The chapter begins with an overview of the research by stating the aim of the research and the question that the research intends to answer through the chosen methodology and method. The chapter discusses the research philosophy and presents the paradigm for the research; it further justifies the research approach and discusses and presents the research design. In addition, data collection, interview questions, interview protocol and the selection of interviewees and conducting the interview, and the method of data analysis are also presented and justified then the validation and research ethics are considered.

5.1 The research overview

Revisiting the overall research question provides an overview of the necessary approach and strategy required to answer it and achieve the overarching objective of the research. The research aims to: "investigate stakeholders' perception of the adoption of Blockchain technology within Nigeria's oil and gas supply chain". The two associated research questions are: "What are the stakeholders' perceptions of Blockchain adoption in the oil and gas supply chain?" and, "How does the perceptions affect Blockchain adoption in the oil and gas supply chain using the UTAUT model?"

The research questions have a pivotal role in determining an appropriate methodology and deciding the design and methods to be adopted to achieve the aim of the research. Furthermore, the selection of appropriate methods requires a review of the methodological approaches that help identify or provides an answer to similar questions. In this research, the philosophical assumption, research design, and the chosen methods' suitability are based on the established body of knowledge, and as adopted by similar research projects in the field (Edmondson and Mcmanus, 2007).

The concept of methodological fit, has deep roots in organisational research based on the state of prior knowledge as a critical determinant of the appropriate research methodology to conduct the study (Edmondson and Mcmanus, 2007). The state of prior knowledge is regarded as a key determinant for the selection of an appropriate research methodology (Dworkin et al., 2010).

5.2 Research philosophy

There is much importance to the understanding of the philosophical framework, as it provides a vital role in the way knowledge is interpreted and perceived (Crossan, 2003). Saunders (2015) defined the research philosophy as a set of beliefs and assumptions regarding the evolution of

knowledge. The research philosophy has been defined as "a movable collection of logically related assumptions, concepts, or propositions that orient thought and knowledge" (Leitch, Hill, and Harrison, 2009). It has also defined as the patterns of ideas and practises that regulate research within a discipline by providing lenses, frameworks, and processes by which the study may be performed (Weaver and Olson, 2006). The philosophical framework is a fundamental step for the researcher in identifying the appropriate research methodology.

The choice of an appropriate research paradigm can be a difficult process, it requires various assessments that inform the researcher why and how that informs the decision for the selection. There are numerous philosophical research paradigms, including positivist, interpretivist, transformative, and pragmatist approaches (Singh, 2019). However, the most widely recognised research philosophical paradigms in social and management perspective are the positivist and interpretivist paradigms (Weaver and Olson, 2006). The selection of an appropriate philosophical stance depends upon the research intent and impetus and prospect of that determines the research line of judgements (Bryman, 2007). Defining the research context allows the researcher to investigate and select the ontological views, epistemological positions, and methods that guide data collection and interpretation (Bracker, 2010). Social science and management researchers are often divided in relation to the appropriate philosophical paradigm to use, as positivism and interpretivism are the most common paradigm used in qualitative research (Symon and Gillian, 2012). According to Scotland, (2012) and Mark *et al.*, (2015) the term positivism refers to the philosophical position of natural scientists who deal with observable reality in society, resulting in the formation of generalisations. Positivism relates to the significance of what is offered in general, with a stricter emphasis on considering pure data and facts without being impacted by human interpretations or bias. However, interpretivism arose from a subjective critique of positivism. Interpretivism is more concerned with in-depth variables and aspects associated to a context; it regards humans as distinct from physical phenomena in that they provide greater depth in meanings on the belief that human beings cannot be investigated in the same manner that physical phenomena were studied (Mark *et al.*, 2015). Table 5-1 compares these paradigms in order to align with the appropriate philosophical stance of this research.

Table 5-1 Comparison between positivist and Interpretivist paradigms (Holden and Lynch, 2006)

	Positivism	Interpretivism
Independence	The observer is regarded as independent from what is being observed.	The observer is considered to be interacting with what is being observed.
Value-freedom/value-laden	The study and how to study are determined by choice of the objective criteria instead of the human beliefs and interests.	The study's interests, beliefs, skills, and values determine what to study and how to study.

	Positivism	Interpretivism
Causality/No causality	The causal explanations and fundamental laws enable the explanation of regularities in human social sciences.	The goal is to understand a situation in social sciences.
Hypothetico-deductive/No hypothetico-deductive reasoning	Science is a process that proceeds through hypothesising the fundamental laws and deducing the kind of observations that demonstrate the truth or falsehood of the hypotheses.	Evidence develops ideas and simultaneous mutual shape of the factors.
Operationalisation	Facts are measured quantitatively through statistical designs and categories and isolated from the study; these concepts operationalised the facts.	This uses small samples to investigate in-depth or qualitatively and identify emerging design categories that are identified during the study process.
Reductionism	To understand a problem, it should be reduced to the simplest possible elements.	To understand a problem, it has to be looked at in the totality of the situation.
Generalisation	To generalise social behaviour, a sufficient size has to be selected. This leads to prediction, explanation and understanding.	Context is everything, the patterns identified theories for developing and understanding.
Research language	It is based on formal settings, the definitions, and an impersonal voice through the accepted quantitative wordings.	It is based on informal settings derived by evolving decisions and personal voices that are based on qualitative works.

Another perspective to address the problems of an informed choice of the research paradigm is to view from the ontological assumption, that is the way the researcher defines the reality and truth, and the epistemological assumption, which is the process in which the researcher comes to know the reality and the truth (Goertz and Mahoney, 2012a). Therefore, for the purpose of this research, the ontology and epistemology will be reviewed and discussed to address the philosophical paradigm for the research.

Ontology

Ontology is the study of 'being' and is concerned with 'what is,' such as the nature of existence and the structure of reality or what is known about the universe (Corlett, 2013). The term ontology refers to dealing with the presence and connection of many parts of society, such as social actors, cultural norms, and social structures; as such, the ontological issues are concerned with the types of entities that exist inside the society (Richards, 2003; Bracker Sean, 2010). Rachel, (2014) asserted that ontology is concerned with "whether or not there is a social reality that exists independently of human conceptions and interpretations, and closely related to this, whether or not there is a shared social reality or only multiple, context-specific". Therefore, ontology involves the way we view the nature of reality and the social environment as to how they exist. For the positivist, they assume that the reality is offered objectively and is quantifiable based on properties that are only independent of the instruments and the

investigator. In this type of belief, only people's statements or perceptions are right or wrong (Bracken, 2010). In contrast, the interpretivist assumes that knowledge and meaning are the act of interpretation. This subjects human behaviour by meaning instead of measurements (Goertz and Mahoney, 2012b).

Epistemology

Epistemology implies the assumptions we make about the type or character of knowledge or how we may learn about the world, it involves the diversity of the way we enquire into the nature of social and physical worlds (Snape and Spencer 2010; Rachel, 2014). According to Scotland, (2012) epistemology is a means of looking at the world and making sense of it. It entails knowledge and, by definition, a particular comprehension of what that knowledge implies. Singh, (2019) explains that epistemology is an issue with what is (or should be) recognised as acceptable knowledge in a field based on different perspectives on how natural and social worlds should be assessed. Hence, epistemology is concerned with the "nature" of knowledge, its possibility, what knowledge is feasible and may be pursued, and what is not, its extent, and validity. Positivists viewed epistemology as the goal of science is to develop the most objective approaches that possibly attain the closest approximation of reality. Hence, the use of variables interacts, causes outcomes and shapes events in quantitative terms (Moon and Blackman, 2014). At the same time, the interpretivist emphasises understanding the world through quotations of an actual conversation from an insider's point of view through first-hand belief or experience and honest reporting mechanism (Dev Singh, 2015).

As discussed above, the choice of the philosophical stance is based on the established body of knowledge and previous applicability within the field of research. As such, while reflecting on the ontological and epistemological assumptions, it is concluded that the interpretivist paradigm offers relevance to the investigative approach and context of this research. The context of the research is to investigate the perceptions of adoption of Blockchain technology in the Nigerian oil and gas industry. Therefore, the research of this nature requires the use of small samples to investigate in-depth and qualitatively to identify emerging categories that are identified during the process that will help understand the phenomenon. Thus, interpretivist offers the opportunity for the observer to interact with what is being observed and understand the situation in social sciences. For example, Mark et al., (2015) posited that interpretivist researchers in supply chain research, focussing on multiple organisations should be interpreted based on their experiences of different realities, as they form part of the decision making process across the supply chain.

This research adopts the interpretivist paradigm to interpret the views of the stakeholders in the Nigerian oil and gas industry on the adoption of Blockchain technology in the supply chain. This is believed to be the most appropriate philosophical stance that can help provide an outcome to the social reality through the meaning of what people produce and their actions. Wang et al. have previously used an

interpretivist approach in supply chain and Blockchain research (Wang et al., 2019) to qualitatively and explore how Blockchain technology may be used to transform the supply chain.

5.3 Qualitative research approach

The chosen philosophical stance provides the foundation for what the approach for the research should be Mark et al. (2015) stated that the research philosophy is vital in identifying an appropriate approach that is relevant to the research's objectives. According to Teherani *et al.*, (2015) the use of a qualitative research approach is based on the systematic investigation of social processes in natural settings. Teherani *et al.*, (2015) and Alase, (2017) revealed that qualitative inquiry involves people experience of the elements of their life, how individuals and groups behave, how organisations work, or how interactions shape relationships. This approach benefits researchers in their capacity to analyse and develop their research investigations that utilise their interpersonal and subjective abilities through a qualitative methodology (Alase, 2017).

However, when selecting the appropriate research approach, Ellram, (1996) described an approach to selecting either a qualitative and quantitative methodology, and provided the objectivity of selecting exploration, explanation, description, prediction as the determined centred on the research question e.g. why, how, who and where etc. The research aims to investigate the adoption of Blockchain technology in the Nigerian oil and gas supply chain. The primary question of this investigates is through the question of why, what, and how events take place throughout the course of the research around the stakeholders perception. This type of approach is based on a fundamentally distinct set of beliefs or perspectives, in that the general belief that no one reality exists; instead, participants' perceptions of reality are elicited through the researcher's study methods (Teherani et al., 2015). However, the choice of the right approach could be subject to bias. Furthermore, in the case of how the bias was tackled is through analysing the qualitative research's strengths and limitations, as shown in Table 5-2.

Table 5-2 Strengths and limitations of the qualitative approach (Anderson, 2010)

Strengths	Limitations
• Offers a detailed and in-depth examination of issues. • The use of interviews is not restricted to specific questions. It can be guided and redirected by the researcher in real-time. • The information available can be revised based on themes and direction as they emerge. • It offers more compelling data based on human experience than in quantitatively based sampling. • Findings are not meant to be generalised since the data are collected from a relatively small number of	• The quality of research depends on the researcher's skills and ability and is more easily influenced by the researcher's personal biases. • It has a time-consuming process to achieve rigor because it requires maintaining, assessing, and demonstrating. • Data analysis is typically time-consuming on account of the volume of data. • It sometimes difficult to be understood and accepted, particularly in a quantitative setting. • It is difficult and time-consuming to characterise in a visual way.

Strengths	Limitations
cases or individuals, but it has a strong basis to be transferred to other contexts.	

To address the limitations in the research process, the research used a variety of strategies. These included using thematic analysis to address personal biases, member checking, and a variety of analytical and reporting tools. The research used well-established qualitative research techniques, a thorough literature review, a sequential analysis process, and documentation of the research process to achieve rigour. The research used the qualitative data analysis tool, NVivo, performed a preliminary analysis, and broke down the laborious data analysis into manageable stages. The research presented the findings in a narrative format, used direct quotes from participants, and used clear, concise language to make sure the research was understood and accepted.

The significant strength of qualitative research is that it provides insights to the emotional and sensory phenomena that can help researchers comprehend the viewpoints of the people they are studying (Mills et al., 2005). Therefore, considering the strengths and the focus of this research, qualitative methods suitable to the nature of the questions that this research seek to answer. Further, another significant justification of the choice of qualitative approach is on inductive and deductive reasoning. Inductive reasoning is about observing individual cases and then trying to make generalisations about the phenomenon at hand (Hyde, 2000). The deductive approach is based on testing a theory with a preliminary theory based on preconceived ideas to form a hypothesis (Azungah, 2018). These two reasoning approaches can be combined to drive a particular research outcome. UTAUT is regarded as the theoretical framework of the research as presented in Chapter 4, the model will help the researcher to view the stakeholders' perception of the adoption of Blockchain technology. Furthermore, the focus of the research on exploring the perceived factors for the adoption of Blockchain technology from the view of the research participants could be regarded as a deductive approach (Johnson-Laird, 2003).

From the perspective of this research, a qualitative approach the most suitable based on the outlined principle of qualitative research. UTAUT model has been widely utilised in a quantitative approach to test the effect of the model on acceptance and use of the technology. However, some studies have previously adopted a qualitative approach in UTAUT induced research (see Alqahtani, Al-Badi and Mayhew, 2014; Knoblock-Hahn and LeRouge, 2014; Rempel and Mellinger, 2015). Therefore, the researcher adopted qualitative research as the most appropriate for the research investigation based on the research, the philosophical stance, the nature of question being asked and the nature of the research been an exploratory research seeking to know what and how.

Wong *et al.*, (2020) demonstrated the applicability of the UTAUT model to predict Blockchain adoption in the supply chain with firms empirically; the approach eliminated the social influence construct of the UTAUT model and introduced the capabilities of Blockchain that include technology readiness, technology affinity and trust. However, the findings suggested the inability of the UTAUT model to predict the adoption of immature technology. Their findings were among the reasons why a different approach is needed to predict and explore the stakeholder's perception of adopting immature Blockchain technology. In addition, the qualitative approach in this research involved the systematic engagement, collection, organisation and interpretation of views of the participants in the Nigerian oil and gas industry on the adoption of Blockchain technology on the supply chain.

5.3.1 Research design

In every research project, the research design serves as an architectural blueprint by ensuring that all research questions and objectives will be addressed through a particular process and provides a basis for repeatability (Rog, 2009). The implementation of a set process determines its credibility, utility, and feasibility (Rog, 2009). According to Creswell *et al.*, (2016), the research design is the process that a researcher adopts to conduct an inquiry. In this research, the strategy to achieve the research aim is to answer the research questions. The research seeks to answer the question relating to the stakeholder's perceptions of the adoption of Blockchain technology and requires exploratory research because it seeks to explore the stakeholders' perception based on the premise that no research has been conducted to address the gaps in this research.

Blockchain adoption and use is still in its infancy; it is poorly understood, in spite of the potential it offers (Francisco and Swanson, 2018). As a result, examining and studying the adoption of Blockchain could be debated in the relevant disciplines. Most of the arguments in Blockchain adoption require an innovative approach to create a unique knowledge that will explore the technology adoption drivers beyond the current ecosystem behaviour (Queiroz and Fosso Wamba, 2019). Therefore, the question set in this research can only be answered through a qualitative exploratory research process because the focus is on getting insights into how the stakeholders perceive the adoption of Blockchain technology (Stebbins, 2000). Therefore, this type of knowledge can only be obtained through qualitative and exploratory research (Edmondson and Mcmanus, 2007). In relation to the process of qualitative research, the process involves designing the mode of data collection, identification of the research participants, contracting the participants, conducting the data collection, and analysing the data. In qualitative research there are critical factors in selecting the appropriate participant for the research, this involves the recruitment

technique followed to identify and engage with the participants. Thus, the researcher presents the process in the qualitative research followed as illustrated in Figure 5-1 below.

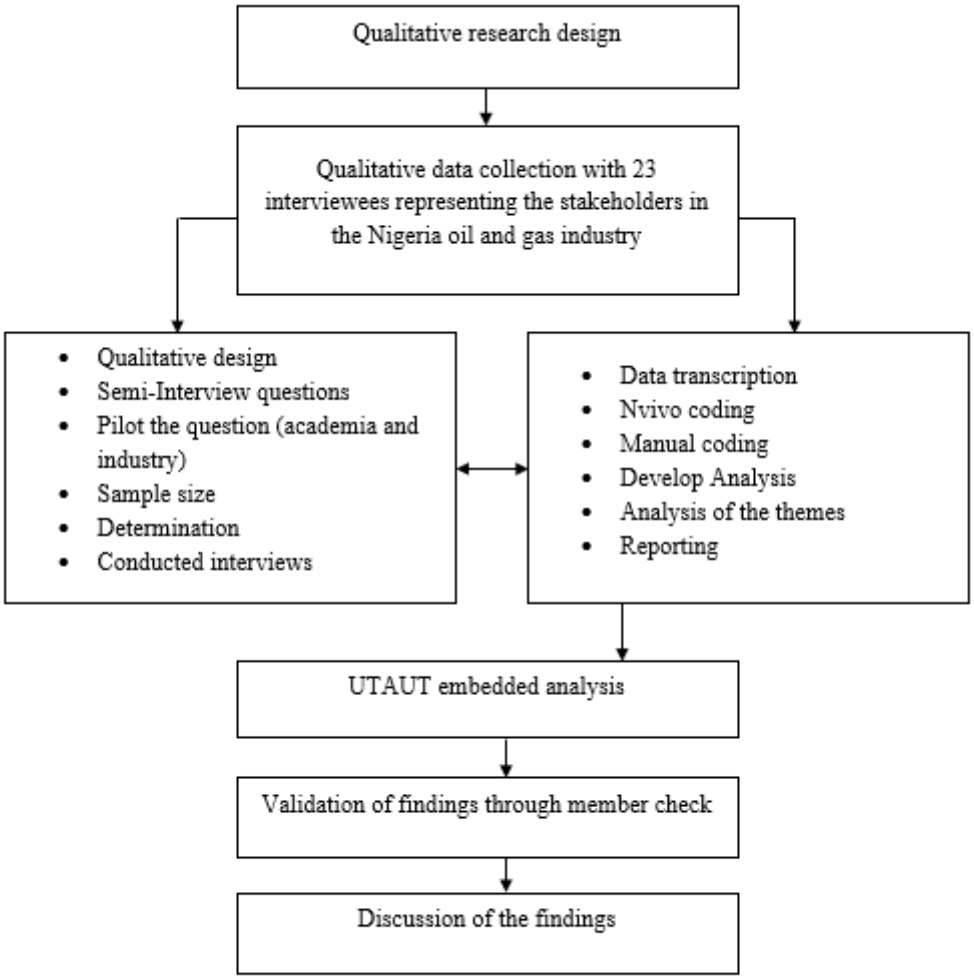

Figure 5-1 Research process

By focusing on the experiences and viewpoints of individuals being studied, qualitative research provides a means of illuminating their subjective meaning, behaviours, and context through the stakeholders in Nigeria's oil and gas industry as the subject of the research investigation. The first stage within Figure 5-1 relates to defining the research questions that were developed based upon the systematic literature review after identifying the gap in the literature. Followed by the qualitative data approach focusing on the participants from twenty-three different organisations within the Nigerian oil and gas industry (the sampling technique will discuss in detail how they emerged and the selection process). The structure of the research process follows, and here the interview questions, piloting question and sample size were decided, and the design of the interview process are presented. The next step involved the transcription, coding and analysis of the data

collected. Upon the review of the themes and the presentation of the outcome, the validation followed. Finally, the process ends with presenting the UTAUT embedded outcome of the analysis and discussion of the result (presented in the next chapter).

5.3.2 Data collection technique

Qualitative research has many data collection forms, such as participant observation, document review, focus groups and interviews (Barrett and Twycross, 2018). Qualitative research gains a deeper understanding of interviewees' perspectives, which necessitates comprehensive, in-depth, and nuanced data to uncover meaningful patterns and trends (Barrett and Twycross, 2018). There are different methods of qualitative data collection:

Interview : is a form of collecting data from participants where the people who are part of the study talk to the interviewer and provide information (Law, Stewart and Letts, 1998; Letts 2007). The interviewer can also take note of how the person acts without saying anything. Interviews put more of an emphasis on listening to people and going where they want to go. Several open-ended questions are asked to get the information that is needed in the time that is available. Interviews are important when you want to learn more about a certain topic. Interviews tend to be cheaper and can be done in a short amount of time, online or in person. One of the greatest challenges with interviews, relates to how the questions asked affect how the research participants answer, and the interviewer should take this into account (Arsel, 2017).

Focus groups: Focus groups are formal interviews using a group of individuals about a topic. The emphasis is to employ open-ended questions and focus on listening and learning from participants, just like individual interviews (Law, Stewart and Letts, 1998; Letts 2007). Focus groups are effective for gathering multiple opinions on a topic. Group members can build on each other's ideas for deeper conversations. Researchers can monitor group interactions. Focus groups can limit people's replies. Focus groups must accommodate both shy and outgoing people. To succeed, the focus group facilitator must know group procedure and interviews (Law, Stewart and Letts, 1998; Letts 2007).

Document review: Qualitative data collecting entails analysing prior experiences (Law, Stewart and Letts, 1998; Letts 2007). Document review uses flexible methods to investigate how previous events and intents were associated owing to their value and meaning (Law, Stewart and Letts, 1998; Letts 2007). Document reviews can provide information that is difficult to obtain through interviews or focus groups, especially when people are unwilling to communicate (Bryman, 2008).

In addition to conducting interviews and focus group, the researcher used observation in order to increase the collected data that is associated to the reactions of the interviewees. As the goal is to

"listen" to or learn from participants about the issue, some researchers consider open-ended surveys and questionnaires qualitative approaches. However, these are restricted and frequently restrain participants. An in-depth interview is different from answering one open-ended question at the end of a survey. The use of interviews is the most popular technique to collect data in qualitative research because of its ability to gather in depth data, connecting with the interviewees and the detail exploration without interference of other interview in the case of focus group (Rachel Ormston, 2014). Table 5-3 below outlined the strengths and weakness of qualitative data collection methods.

Table 5-3 Strengths and weaknesses of qualitative data collection methods (Bryman 2008).

Data collection methods	Pros	Cons
Interviews	Allows participants to express their own ideas. Allows interviewer to be responsive to individual differences and situational circumstances.	Minimal control over the order in which the topics are covered. Usually, the small sample size limited due to cost and time.
Focus group	Allows organised discussion structured in a flexible way. Provides an opportunity for all to participate and give their opinions. Dominant and submissive participants can be directed and controlled. The discussion generated between participants. A large quantity of information was collected in a short amount of time.	The researcher has less control over the flow of discussion. Facilitating focus group interviews requires considerable skill. Difficult to distinguish between individual view and group view. More difficult to organise.
Observation	Allows researcher immersion and prolonged involvement with participants. Encourages free and open conversation with the participants.	Altered behaviours of observed groups by the presence of the researcher. Takes time to build trust with participants.
Detached observation	Reveals descriptions of behaviours by stepping outside the group. Allows identification of recurring patterns of behaviours that participants may be unable to recognise or reveal themselves.	Potential researcher bias in the design of a study. Sources or participants may not be equally credible. Analysis of observation can be biased.

Interviews were considered as the method of data collection for the research, therefore, the use of the following techniques were employed to overcome the shortcomings of using interviews as a data collection method. In order to maintain consistency while allowing for flexibility, the research used a semi-structured interview guide, which helped to reduce the restriction of having little control over the order in which the questions were covered. In order to increase the sample size and

address the issue of small sample size limited by cost and time, and also used purposeful sampling and methods like snowball sampling and until when saturation was achieved.

In order to achieve the ultimate goal of the research and have comprehensive and in-depth data to uncover the meanings and patterns of trends in the perception of the adoption of Blockchain, an interview was utilised as the method of data collection.

For the research that seeks to investigate the perceptions of stakeholders on the adoption of Blockchain technology, data were gathered through interviews, the decision to use interviews as a way to gather information is based on three main things. First, they can be used to find out what research participants think and feel about sensitive and complicated issues like the industries supply chain and the adoption of Blockchain technology. They can also be used to find out more information and make answers clearer. Second, they give researchers the freedom to look into themes that research participants did not expect to be important. Third, at the end of the interview, it allows the interviewees to add more details to anything they feel at the end of the interview and that provides further insights to the research.

Based on the above, the selection of interview allows the interviewees to express their views about the Blockchain technology adoption and enable the researcher to engage the participants while differentiating views to get in-depth knowledge (Chekhovskiy and Chekhovskiy, 2009). Also, in exploratory and interpretive research, interview data were collected from sources directly related to individuals who have had the experiences under investigation, i.e. targeted participants from the Nigerian oil and gas industry (Creswell, 1998:54; Stebbins, 2000). Qualitative research projects utilise interviews as a means of data gathering, and when it comes to acquiring in-depth information about a specific occurrence, interviews are the most direct and straightforward method of data collection instead of observations and surveys (Barrett and Twycross, 2018).

An interview may be classified into structured, semi-structured, and unstructured (Fossey, Harvey, McDermott, and Davidson, 2002). Structured, semi-structured, and unstructured interviews are all ways to collect information from interviewees in qualitative research. The main difference is the level of structure in the way they are done. Therefore, it is important to discuss them below:

- Structured interviews are the most rigid, it focuses on asking questions in a particular order. Most of the time, these interviews are part of large-scale research projects that want to get data that can be compared across participants. They are also helpful when a researcher wants to compare how different groups answered the responses to the question strictly (DiCicco-Bloom and Crabtree, 2006).

- The semi-structured interviews, it is a form of interview that is less rigid than structured interviews, but the interviewer will still ask a set list of questions. But based on how the participant answers, the interviewer can also ask follow-up questions or try to get more information. This kind of interview is good when the researcher wants to learn more about the person being interviewed and exploring new perspectives (Houghton, Casey, Shaw, and Murphy, 2013).
- Unstructured interviews are interviews that do not have a set of list of questions, so the person conducting the interview can ask anything they think is important to the research (Barrett and Twycross, 2018). The interviewer could also follow up on any interesting ideas that come up during the conversation.

Each of the three distinct kinds of interviews has its own strengths and weaknesses. Structured interviews are useful for gathering data that can be compared, but they may not allow for a deep dive into the experiences of the interviewees. Even though semi-structured interviews allow for more in-depth information, they may still be limited by a list of questions that have already been decided. Unstructured interviews give you the most freedom, but the data you get from them may be harder to analyse.

Semi-structured interviews provide the required degree of flexibility to approach the interviewees with pre-existing knowledge of the research area, having conducted a systematic literature review and the UTAUT theoretical framework that underpins the investigation. The semi-structured interview gives the opportunity for in-depth responses and getting to know more about the discussion by additional follow up question, this provided rich data that will translate to answering the research question beyond the intended question only as it was in the case of structured interviews.

Therefore, semi-structured interviews are often regarded as a good option for qualitative research aimed at examining perceptions because they provide a balance of structure and flexibility (Alqahtani et al., 2014). The fact that semi-structured interviews use a predetermined list of questions, the researcher can ensure that each participant is asked the same questions, which is useful for comparing responses from different participants. As a result, the researcher can discover patterns and themes in the data that would not have been apparent if the questions had been left to their own plans. Another justification is that semi-structured interviews are adaptable, the interviewer tailor questions based on the interviewee's responses and elicit additional information where needed. Because the interviewees may have different perspectives and opinions of the research, this can be particularly useful in research aimed at examining perceptions. Semi-structured interviews can provide the interviewer with a more in-depth understanding of the interviewees' perceptions by allowing them to discuss these differences in greater detail than expected in order methods. This research believes that semi-structured interviews allow the researcher to collect rich and detailed data that is more in-depth than structured interviews. Therefore, the research

adopted semi-structured interviews as an effective method for this qualitative research that investigate perceptions since they strike a balance between structure and unstructured, allowing the researcher to collect comparable data while also allowing in-depth exploration of interviewees' perspectives and opinions.

5.3.3 Interview question design

The design of the interview questions is a critical step in the research methodology process that necessitates consideration in relation to what to ask and how to ask it (Rubin and Bellamy, 2012). The structure of the interview questions is determined by the researcher's subject area expertise and past knowledge (Satherley, 2009). For example, a lack of familiarity with the issue under investigation, may result with the negative consequence of the interview questions becoming overly broad and lacking the focus to gather the required data. The interview questions may initially be broad and then become more specific as the researcher learns more about the area of interest. In developing a research question, the following are recommended (Rubin and Bellamy, 2012):

- Outline the study's major research questions and the broad areas of knowledge that are relevant to answering these questions.
- Create questions within each of these major areas, tailoring them to specific types of respondents. The goal here is to tap into their experiences and expertise.
- Tailor the interview language to the respondent (industry, context, profession, etc.).
- Craft questions so that respondents are motivated to respond completely and honestly.
- Ask "how" questions rather than "why" questions to elicit process stories rather than acceptable "accounts" of behaviour.
- Create probes to elicit more detailed and elaborate responses to key questions. The more specific, the better.
- Begin the interview with a "warm-up" question—something that the respondent can easily and briefly answer (though not too long). It doesn't have to be directly related to what you're trying to find out (though it could), but this initial rapport-building will put you at ease with one another and thus make the rest of the interview flow more smoothly.
- Consider the interview's logical flow. What topics should come first? What happens "naturally" after that? After a few interviews, this may require some adjusting.
- Difficult or potentially embarrassing questions should be asked near the end of the interview, after rapport has been established.
- The final question should provide some closure to the interview and leave the respondent feeling empowered, heard, or otherwise grateful that they spoke with you.

Table 5-4 and Table 5-5 provides the preliminary and main interview questions, rationale and justification for the questions considered for this research. The research follows the recommendation of Roberts, (2020) as posited that the initial interview question should be immediately and closely related to the research issue, as in "Tell me about your experience..." Then, interview tactics can be employed to keep the interviewee talking, and to dig further into what is being expressed. Potential follow-up questions and probes can be prepared and used to assist the researcher in obtaining a detailed and complete description of the insights.

Table 5-4 Preliminary interview questions

Question	Rationale
Tell me about your job role and responsibility in this organisation?	The rationale for this question is to identify the stakeholders with the relevant area of competency to discuss Blockchain and supply chain adoption.
What part of the supply chain stream of the oil industry does your organisation operate?	The rationale for the question is to enable cross-sectional analysis of data among the three streams, upstream, midstream and upstream, this will help in validating the data and aim to address the whole spectrum of the industry as the research desires.
How long have you been working in the industry?	It is expected that experience may play an in influencing the accuracy of the results, therefore, the rationale of this question is the more experienced a response is, the more in-depth knowledge can be gained; hence the question will help analyse interviewees' feedback based on the number of years of industrial experience.

Table 5-5 lists the main interview questions that are guided by the literature. Rubin and Bellamy, (2012) provided guidance when creating interview questions that uses a strategy of dividing the topic down into its essential components. Then, create one question to address each section, and ask the interviewee to provide several examples in order to obtain a rich account of the event, experience, or phenomena. At the same time, utilising follow-up questions to get more information. These above points were considered in designing the interview questions to gather the important and relevant insights from the participants. The main interview questions are designed based on the review of the systematic literature, the context and the theoretical stance. The two research questions are embedded into the interview questions and the two distinct research questions. Therefore, the question from the aims of the research are.

- *What are the stakeholders' perceptions of Blockchain adoption in the oil and gas supply chain?*
- *How does the perception affect Blockchain adoption in the oil and gas supply chain using the UTAUT model?*

The UTAUT has been justified as the chosen theoretical framework for the research, as such, the UTAUT constructs are being used to help answer the questions raised above, and the literature was used to reference the design and rationale for the interview questions to be asked. The interview questions were pilot tested with two academics and two professionals, who provided valuable feedback and insights that helped shape the final interview questions and provided a clearer idea of the nature of the answers expected. In particular, question 2 on contextual factors was added as a result of professional input, which increased the comprehensiveness of the interview questions. The main questions are divided into two groups of two questions, and the interview questions are divided into sixteen groups of two questions. Table 5-5 shows the main questions.

Table 5-5 Main interview questions

Research question 1:	How would the stakeholder's perception on the adoption of Blockchain in the oil and gas supply chain be examined through the Unified Theory of Acceptance and Use of Technology (UTAUT)? The UTAUT model has been widely applied in technology adoption research to assess adoption, acceptance and use of technology. The question is designed to use the constructs of the UTAUT in understanding the stakeholder perception on adoption of the Blockchain technology in supply chain. The constructs are, performance expectancy, effort expectancy, social influence and facilitating condition. In essence these constructs are directly predictors of behavioural intention and by extension adoption of the technology without facilitating condition which directly indicate adoption. Therefore, all the interview questions were tailored to the UTAUT constructs.
Interview question 1, 2 and 3	***Performance expectancy*** Do you think using Blockchain technology will enhance oil and gas supply chain (operations and performance) in Nigeria? What is your view on the adoption of Blockchain technology in the industry in Nigeria? What do you think is the potential advantage or disadvantage of using Blockchain in the oil and gas supply chain in Nigeria?
	Rationale This is to determine the stakeholder view on the degree at which they believe the Blockchain in their supply chains will help them achieve their supply chain objective and everyday jobs
	Expected answers The expected answer should demonstrate an understanding of the importance of the technology in assisting them to meet supply chain objectives, and help in job and satisfaction.
	Supporting literature Venkatesh et al. 2003; Venkatesh et al. Xu 2012 "the degree to which an individual believes that using the system will help" them to benefit from its service (Venkatesh et al. 2003, p. 447) According to the literature has captured the extent at which the technology is assessed based on this construct.
Interview question 4 and 5	***Effort Expectancy*** What is your view on the potential ease or difficulty to use Blockchain in the oil and gas supply chain in Nigeria?

	How compatible do you think will the Blockchain be with your existing systems?
	Rationale The question on this section is determined to assess the perceived degree of ease of use of the Blockchain in supply chain among the stakeholders. Generally, the stakeholders are expected to express their view of the degree of ease of use of technology both on adoption and use.
	Expected answers. Ease of use is attached to the success of technology, the more complex a system is the likelihood it will not be use by the intended users. This question is expected to gain insights as to how stakeholders perceive ease of use of the Blockchain in their supply chains.
	Supporting literature (Venkatesh et al. 2003; Venkatesh et al. Xu 2012) "The degree of ease associated with the use of the system" (Venkatesh et al. 2003, p. 450).
Interview question 6 and 7	***Social influence*** Which category of stakeholders would influence the adoption of Blockchain in the oil and gas industry in Nigeria? What impact would the influence of the stakeholders make on the decision to adopt the Blockchain?
	Rationale Questions in this section are aligned with the construct of the social influence that is the degree to which a stakeholder perceives that important other believe he or she should adopt the technology. Hence the rationale is to determine from the stakeholders the level at which important others can influence their decision to adopt Blockchain in their supply chain.
	Expected answers. Blockchain is not a standalone technology it compliments other technologies, in trying to answer the questions in this section the research is expected to have the views of the stakeholder to an extent that other supply chain partners that they build trust with can influence their decision to adopt the Blockchain.
	Supporting literature Social influence is the extent to which stakeholders perceive that important other (i.e., trusted partners) believe they should use a particular technology (Venkatesh et al. 2003; Venkatesh et al. Xu 2012).
Interview question 8, 9 and 10	***Facilitating condition*** From your point of view, what are the facilitating infrastructures that are available to support the adoption of Blockchain? In your view do you think the knowledge and awareness of the Blockchain is influential to the adoption? Can organisations gain a competitive advantage by adopting Blockchain in their supply chain?
	Rationale FC is one of the constructs that directly predicts the actual adoption of the technology, accordingly, the question under FC is designed to assess the facilitating condition that can influence the adoption of Blockchain in the oil and gas supply

	chain. FC, therefore, can be defined as the degree to which a stakeholder believes that organisational and technical infrastructure exists to support the adoption of the technology.
	Expected answers. The answer expected from this question is to outline and discuss the technology and implementation capabilities of the stakeholders to adopt the Blockchain.
	Supporting literature Blockchain has legal and regulatory challenges which remain, as well as questions as to how the infrastructure is maintained, to whom the ownership belongs to, and which business paradigm changes are required to sustainably run such decentralised business models (Beck et al. 2018; Seidel 2017; Voshmgir 2017). The underlying construct of facilitating condition is operated to include aspects of the technological and/or organisational environment that are designed to remove barriers to use (Keong et al., 2012).
Interview question 11, 12 and 13	***Behavioural intention*** In your view when do you predict the adoption of Blockchain for your supply chains? What is the level of your readiness to adopt the technology? Would you consider influencing other key supply chain stakeholders to consider the adoption of Blockchain technology?
	Rationale Behavioural intention is the stakeholder's readiness to perform a specific action or behaviour. The question rationale is to determine if the stakeholder's readiness to adopt the Blockchain for their supply chain. In general, the stronger the intention to perform a certain behaviour, the more likely it is that such performance will take place (Ajzen, 1991).
	Expected answers. Consistent with previous studies, it is expected that the intention to adopt will be translated to the adoption of the Blockchain in supply chain.
	Supporting literature (Brown and Venkatesh 2005; Venkatesh et al. 2003).
Interview question section 2	What are the contextual factors that influence the adoption of Blockchain technology in the oil and gas supply chain among firms in Nigeria? This question is the second major research question which seek to identify other contextual factors that can influence the adoption of Blockchain in the oil and gas supply chain in Nigeria. At the end the research is expected to confirm the relevance of the UTAUT model by identifying the contextual factors that influence the adoption of Blockchain in the oil and gas supply chain in Nigeria if any.
Interview question 14, 15 and 16	***Identifying other contextual factors*** What do you think would be the enabling factor for the adoption of Blockchain among stakeholders in the oil and gas supply chain in Nigeria? What will motivate the supply chain partners to consider the decision to adopt Blockchain for their supply chains? What other things do you think will accelerate the adoption among supply chain partners in the Nigerian oil and gas industry? Is there any suggestion that may help to encourage the adoption of Blockchain in the oil and gas supply chain in Nigeria?

	Rationale The rationale for the questions under this section is to critically identify contextual factors that influence the adoption of Blockchain in the supply chain in the Nigerian oil and gas industry.
	Expected answers. The answer expected here is a robust factor that goes beyond the UTAUT constructs and that can influence the adoption of Blockchain in the oil and gas supply chain in Nigeria both at organisation, industry and country-specific since the oil and gas industry is highly regulated and serves as a major source of revenue to the Government of Nigeria, therefore, it is a business of interest to the wider context.
	Supporting literature Many researchers agree that BC technological qualities -specifically immutability, transparency, data security, and disintermediation- may significantly support key supply chains objectives in addressing most of the supply chain challenges of inefficacy, lack of transparency and unethical behaviours (Bumblauskas et al., 2020; George et al., 2019). Contextually, the prevalent lack of supply chain transparency is on the rise in the Nigerian oil and gas industry, therefore the question here are designed to see if the advantage offered by Blockchain can be a contextual factor that will influence adoption

5.3.4 Selection of interviewees and conducting the interviews

Purposive sampling was deemed appropriate since the study required the focus on a specific group with experience and understanding of the issues under inquiry (Guarte and Barrios, 2007; Cresswell and Clak, 2011). As a result, selecting participants familiar with the concepts and subject matter was considered to be more critical than a random approach. As opposed to random sampling, purposive sampling is best employed in research that respects variety in the participants' different perspectives, ideas, and opinions within the speciality of the subject of the investigation. This research explores the perception of the stakeholders on the adoption of Blockchain in the oil and gas industry through the response of interview participants across the industry in Nigeria. Consequently, getting across to this kind of interviewee is most suitable using purposive sampling, which is also compatible with the research's view of identifying the relevant stakeholders for the adoption of Blockchain in the oil and gas supply chain. However, the research also relies on snowball sampling to achieve the maximum expected number and interviewees across relevant sectors within the industry in Nigeria. Snowball sampling is excellent for engaging individuals who are challenging to reach or are recommended by previously identified interviewees (Mustafa *et al.*, 2020). The sample size in qualitative research does not need to be specific since researchers do not try to reach generalisations but rather to explain and comprehend the phenomena against the objective of quantitative research that focuses on larger sample size (Guest, Bunce, and Johnson, 2006). A sample of individuals from the target group who have not previously described

experiences could also improve information power. However, Glaser and Strauss (1999) first introduced the saturation concept as a specific element of constant comparison in Grounded Theory analysis, which stated that sample size is evaluated as part of the ongoing analysis, in which each new observation is compared to previous analysis to identify similarities and differences. Along the line of this argument is achieving saturation, which "although the concept of saturation is useful conceptually, it does not provide much practical guidance for estimating sample sizes for robust research prior to data collection" (Guest, Bunce, and Johnson 2005). Furthermore, since there is no single answer to the question of what sample size is adequate, there is also no single answer to the question of what sample size is adequate to reach theoretical saturation. (Patton, 1999) posited that there are no defined rules for calculating sample size in qualitative inquiry. However, factors such as the heterogeneity of the studied population, the scope of the study, and the methods and their application (such as the length of the interviews) play a significant role in achieving the level of saturation (Baker and Edwards, 2012).

This research identified 25 potential interviewees that represent the strategic supply chain management within the industry, as the breadth of the interviewee's roles needs to represent the views of the stakeholders. The process of identification of the stakeholders are based on the access to the petroleum technology development fund stakeholders record and the stakeholders mapping conducted through review of the industry's regulatory, operational environment and business landscape. As mentioned, the process of identifying and contacting the potential interviewees was mainly with the support of the Petroleum Technology Development Fund (PTDF). The researcher began by contacting the PTDF in order to attempt to get an introduction letter to the oil and gas companies. Instead, the PTDF produced a letter (see Appendix 4) and sent it directly to the respective organisations and companies, highlighting the need to provide the researcher with access and support needed for the conduct of the research. The letters have helped get the management staff's attention in most of the organisations to participate in this research. As mentioned, this was an opportunity to use snowball sampling in identifying and engaging with other relevant participants.

Of the 25 potential interviewees identified, 23 were interviewed, the 2 that did not participate were due not responding after several attempt and sending follow up letters and email through the PTDF. The interview began on 10th of March 2020 in Abuja Nigeria, the 18 of the interviews were conducted face to face, and the five were online via Zoom due to travel restrictions at the beginning of the lockdown due to the covid19 pandemic. However, the online process was seamless due to the flexible time for the interviewees being considered. It gave them the chance to express themselves and provide additional insight without hesitation. The face-to-face interviews all took

place at the interviewees' offices and premises except for one participant that was held in an alternative location due to offsite commitments of the interviewee. The interviews lasted between 25 and 90 minutes. The sessions were all recorded using a portable recorder, and consent to record was received from the interviewees before the commencement of the interviews. The stopping point for data collection within qualitative research may correspond to when the information gathered either becomes redundant, or is at a saturation point (Mason, 2010). This research continued to interview interviewees until the point at which the questions were covered, and the last three interviewees repeating the answers from previous responses. At that point, the researcher believed that saturation had been achieved.

Table 5-6 provides a profile of the interviewees engaged with this research.

Table 5-6 Profile of the research interviewees

Codes Generated	Job Function	Sector	Years of Experience	Nature of Company
RP-01	Blockchain Consultant	Technology	5-10 Years	Technology Company
RP-02	Business Transformation	Upstream	10-15 Years	National Oil Company
RP-03	Supply Chain	Upstream	15-20 Years	Exploration and Production
RP-04	System Management	Mid-stream	15-20 Years	Mid-Stream Logistics
RP-05	Business Automation	Upstream	20-25 Years	International Oil Company
RP-06	Contractor	Upstream	25-30 Years	Oil servicing
RP-07	Procurement Technology	Upstream	10-15 Years	Gas and Power
RP-08	Procurement	Downstream	10-15 Years	Downstream Operator
RP-09	Procurement	Upstream	10-15 Years	Gas and Power
RP-10	Logistics	Upstream	10-15 Years	Marine Logistics
RP-11	Marketer	Downstream	10-15 Years	Product Distribution
RP-12	Standard and Policy	Downstream	10-15 Years	Oil Company Government
RP-13	Logistics	Upstream	10-15 Years	Crude Trader
RP-14	Business Development	Upstream	10-15 Years	Vessel and Engineering Services
RP-15	Oil servicing	Government	10-15 Years	Ministry of Petroleum
RP-16	Technology Adoption and Strategy	Downstream	20-25 Years	Distribution and Retail
RP-17	Technology Adoption and Strategy	Downstream	15-20 Years	Energy Company
RP-18	Assets Management	Downstream	10-15 Years	Downstream Operator
RP-19	Contract and Commercial	Mid and downstream	25-30 Years	Supply Chain Firm
RP-20	Crude Oil Pricing	Upstream	5-10 Years	Oil Company Government

Codes Generated	Job Function	Sector	Years of Experience	Nature of Company
RP-21	Engineering and Cost Estimation	Downstream	15-20 Years	Local Oil Company
RP-22	Regulations and enforcement	Regulator	10-15 years	Regulatory Government Sector
RP-23	Supply chain directorate	Upstream	10-15 years	Major operators

The profiles illustrated represents the oil and gas industry as described in Chapter 3, Section 3.3 and shows how diverse the interviewees are within the oil and gas supply chain and their experiences within the different areas of the industry. These individuals represent the essential strategic functions within the three segments of the oil and gas industry, including regulations and governance. The breadth of scope of the interviewees is critical to exploring the views around the adoption of Blockchain technology from a multi-organisational levels and perspective, but also representing unique industry settings that faces the challenges that this research identified within the Chapter 3 Section 3.4..

5.3.5 Interview protocol

An interview protocol represents the conditions that guide research interviews, such as access to participants, establishing trust, the location, the duration of the interview, the order, quality, and clarity of questions, and the overall procedure for conducting interviews (Patton, 1999; Rubin and Bellamy, 2012). Conducting interviews in qualitative research require the protocol to be clear and include detailed procedures or instruments that will improve the reliability of the interview procedures. A reliable interview protocol should allow accurate and repeatable data to be sourced from the qualitative inquiry because it involves a systematic, consistent and comprehensive process (Gugiu and Rodríguez-Campos, 2007). The dependability of the interview process relates to how explicit the protocol was followed; a systematic approach to establishing a clear protocol is the Interview Protocol Refinement (IPR), which consists of a four-phase approach for designing and revising an interview procedure (Gugiu and Rodríguez-Campos, 2007). These four phases are as follows:

- Verify that the interview questions directly correspond with a research question, this was done with the supervisory team and two academics, at the end of the process the comments were used to improve on the questions.
- Develop inquiry-based conversations, streamlined process that categories the questions into a systematic format starting with preliminary questions and the main questions.

- Gather input on interview procedures, the knowledge of the industry and access provided the researcher to plan the procedures to follow which include the timing for the interview, location and convenience of the interviewees.

Table 5-7 The stages of the interview procedure

Activity	Procedure	Timeline
Travel to Nigeria	To get the letters from the university signed by the supervisory team	1 week
Contacted PTDF for access to the industry and letters of introduction to the stakeholders	PTD provided the letters and sent them to the stakeholders organisation	2 weeks
Interviews	Conducted on-site interviews with stakeholders in the Nigeria oil and gas industry. 18 interviews were conducted in person	2 months
Online interview	Conducted online interview via zoom with five stakeholders that did not make it face to face	2 weeks

The interview questions were aligned to the literature based on the approach of asking questions on technology adoption guided by the UTAUT model. The alignment between the interview questions and the research questions was illustrated within Table 5-5. The questions were sent to academics and professionals in Blockchain technology and supply chain management as started above. Feedback and suggestions were incorporated into the reviewed questions (attached in Appendix 1). The interviews were conducted in Nigeria in Abuja, Lagos and Port Harcourt, the major cities with the oil and gas sector presence between March to May 2020 in Nigeria. The questions, as detailed in Table 5.3 and 5.4, were carefully crafted to get the answers and in-depth data that will achieve the aim of the research. The questions have outlined an anticipated answers as demonstrated from the UTAUT model and the extant literature in Blockchain technology and supply chain.

5.3.6 Data analysis

The data collected from the interviews were transcribed and coded by the researcher in order to arrive at the analysis. This process involved the conversion of the audio of every interview conducted, and this process is mainly manual without any tool that provides a better way of managing the large sum of the data. The transcription process is an important step in the analysis, as it provides the opportunity for the researchers to familiarise themselves with the data (Mclellan, Macqueen, and Neidig, 2003). The research conducted the transcription of the data and stored the data for further analysis. Qualitative research uses a systematic and rigorous technique to answer questions for example about what something is like (such as a stakeholders' experience), what individuals' think or feel about something that has occurred, and why something has happened the way it has. In this scenario, data is often presented in the form of words or text, but it may also

contain visual representations (Seers, 2012). In order to understand the data collected, there are established approaches that research follows to interpreted and report the data called the qualitative analysis (Seers, 2012).

According to Braun and Clarke, (2006), thematic analysis is a qualitative data analysis approach that involves searching through a data collection to locate, evaluate, and report on repeating patterns. It is a data analysis approach that involves the interpretation through the processes of picking codes and generating themes from the transcribed data (Nowell *et al*, 2017a). Thematic analysis necessitates researchers asking themselves a variety of questions, the most common of which is "theme" hence, theme captures a salient aspect of the data in a patterned way, regardless of whether that theme captures the majority experience. As a result, rather than asking quantitative questions, thematic analysts ask whether a set of data answers the research question in a meaningful way (Braun and Clarke, 2006; Vaismoradi *et al.*, 2016).

Content analysis is a form of analysis method that identifies specific words or concepts in a context to answer or report specific case and could have been utilised instead of thematic. According to Marks and Yardley, (2011) a theme in content analysis is the manifest, recurring, or directly observable content of the data. However, thematic analysis was chosen because it places a greater emphasis on the qualitative aspect of the data being collected. Further, the choice of thematic analysis offers more useful technique for comparing the perspectives of various research interviewees in order to produce unexpected insights. For this research, thematic analysis is helpful for summarising important aspects of a large data set collected as it compels the researcher to manage the data in a structured manner, resulting in a report that is organised and clear with useful outcome that represents the views of the interviewees.

In order to conduct the thematic analysis, 'NVivo', a software for qualitative analysis was utilised. NVivo help to identify patterns of information for a set of data through nodes which is an extract of information from the data called coding in order to generate set of themes that are grouped under categories (see Figure 5-2).

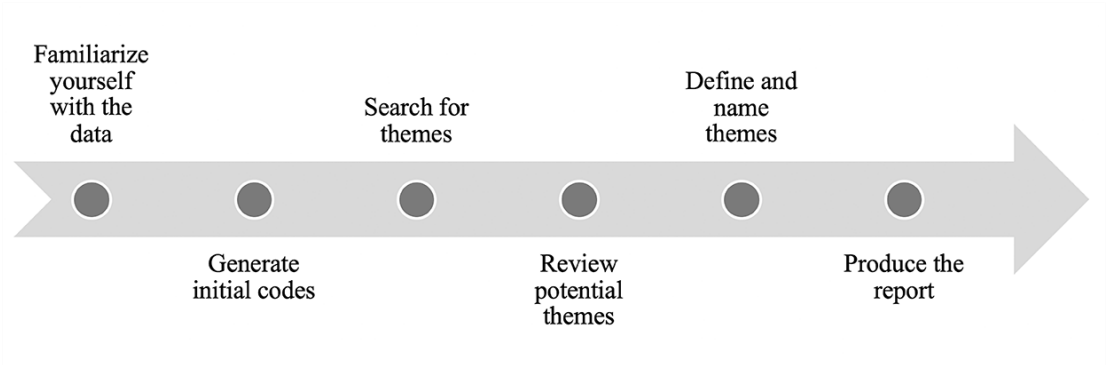

Figure 5-2 Thematic analysis phases adopted from Braun and Clarke, 2012)

Importantly, for the source of the data NVivo imports all transcripts and generates initial codes, NVivo allows multiple stages to generate initial codes and re-do the process until satisfied. It enables the researcher to merge codes and move codes from one folder to another. The process of matching codes to highlighted or coloured passages continued after reading the transcripts. Transcripts were compared line by line to see if previously assigned codes were consistent. As the process went on, some codes were renamed, and others were subsumed by others. Codes were categorised. The research repeated NVivo coding, the codes became more refined, and some of the initial codes were again subsumed by others while a few new codes emerged. For consistency and reliability of the process and procedure, the researcher conducted a separate manual coding without the use of NVivo. The coding and generating themes were described in Figure 5-3 below.

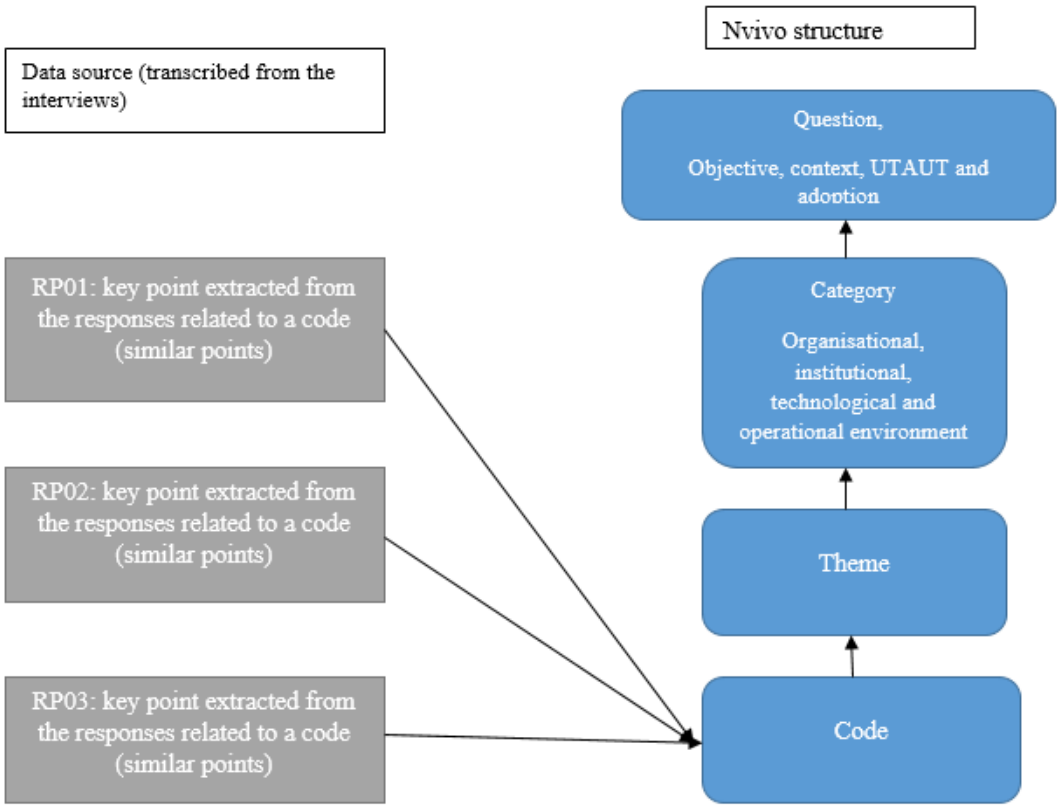

Figure 5-3 NVivo coding process

The above was the process that the researcher utilises in order to get the patterns of the data through consistent highlights of relevant content that has common phrases within the data. The process was continuous until when the structure that will enable synthesis was achieved. The outcome of the manual process was compared with the NVivo version to ensure there was not any form of bias.

NVivo is a powerful software tool that can help with thematic analysis by providing a platform for organising, analysing, and interpreting qualitative data. Thematic analysis in NVivo involves several stages, which are outlined below:

- Familiarise yourself with the data - the first process in conducting a thematic analysis is to become acquainted with the data. This entails reading and rereading the data, taking notes, and identifying any initial impressions or themes that emerge from the data.
- Coding the data – the process of doing the data. Coding entails identifying and labelling sections of data that relate to specific themes or categories. Coding in NVivo can be done manually by highlighting sections of text and assigning them to a code, or by using auto-coding features to automatically identify sections of data that relate to specific topics or concepts.

- Organising the codes- the process after the data has been coded, the next step is to organise the codes into groups or categories. This can be accomplished by creating nodes in NVivo to represent various categories or themes, and then dragging and dropping the relevant codes into the appropriate nodes.
- Creating themes – this involves process where the codes have been organised into categories, the next step is to create themes. This entails identifying patterns and connections between the various codes and categories and synthesising them into broader themes or concepts.

Themes are named after they have been developed. This entails coming up with descriptive and meaningful names for each theme that capture the essence of the data and the insights gained from the analysis. Table 5-8 provides the procedure adopted in developing the thematic. The coding book is attached to Appendix 6.

Table 5-8 Example of how themes were developed on NVivo

Stage	Process from NVivo
1. Familiarisation with the data	Read every transcript of the interviews 5 times and identifying key words, pattens and narratives.
2. Coding the data	Coded sections from the transcripts and the keywords in bold from 5 respondents <Files\\RP- 23> - § 1 reference coded [5.71% Coverage] Reference 1 - 5.71% Coverage "So internally, the key stakeholders than can make a move for the adoption is our Board of directors, the **company's leadership that top management**, the Staff, JV partners and Vendors. The stakeholder influences our major partners the NNPC, the government industry regulator DPR, and other policymakers within the space. It is not because of the trust, but they can always lead initiative or innovation like this and scale through" <Files\\RP-02> - § 1 reference coded [4.03% Coverage] Reference 1 - 4.03% Coverage "I think that as much as I feel, I think all categories are important, but the key word here is influence, that will be **leadership the senior management** of all stakeholders to key in. Once any management like I told you earlier, we are into what management what to do, leadership means the management can come up that we want to make blockchain work, more than in a very short time you will see that it is working. So, the greatest influences are the **management leadership**" <Files\\RP-03> - § 2 references coded [6.00% Coverage] Reference 1 - 1.94% Coverage "first of all you need the **leadership** should be able be aware of what this is, every should understand the issues around supply chain, somebody should create awareness of what blockchain can do is it that the company can drive value, is it going to be less costly than what they have today" Reference 2 - 4.05% Coverage "So, what I think the stakeholders can do is mention the typical the **leadership at strategic level**, some of them is to start commitment in terms of the adoption, leadership directives, financial commitments and then the able to cascade and communicate that down the line so

Stage	Process from NVivo
	that the user the leadership is not the one to use that build does at tactical level. They should be able to communicate to them on the benefit, what is need from them and others. I think commitments in terms of financial and direction and **leadership** will be able to enhance adoption and usage of the blockchain for supply chain" <Files\\RP-06> - § 3 references coded [4.63% Coverage] Reference 1 - 2.28% Coverage "I think of course, the key thing is **the leadership** of the supply chain functions. In the various operating entities, how they sale the adoption of blockchain within **the organisation** to create the pool for it. Secondly is how the then socialise and secure alignment of joint venture (JV) partners in the case of the JV companies this will mean getting the likes of NAPIMS, to actually buy into the idea to support it. Because not only they will need to endorse the concept but to support the cost of implementing, so by that the technology can thrive"
	The above theme, there are a total of 23 codes and 11 nodes that forms the theme (refer to Appendix 6 for details). In the presentation of the theme, the quotes there were used are for example from RP23, RP02, RP03, RP06, RP09 and R16
3. Organising the codes	The process of bringing together the keywords (codes) into nodes e.g.- "**leadership that top management" and "leadership the senior management"** and "**management leadership**" and "**leadership at strategic level" and "the organisation"** The above are the examples of reoccurring keywords from the theme of leadership and senior management.
4. Developing themes	The next step was to identify patterns and connections between codes and what they had communicated in building a meaning based on the keywords (codes) and the (nodes). Reading through Process 2 with key words highlighted to bring meaning and consistency of opinion between different responses, for example. This process was built to bring the quotes together from the nodes so that themes are formed. E.g., Bringing together all quotes from RP RP02, RP03, RP06, RP09 and R16 and synthesis them into a meaningful conversation.
5. Naming of themes	Process 4 resulted in the theme's naming. It was known as "Leadership and senior management" in this instance.
6. Categorising themes	The process generated 18 themes, which were then combined into 14 themes. Among the 14 themes are classifications based on their common influence and roles, for example, leadership and senior management align closely with the role and influence of the organisation on Blockchain adoption. This process resulted in four categories, with leadership and senior management falling under "organisational" and the remaining categories being institutional, technological, and operational environment. The reason for bringing together the themes from 18 to 14 was due to the absorption of the four themes into sub-themes based on the manual coding that was conducted. The process was the same as the previous process followed.

The final coding sheet was created after reviewing more paths and finding and no new codes or categories were found. At the point, the research has reached saturation, and a full coding sheet

was created based on interviewees responses. Further, the process of naming and defining the themes, by identifying through categorising the themes, that enabled the naming and defining of every theme and lastly the reporting in a form of drafting the outcome of the (thematic analysis) in Chapter 6. The reporting is the essential aspect that allows the researcher to synthesise and make meaning from the themes and responses from the data, quotes were used and literature and the UTAUT model were reflected to identify consistency and inconsistency in the findings.

This research followed the above systematic process and conducted the analysis of the data thematically. Thematic analysis extracts are demonstrative of the researcher's analytical points regarding the data and have been used to illustrate/support an analysis that goes beyond the unique content, to make sense of the data, and explain to the readers what it does or maybe picked from the extracts of the richness of the data (Braun and Clarke, 2006).

5.4 Research credibility

For qualitative research to gain recognition and significance in the research community, it must be performed rigorously and methodically in order to provide meaningful and valuable results (Krefting, 1991). This should demonstrate that the data analysis was done precisely, consistently, and exhaustively by documenting, systematising, and revealing the techniques of analysis in sufficient detail to allow the reader to judge whether the process is credible (Nowell *et al*, 2017). Achieving the trustworthiness of this research is based on the recommendation that the qualitative evaluation criteria of validation are about trustworthiness through credibility, transferability, dependability, and confirmability (Lincoln and Guba, 1985; Krefting, 1991).

One of the obstacles of achieving the trustworthiness of the research is bias. Therefore, the bias concern should instead be whether the researcher has been transparent and reflexive, i.e. critically self-reflective regarding their own preconceptions, relationship dynamics, and analytic focus regarding the processes by which data have been collected, analysed, and presented (Cresswell, 1994; Levitt, 2021). The researcher has collected rich and dense data from the participants which focuses on the research, and it is a multisite investigation; and uses systematic approach from identifying the problem to the research process to answer the research questions. This research has followed all the process as described by Creswell to be transparent, reflexive and critical of all the processes and evidence collected and analysed, including negative responses were all analysed and reported.

From the perspective of this research, the documentation of every step in this research demonstrated the adequacy of evidence of process, procedure, documentation and reporting. The findings were compared to the lens of the UTAUT theory to better understand the data, and it serves as a form of

theoretical triangulation which is a form of dependability of the research outcome. The member check, also known as member validation, is a study step in which "the preliminary report (case) is returned to the participants and subjected to the examination of the participants who contributed information" (Lincoln and Guba, 1985; Seale, 1999; Koelsch, 2013). The research adopted a member check to ensure that there was a form of validation of the outcome with the interviewees that contributed to the data collection stage. The interviewees who contributed to the research supported the outcome as it has reflected on their views earlier provided during the data collection process as part of the member check process conducted.

In relation to the reliability of the research, the research protocol for the qualitative inquiry is the process that provides an account of the process followed to arrive at the research conclusion. In addition, the researcher's knowledge of the shortcomings associated with the subjectivity of qualitative research, and the ability to increase the reliability has offered the consistency to keep close to the data. The process of analysing and supporting every statement with quotations from the original sourced data serves as a strong reliability assurance for the research.

5.5 Research ethical considerations

Ethical considerations are important to any research, from conception to completion. For example, qualitative research that utilises the interpretivism paradigm might have ethical issues depending on the researcher's viewpoint. This research was strictly conducted within the ethical guidelines of the University of Strathclyde. The process of gaining ethical approval requires making declarations and a review of the research questions by the supervisory team before submission to the ethics committee. Approval for ethics was granted before moving to the field for data collection.

During the fieldwork, all research interviewees were made aware of the research purpose and informed consent was provided with the option to back out of the research at any stage. The research process was completed openly and transparently whilst all processes were documented, and data collection and transcription were managed securely for the required period approved by the university. As a matter of ethical stance, the greatest concern of research participants in the Nigerian oil and gas industry is the potential harm that could result from the disclosure of certain information, such as identity. The interviewees may not wish to participate or share certain confidential or private information as a result. To encourage participation, therefore, each interviewee was assured that his or her anonymity would be protected as stated in the interview consent form which everyone has signed. In addition, the researcher reassured the interviewees that their identities would not be revealed and that the information they provided would only be used

for the purpose of this research on the perception of adoption of Blockchain in the oil and gas supply chain.

5.6 Summary

The research methodology and methods were presented in this chapter. The chapter summary justified the interpretivist philosophical position, and the research aims was accomplished through qualitative, interpretivist research that aimed to understand social phenomena through the eyes of those who experience them. The research used a semi-structured interview to collect in-depth data while also allowing for flexibility and spontaneity during the conversation to gain insights into the topic. Thematic analysis was used as the research method, allowing the researcher to uncover recurring patterns, themes, and connections. To organise code and aid in the analysis of qualitative data, such as semi-structured interview transcripts, the NVivo software programme was used. The chapter discussed how the research gained credibility as well as the ethical considerations. The next chapter is the detailed presentation of the thematic analysis.

6 Thematic analysis

This chapter presents the findings of the thematic analysis conducted in this research. The previous chapter presented the methodology and method adopted for the research and identified thematic as being justified as the data analysis method. The thematic analysis was for the data collected through semi-structured interviews with stakeholders from the Nigerian oil and gas industry. The interviews were carried out to identify from the views, feelings and perception of the interviewees on the factors for the adoption of Blockchain in the oil and gas supply chain. Furthermore, in order to align with the research practice in the presentation of thematic analysis, Vaismoradi *et al.*, (2016) mentioned phases that researchers follow to address thematic analysis presentation, including initialisation (coding process), construction (synthesis of code to bring meanings), rectification (cross checking of codes, meanings and grouping) and finalisation (reporting). Therefore, this research's thematic analysis was done to reflect the recommendation above, and in interpreting the findings these processes are duly incorporated. In addition, verbatim quotations are utilised in the body of the text as supporting evidence for the presentations that precisely illustrate the richness of research responses, experiences, opinions, and views.

The chapter begins with the background of the research participants, the research themes, and the presentation of the themes, and concludes with the summary of findings.

6.1 Background of the research participants

As stated in the previous chapter, the research was conducted qualitatively and gathered data from participants from key positions across Nigeria's oil and gas industry. These participants came from the core supply chain cycle in the upstream, mid, and downstream, as well as relevant stakeholders from regulatory agencies, policy makers, the private sector and independent operators. The participants have 5 – 25 years of industry and related experiences. They are also considered based on their relations to supply chain, technology or business transformation and regulatory responsibility or services. The diversity of the research participants has aided in gathering and producing rich data through their personal views, influence and experience on the subject under investigation. Table 5-6 provides the profile of the research participants.

The interviewees above represent the breadth of the oil and gas critical stakeholders, although other aspect of the industry like the upstream have more representation of participants, this is due to access and the relevance of the participants' subject matter knowledge, as discussed in Chapter 5 Section 5.3.1 on the selection of interviewees. The participants listed above represent the breadth

of the oil and gas critical stakeholders across the industry as it was presented in Chapter 5 Section 5.3.1 on the selection of interviewees.

The themes from the research findings were based on the data collected through interviews as stated above. The process of the data collected follows the transcription, coding, analysing and presentation. The theme presentation was designed to streamline the themes based on their relevance to each other and serve as a synthesis of the themes and information generated (Vaismoradi et al., 2016). In qualitative research, identifying and categorising themes is critical to ensuring the validity and reliability of the findings. While categories and themes serve different functions and are developed using different approaches, they are sometimes used interchangeably in completed research, which can lead to a lack of coherence between methods and results. Themes represent the meaningful "essence" that runs through the data and provide the basic topic that the narrative is about, whereas categories are used to organise and describe similar data, allowing researchers to define and compare them with other categories. This research ensures that the findings accurately reflect the data and contribute to a more comprehensive understanding of the research topic by properly identifying and categorising themes.

As a result of the process as described in Chapter 5.3.6 the themes that emerged were categorised into four categories: organisational; institutional; technological; and, operational environment, with 14 themes identified within these categories (see Figure 6-1) for the purpose of the presentation, each of the categories are elaborated into different sections: organisational, institutional, technical, and operational environment with analysis of the themes into sub-sections.

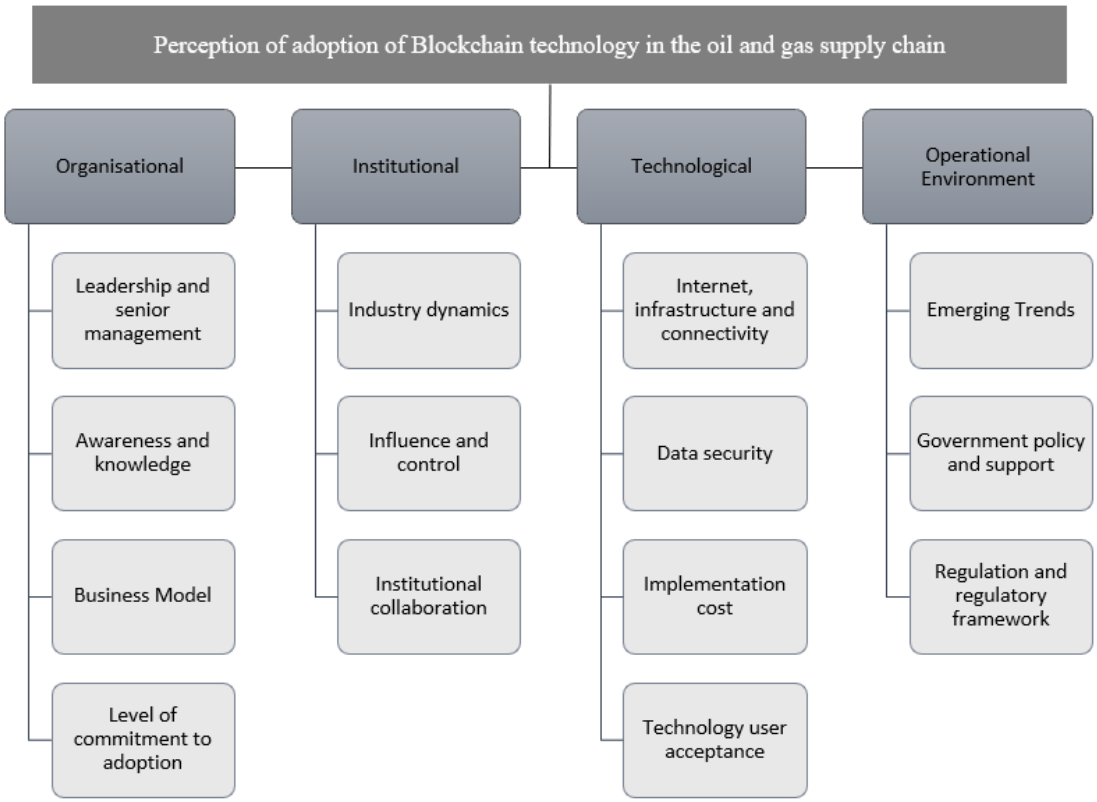

Figure 6-1 Summary of the thematic findings

The key objective of the research process is to explore how stakeholders perceive the adoption of Blockchain in Nigeria's oil and gas supply chain. The findings are viewed from the UTAUT lens, and each theme were reflected to the constructs of the UTAUT model; performance expectancy, effort expectancy, social influence and facilitating condition.

6.2 Organisational

This section presents findings that emerged in the first categorisation of the thematic analysis which is organisational. The consideration is on the organisational aspects relating to the themes and explicit content of the analysis are related to the organisational context. In this case, the themes under the organisational category are leadership and senior management; awareness and knowledge; business model; and level of commitment to adoption. All analysis for the themes is based on the participants' responses and presents the outcome to highlight its significance in this research of factors for the adoption of Blockchain technology in the oil and gas supply chain.

6.2.1 Leadership and senior management

The research interviewees pointed out the role of the leadership and senior management in driving the adoption of Blockchain for the oil and gas supply chain. Specifically, the leadership and senior

management roles in top-level decisions, supply chain partners, major players, and effective communications. For example, RP23 and RP07 mentioned key stakeholders like the board of directors are the leadership top management required to drive the Blockchain technology adoption not only because of the trust, but also the need to lead the initiative or the innovation:

> *"So internally, the key stakeholders that can make a move for the adoption is our Board of directors, the company's leadership that top management, the Staff, JV partners and Vendors. The stakeholder influences our major partners the NNPC, the government-industry regulator DPR, and other policymakers within the space. It is not because of the trust, but they can always lead initiative or innovation like this and scale through."* ***RP23***

> *"The top management, in my opinion, like the board of companies, the staff of any company been the drivers. For the top management, they should be able to take the decisive decision, their buying can accelerate the top, especially when they have good perception."* ***RP07***

Interviewees revealed that all categories of stakeholders are important. The interviewees consistently mentioned leadership and senior management across all the organisational levels. They could show leadership and willingness to adopt Blockchain technology. RP02 stated that:

> *"I think all categories are important, but the key word here is influence, which will be leadership and the senior management of all stakeholders to key-in. Once any management like I told you earlier, we are into what management what to do, leadership means the management can come up, that we want to make Blockchain work, in a very short time you will see that it is working. So, the greatest influences are the management leadership."* ***RP02***

> *"First of all, you need the leadership to be able to be aware of what this is, everyone should understand the issues around supply chain, somebody should create awareness of what Blockchain can do, is it that the company can drive value, is it going to be less costly than what they have today."* ***RP03***

Furthermore, some interviewees stated specific leadership of the supply chain function should sell the adoption of the Blockchain within the organisation. That can be extended to outside stakeholders and get the buying of all supply chain actors to adopt. RP06 mentioned that:

> *"I think of course, the key thing is the leadership of the supply chain functions, in the various operating entities, how they sell the adoption of Blockchain within the organisation to create the best for it."* ***RP06***

> *"So there must be that clear strategy within the organisation, the leadership in the organisation must buy into it as well as the external stakeholders who need to play their role in implementing and have a handshake, and you need to have a number of leading supply chain partners who are ahead of the cause in terms of using Blockchain in their supply chain around the world that can be an accelerator to implement it quickly."* ***RP06***

The interviewees stated the commitment of the top management is evident because they have started sharing ideas about the Blockchain. For example, RP08 exclaimed that the top management of their organisation had started discussing Blockchain as the future of the industry and saw the

potential of full implementation within the next five to ten years, especially at the enterprise level:

> *"There is a time in a meeting I heard some of the top management mention that Blockchain technology is the future of the industry, I was impressed".* ***RP08***

The following quotation from RP02 emphasises the role of supply chain organisations through their leadership to recognise that it is something they need:

> *"The leadership of the supply chain organisation first recognising that this is something that they need to get after, rather than continue with traditional manual approaches."* ***RP02***

The leadership should engage in strategic decision-making, take the lead, and show examples of the technology's problems. In doing that, many will follow suit. RP16 responded, for instance, that:

> *"For me as a leader, we have a major role to play, that will influence the adoption, especially through strategic decision-making in our organisation. We need someone to take the lead, show an example of how the technology can solve the industry's problem apply it and then because of the competitive nature of the industry others will definitely follow suit."* ***RP16***

It could be deduced from the above responses and findings that the interviewees identified the significance of leadership and senior management as an influence on the adoption of the technology. Furthermore, through decision-making, the importance of innovation and alignment with their external stakeholder was recognised as a critical driver for the adoption of Blockchain technology in the Nigeria oil and gas industry. From the perspective of UTAUT model, social influences show the effect of someone important would influence the adoption of technology. The responses above, confirms the critical role of leadership and senior management on adoption of Blockchain technology within the Nigerian oil and gas industry. The literature has confirmed the role of top management support is an influential factor construct (Mali*k et al*, 2021). According to (Malik et al., 2021) top management support is amongst the factors that lead to Blockchain adoption in an organisation, in comparing the literature to the social influence, the more the senior management within the industry accept the Blockchain, the chances that the influence of the senior management will have effect on their organisations.

6.2.1.1 Supply chain partners

Supply chain partners play a pivotal role, according to the research findings. The role is linked to leadership and senior management. The leadership and senior management within the supply chain function was identified as a factor that will influence the adoption of Blockchain for the oil and gas supply chain. The supply chain partners cut across different value chain segments across stages of operations and management levels.

> *"The leadership of supply chain partners, because they have a lot of roles, if you know a customer need something and you know that it is only that supplier that can provide it and if they say this is how they do their business, it means they are going to have a great influence on the adoption. So, supplier has a strong influence to drive Blockchain technology in our*

industry." ***RP04***

Many interviewees indicated the suppliers as the major drivers because they can force their partners to adopt the Blockchain. However, other partners will not be left out in the process. This calls for competition among the partners. For example, one interviewee said:

> *"For me, the enabling factor is that everybody will also be forced to comply when the majors and the key suppliers adopt Blockchain. Because we would not want to be left out, you cannot even afford to be left out."* ***RP02***

Another research interviewee added that the role of the supply chain partners, primarily the supplier that has a presence globally, can drive the adoption. They have the capacity and resources to initiate and execute. Their influence can bring across together through leadership and the strategic role they will play. RP06 stated that:

> *"Then you are looking at supply chain partners who are going to be impacted they are the suppliers, particularly the entities with robust system and capabilities and who they may have been already exposed to Blockchain application in other parts of the world, those ones maybe the front runners to engage the people who can make a strong representation of that technology within the supply chain community".* ***RP06***

RP06 added that the leadership of the organisation should identify and recognise those partners and what the benefit will be when the Blockchain technology is adopted against the traditional system:

> *"So, like I said the leadership of the organisation of the supply chain organisation first need to recognise this is something to get after rather than continuing with traditional almost manual approaches".* ***RP06***

Supply chain partners are going to be impacted by the adoption of Blockchain in the supply chain. Still, the big players will gain more from the adoption because their opportunities might have exposed them to the adoption. The relevance of the supply chain players to show leadership is evident from the findings. The leading supply chain partners across the industry can accelerate the adoption because they will have experience using it in their operations before, so the interviewees believed the supply chain partners are influential in leading the adoption. RP07 explained the above:

> *"If leading supply chain partners who are already ahead of the others in terms of using Blockchain in their operations somewhere around the world, then that can become accelerator to help us implement quickly."* ***RP07***

Findings concerning the supply chain partners provided a background to their role, particularly suppliers with a global outlook that can serve as copying points for others. It is interesting to see how participants mentioned the critical part of the supply chain partners, which can be related to leadership and senior management responsibilities to drive the adoption of Blockchain technology. Regarding the role of specific management, the aspect of the UTAUT construct of social influence has not emphasised critical or specific stakeholders that will influence adoption. This is significant

from the perspective of this research, as certain stakeholders wield more influence than others; supply chain partners are an example of such stakeholders due to the crucial role they played in the adoption decision.

6.2.1.2 Major industry players

Aside from the supply chain partners, the interviewees pointed to major industry as critical stakeholders in determining the adoption of Blockchain in the supply chain within the industry. The major players are considered essential drivers to the adoption, and they have a leadership role to contribute. The interviewee's view is concerning data and technology solutions and how to use the influence of the leadership and senior management to communicate the benefit of the adoption to these major players. By so doing, investment can be wooed from the identified players in the industry. RP06 reiterated that identifying the major players and making them realise the benefit of the adoption of Blockchain will open more opportunities for adoption. The interviewee mentioned that:

> *"So, we just need one main and major player to follow through and begin to cream the benefits. So, it will open the tap and open the wave for others to see and copy that line."* ***RP06***

The above quotation from RP06 highlighted the level of readiness of some major players, but the issue is to look if it is something the industry needs:

> *"I think for the major players, the readiness is ok, and it is just for them to decide if it is something they are ready to do or not, and the staffing right now are new generation staff, every staff might have already tried the bitcoin or whatever it is, or they must have heard about it because normally young guys right are into digital innovation."* ***RP09***

> *"I think what everyone is waiting for is significant players in the industry to take the initial risk of trying it out, and once it is successful, I think that can become the point that we can overcome the limiting friction in the adoption of that technology. It is also not clear to me what the general attitude with the adoption of this technology is by all players because it is not just the operators."* ***RP11***

To further elaborate on the relevance of the major players, some interviewees stated that those major players have the financial commitment to adopt. For example, RP15 stated that:

> *"The suggestion is that we need to pick the drivers in the industry and the big industry players need to come in, they have the financial muscles to adopt it, and the government need also to go in there, because one of the issues about the Blockchain is that information stored and shared cannot be publicly tampered with, this is very important."* ***RP15***

The findings revealed the major players as drivers of Blockchain adoption as having the leadership capability to influence the adoption. The major players have the financial and innovative resources to adopt Blockchain, and the significant influence will come from the major players if the commitment is there. Just like in the supply chain partners, major industry players are critical

stakeholders and the UTAUT construct of social influence is about recognising how important others will influence the adoption of technology. The literature highlighted the critical stakeholders in industry, and those stakeholders are critical to influence the adoption decision.

6.2.1.3 Top-level decision

Despite the role of the leadership, supply chain partners, and the major players, another aspect that is critical from the findings is the top-level decision to adopt the Blockchain technology despite assessing the benefits and limitations. The research interviewees mentioned the critical role of top-level decisions, particularly from the cross-management level. For instance, RP05 revealed that the intention should be made known at the highest decision-making level:

> *"I think the first thing that needs to happen is for the intention to be made known at the highest level. If it is coming from another level, it will not be taken seriously. Because people know that is the top-level decision, so it is difficult to justify value for something like Blockchain because you cannot be seen in a corner and shown values. It has to be driven by a person that holds or group that holds a lot of the ACs such that if they make that move, the supply chain or the industries in the supply chain will begin to set up knowing that is an important move. If at the highest level that intention is to make known cascade down the chain to the various level of leadership and management and it is now understood that this is serious everybody in the system, I believe will begin to make their bid."* ***RP05***

RP20 further reiterated the earlier assertions that the supply chain management leadership should trigger their decision to adopt at the highest level. Doing that will help give clear direction and achievable the targets:

> *"The technology will do their bit, the SCM will do, and the external parties will begin to ask a question. So yes, I think that is what makes some stakeholders that are action-based, they need to do something but the trigger the contribution that the highest level needs to make is to make that intention known as in 2025 Nigerian supply chain in the oil and gas will be driven by Blockchain—emerging the supply chain leaders saying that the industry will go Blockchain."* ***RP20***

The decision making at the highest level will create a culture to adapt fully; RP21 stated that:

> *"The stronghold they have is the system that can influence a lot of decisions from the government. So, the industry regulators are to make up their minds to accept or reject, so inevitably, they are ready to let go of the traditional ways of doing things. The revolution is coming, and they need to act, but they can still say how this thing works out and manages the traditional ways of doing business."* ***RP21***

Through effective communication, the leadership and senior management will address any technical gap that will arise because of the Blockchain adoption. The purpose of leadership and the top-level decision is to drive the agenda of the adoption through effective communication to influence the adoption. Interviewees stated that some enabling factors are the ability to effectively

communicate the innovative solution of the Blockchain to the supply chain stakeholders. The comment of RP03 has stated the effective communication and how that would enable the adoption:

> *"One of the enabling factors, the key one is effective communication, which I used it several times because it is very key looking at typical change management process you prepare people to manage change and reinforce the change, it is a new technology new solution that has not been used, people have not seen, though it has been used somewhere and they are making progress."* ***RP03***

To the extent that the leadership needs to communicate and make the Blockchain solutions to the management effectively, doing so will create awareness and let them understand the importance and the value of any Blockchain technology solution for the industry. RP08 stated that:

> *"First is to prepare the mind of leaders, they are the one to communicate, the management needs to be at the centre for effective communicate, this will create the awareness, let them understand the importance and the value, trust me if they are able to see the value on this, I do not think the current management of this organisation will waste any time to invest in this technology. That is what I think is the first enabling factor as it is now."* ***RP08***

Many interviewees stated that once the value of the technology holds, it can be effectively communicated, particularly to the right management that handles high-level decisions. Blockchain adoption will be successful without wasting time. It was also revealed that effective communication could make the right commitment and enhance the credibility of Blockchain adoption. The following statement from RP04 further underscores the views on the extent of the communication that will enable the Blockchain technology adoption:

> *"So basically, they have to have that commitment right, they have to be first of all they have to use it, if you are not using it, you will not have that credibility of expecting the adoption. If you are using it consistently and you say, ok, this is how we are going to work with you going forward, it will work, and communication is also essential. They are going to communicate by letting people know that Blockchain, even though people think about the smuggling of precious stone, should communicate and demonstrate that you can use Blockchain for business for normal business operations on shady things that cannot be tracked and things like that. It is very tricky. I think the most important thing is for them to be able to demonstrate how it works so that people will be comfortable with it."* ***RP04***

This section has revealed, in summary, the perception from the organisational level, including leadership and senior management, regarding the importance of supply chain partners, major players, and effective communications. Significant is how the findings are perceived as influential factors in the oil and gas industry's adoption of Blockchain. The UTAUT construct of social influence exemplifies the impact of influential others on technology adoption. In consideration of the significance of these findings to the construct, top-level decisions align with the strategic role of leadership and senior management, provide the basis for top-level decision-making, and have an

impact on the adoption. Literature indicates that the decision of stakeholders influences the adoption of Blockchain technology at the organisational level (Orji *et al*, 2020a).

6.2.2 Awareness and knowledge

Another significant finding from the analysis under the organisational is the awareness and knowledge of Blockchain technology. The interviewees perceived that awareness and knowledge considerably impact the adoption. The more awareness and knowledge of Blockchain technology, the higher chance of adoption and use of the technology. Interviewees notably revealed the awareness and knowledge as a factor for the adoption within the oil and gas supply chain; for example, one of the interviewees stated that:

> *"I have a formal education on Blockchain and digital financial assets from a university in Cyprus, then I have extensive experience for the past four years on understanding Blockchain technology application and where it intersects with regulation and government policies, but I can tell you the lack of awareness and knowledge is a big factor to the adoption."* ***RP01***

> *"The major contribution of any stakeholder in the industry is to speak the business's language, critically outline the benefit of the Blockchain, and why it is relevant to the industry. Then, once the majority of the players buy into it, awareness, education and capacity building can pave the way for full utilisation. So, all stakeholders have a role to play through the adoption process, especially at industry scale."* ***RP22***

The findings in both RP01 and RP22 highlighted the importance of Blockchain technology awareness and how it will aid in adoption. In this case, Blockchain knowledge and awareness are still limited, but the findings demonstrate how important it is to adoption and how stakeholders at the organisational level can help create awareness. Another interviewee expressed out the importance of creating awareness of the technology and providing a level of awareness across organisation on the benefits of adopting Blockchain technology, for example, RP06 stated that:

> *"I am too familiar, to be honest, but my understanding of Blockchain application is not advanced; the only area of what I have seen is the digital currency, and I heard it a lot in the news. But during my studies at the university where I did my masters in procurement, we touched a bit about it."* ***RP06***

> *"So, most of the knowledge about Blockchain is not practical; the knowledge and practice experience in Blockchain cannot go beyond familiarity with the concepts. Everyone is eyeing for opportunities to really have a deeper understating and practical approach. My hope is that I will do a little bit of practice to be able to implement it somewhere and see it working to deliver the benefit and promises it holds."* ***RP06***

The above findings have revealed the understanding of the Blockchain technology from the participant's point of view but stated the lack of awareness and understanding as a factor. However, the interviewees believed that awareness is not beyond familiarity with the concept. Awareness of Blockchain technology is necessary to drive its adoption among the stakeholders. While

interviewees stated that they have a good understanding of the Blockchain but lack the practical application and experience, it limits the knowledge from an adoption point of view. Therefore, creating awareness will give Blockchain adoption a competitive advantage in line with the digital transformation drive in the industry.

> *"The industry should start creating awareness and invest in Blockchain technology to make the industry competitive and relevant in line with global digital transformation, and I know covid-19 will be an enabler."* ***RP23***

The findings revealed that there is a need to educate and create awareness to harness the opportunities of Blockchain technology at the organisational level. No matter how good the technology potential is, it will not scale to the adoption level if the right people are unaware of the benefits. One of the interviewees stated:

> *"They also need to educate participants because no matter how fantastic technology is and the people for whom that technology should transform the way they do business or the way they operate, if they do not understand how that technology works and how to apply it, then they will not be able to use it appropriately, there is need for education drive, the awareness you know, certification, professional certifications may be required so that the industry has grown the way it is expected."* ***RP01***

Considering the unanimous perception of the interviewees that the awareness is not there, the interviewees believed that the knowledge of the technology is deficient in the space they operate. But they all thought that with the right information, the adoption would thrive, but the approach should be aggressive before the adoption:

> *"Most of the knowledge that we have currently in Blockchain space is very low, the knowledge is not there, and everyone learns at the same time. So, one of the fastest-growing industries is that of learning and continuous learning that any active player in the industry needs to do because you blink an eye, you will be outdated."* ***RP04***

> *"The knowledge as I mentioned to you, personally if you are looking at the competency level, we have awareness, knowledge, skill and then master. I am just at the knowledge stage because I have not used it. I think currently, the awareness is not there."* ***RP03***

> *"So that is why I said awareness is key, create that awareness, champion it, and look for people and sell the ideas, the value proposition why should we get it, why is it better than what we currently have."* ***RP04***

One of the interviewees revealed the importance of stakeholder's awareness of the Blockchain technology:

> *"I think there is a need to increase stakeholder's awareness and education on Blockchain capability because I think if at my level a senior manager if I speak to my colleagues about Blockchain, I can tell you just about 1% of them understand. So, what it means is there is a need to increase the awareness and education around what Blockchain offers, especially in Nigeria."* ***RP13***

"For me, I think the level of awareness is low for me to intensify the education; that is the first thing to do if the awareness increases. Then, I think adoption will also fall in line, but today I think the awareness is shallow." ***RP10***

Interestingly, with the interviewee's view above, many interviewees mentioned the need to increase awareness from the industry level through collective awareness, campaigns, and education. RP16, for example, said:

"The industry as a whole needs reorientation about technology and its impact on the survival of the industry. Yes, the industry is always lagging behind when it comes to technology adoption, but in this case, we expect different results from all stakeholders if the right awareness is created." ***RP16***

"I will strongly advocate continued awareness and engagement with all stakeholders beyond the company level, and you know supply chain is outside the company level. For those at the top should be reminded the world is not static; things are changing. It is no longer the case; people go for what makes their lives easier, Blockchain technology is here to stay, and we have to join hands and be part of this transformation. The world is a global village, and we must embrace it." ***RP20***

Despite the fact that awareness and knowledge are recognised as factors in Blockchain adoption in this study, the UTAUT construct of effort expectancy shows that the ease of use and understanding associated with technology will influence the technology's adoption (Venkatesh, Thong and Xu, 2016). Though not directly related to the UTAUT construct, literature has shown the effect of awareness and knowledge of technology in adoption decisions (Mohammed et al. 2020). Furthermore, Khazaeir (2020) stated that Blockchain technology awareness promotes adoption. The findings have revealed the challenges of Blockchain technology awareness and knowledge, but also the optimism of adoption due to how quickly Blockchain technology is thriving across the industry. Furthermore, the interviewees provided some insight into how organisations can raise the necessary technology awareness.

6.2.2.1 Lack of knowledge

Many interviewees have perceived a lack of knowledge of the Blockchain as evident from their interactions with the industry players. The interviewees claimed that the knowledge of Blockchain is not there and recognises that the level of knowledge of the technology will influence the level of adoption. Many of the interviewees that commented on the lack of knowledge do so from leading the creation of the knowledge amongst their peers in their respective organisations. For example.

"The knowledge is not there. I guarantee you many actors are not well-grounded in this technology of Blockchain. That means if you have well-informed actors, it can influence, and a lack of awareness and knowledge can impede the adoption. For example, even among the international oil companies, I know a lot of the leaders do not see Blockchain as an option simply because they do not have the knowledge of its powers and how it can be applicable to

their supply chains." ***RP22***

"People may be excited stating Blockchain, but once they begin to open that king of words, they will begin to see the reason why we cannot do it just like that. So, the level of knowledge we currently have will hinder adoption. ***RP05***

"It is not sufficient; it is very low, and that is the biggest setback for the adoption." ***RP15***

The interviewees attributed the lack of adoption to the level of knowledge of the technology. Some went to the extent of providing an example of how many leaders in the industry do not have the knowledge to decide whether it is useful or not. Therefore, the current status has negatively affected the adoption of the technology from their perspective:

"I emphasise that until we have a working model that delivers value, people can point to and say, this is how Blockchain is working in so and so company. The understanding of it beyond just a theory-based knowledge would continue to be limited." ***RP06***

"From my experience, the knowledge is not yet sufficient to push adoption. In the industry, generally, Blockchain knowledge has not gained enough big ground when it comes to the industry itself and stakeholders. It is still low on how it can affect any serious decision." ***RP10***

The interviewees believed that the better the understanding, the higher the chances of the adoption and getting the necessary buy-in from organisations. Having the knowledge will also help organisations assess the risk and benefits involved and the stakeholders decide where and when to adopt Blockchain technology for their supply chain operations. RP21 stressed that:

"the better the understanding of the Blockchain, the better the analysis of the risk involved and the more informed the stakeholders will be that decision-makers have or are exposed the faster they accept or reject." ***RP21***

According to the responses of the participants, a lack of understanding is a factor affecting the adoption of Blockchain in the oil and gas supply chain. That is, better understanding can lead to adoption, while a lack of understanding can lead to impediments. The findings indicate that there is a limited understanding of Blockchain technology, and this lack of basic understanding of the technology influences organisations' adoption decisions. Many of it is only limited to its financial sector potential:

"The problem with lack of understanding Blockchain is when most people see Blockchain as the financial application which is the cryptocurrency, and you see that is a big problem because that is not what it is. So that is the reason why better understanding will lead to adoption". ***RP08***

Another interviewee has a deep-rooted belief that most of the stakeholders only know about cryptocurrency. When you talk about adoption, the only areas organisations and stakeholders think about is how the cryptocurrency can apply to what they do which the Nigerian government has

banned. This has affected the ability to explore the potentials of Blockchain technology since it has already been banned:

> *"These stakeholders, if you ask them in most cases, the only thing they know about Blockchain is a cryptocurrency technology and therefore is bad, a lot of awareness has to be done."* ***RP09***

A practical example of the application of Blockchain technology on a project that uses cryptocurrency for payment is a validation of some of the interviewees' perceived areas of adoption. Still, due to the lack of understanding of the benefit of the technology, the project faced many challenges that affected its full-scale adoption. RP10 give his experience on that:

> *"Let me give a practical example with what we have experienced while working on a platform; when we started, we intended to make use of Blockchain technology itself, and that involved cryptocurrency, bitcoin and use it for settlement; the players currently are not well educated when it comes to applying such technology, they are not open to use digital currency for payment, that's the problem we have faced actually."* ***RP10***

It is further discovered that the stakeholders need to recognise the importance of advancing their understanding of the technology and what will enable them to identify areas of application:

> *"The effective contribution should start from the point that every recognised stakeholder needs to advance their understanding on what Blockchain is all about and look at it carefully, and even this Blockchain needs to be tested as so on."* ***RP15***

> *"There is no doubt that it is a new technology that is coming to the space now, people need to understand it clearly as I said earlier by the next 10 – 20 years people will be ready, but for now, with the poor information about it am not sure we are prepared for now, but when we get information about it we try to adopt it."* ***RP17***

As demonstrated above, some of the interviewees stated that no one is ready for the adoption because the understanding is not there. Even among the top stakeholders that are expected to drive the adoption. RP18 put forward some perspective:

> *"I don't think the knowledge is sufficient. Because I know a lot of people that do not know anything about Blockchain in the oil and gas, and you know, I have not heard anyone discussing it among top stakeholders, the different engagements that I have been hearing or being part of, so I think there is a serious lack of knowledge on Blockchain among stakeholders in Nigeria. So it is insufficient, and many things need to be done to create its awareness."* ***RP18***

The perceived lack of knowledge reveals the impact on adoption and why stakeholders believe that when Blockchain knowledge is abundant, the scalability and chances of adoption will be very high among organisations and stakeholders in the industry. This has highlighted the importance of understanding the technology before implementing it across the industry. A lack of knowledge can lead to a lack of understanding of Blockchain technology adoption. The preceding aspect of

Blockchain technology ignorance is to emphasise the findings of the relevance of knowledge and awareness from the perspective of stakeholders. The UTAUT construct of effort expectancy demonstrates the effect of knowledge on simplifying and influencing adoption.

6.2.2.2 Education and skilling

The interviewees admitted that education and skilling are regarded as what will influence the adoption, mainly due to the evidence that the interviewees perceived on the lack of knowledge and understanding of Blockchain technology in the industry. Therefore, education and skilling are perceived to be a factor to be taken into consideration by organisations that want to drive the benefits of the Blockchain technology for their supply chain:

> *"We need more tenacity in terms of education in terms of showcasing possibilities, and if need be, can we do some pilots and take some of the low-hanging supply chain issues that we have those that drawn regularly."* ***RP12***

For instance, another interviewee alluded that educating the industry players on the impact of the Blockchain technology will influence the adoption. Citing the relevance of educating the benefits of the technology and how company can add value by leveraging the adoption. Both RP10 and RP13's comments were in agreement on the significance of educating the industry players:

> *"Educating the players in the industry on how much good this can actually help their business; like I said, there is no business that will like not to make more money if such a solution will help the player to reduce cost."* ***RP10***

> *"Making business justification to adopt it become the next level, but the first thing is educating these key players on the capability of Blockchain and making the business justification for them."* ***RP13***

Findings also revealed that research can also enhance the adoption and showcase the potential of the technology to the supply chain. Other interviewees stated this as a step that will enlighten the stakeholder to understand and appreciate the importance of Blockchain technology through scientifically proven methods:

> *"I think this proposition and this study you are doing is one of the steps. We need more determination to education and enlightenment in terms of showcasing possibilities. If need be, can we do some pilots and take some of the low hanging supply chain issues that we have, those we can regularly use pilot, then we see the gains."* ***RP17***

The aspects of the awareness and knowledge based on the stakeholders' perception is an integral part of the Blockchain adoption, as the critical aspect that involves the level of knowledge, awareness and understanding, as well as education and skilling. These are all essential aspects organisations should consider when exploring the opportunities Blockchain offers to the supply chain. UTAUT focuses on the constructs that influence technology adoption through the lens of how behaviours affect the adoption decision; the overall relevance of awareness and knowledge

themes shows that if knowledge, understanding, and education on the benefits, adoption, and use of technology are available within the oil and gas supply chain, effort expectancy plays a significant role in the adoption. The availability of resources and support, including technological knowledge, aids in its adoption and use. As a result, the previous findings focused on the critical role of knowledge and awareness in the adoption of Blockchain within the supply chain (Montecchi, Plangger and Etter, 2019).

6.2.3 Business model

Developing an unblemished business model is a significant aspect of any technology adoption, particularly Blockchain technology. Based on the findings, justifying the business through case creation is as important as the success of technology adoption. The interviewees pointed out the need for a business model to enable the technology adoption scale through organisations. The emphasis given by the interviewees on the business model demonstrated their perceived factors on how Blockchain can scale from their respective organisational points of view:

> *"The major contribution of any stakeholder in the industry is to speak the business's language, critically outline the benefit of the innovation, and why it is relevant to the industry, then tailor that to the organisational specific needs."* ***RP22***

> *"Once the awareness is created and industry leaders support the use. But at the moment, the framework to adopt the technology is not available to the industry. Nevertheless, I can see an integrated solution that will support contract management, reduce wastages in contract cycle time and reduce over-reliance on third-party companies."* ***RP23***

> *"I have not seen a strong business model for its adoption if I see a business model that looks that is workable, you know the supply chain cut across a global scope across several industries."* ***RP20***

Supply chain leadership have a role in identifying the business case, which means it is not only to the technologist. Their responsibility is to ensure they have a robust business case across the supply chain function that will help the take-off of the Blockchain application:

> *"I think it would depend on what you want from those stakeholders to do like I mentioned in the case of the supply chain leadership of the various entities is to really develop business case a robust business case for the take-off of Blockchain, that is really important to offer a strategic paper and figure out what this thing is and how to apply it to unlock and continuingly extract value or the enterprises, and articulate all the benefit that has to do the work and continuing value will be. So that really is what will be the contribution."* ***RP06***

Another interviewee mentioned that a reduction in human interference can generate efficiency and accuracy and reduce transaction costs for the entire supply chain function. The assertion here can help shape a better understanding of designing a business model for the supply chain:

> *"I think it is the business case if you make a sound business case for that which you are going*

to and proffer some sort of digital processing where machines do the things that you want machines to do. You minimise human interactions to generate efficiencies and accuracy and lower the cost of transactions." ***RP06***

An individual company can start the exploration and adoption of Blockchain technology for their supply chains; according to RP14, it is still early to look at industry-wide applications:

"Individual Company in my opinion as early as possible, we are in the age and era where everybody is looking for better technology to enhance the process and achieve great performance. The Covid19 situation has taught us we can actually make use of the internet and technology to improve our business, you can use things using IT tools you will find out most offices now are utilising it, so it is a great time to see adoption if the right business model is in place." ***RP14***

Disruption to the oil and gas supply chain is a risk that most players are sceptical about trying innovations. The business model is vital to alleviate the fear of potential disruption. One of the interviewees believed:

"We need a model, we can talk about Blockchain but if there is no reference to prove to stakeholders the advantage of this system then it will just be another disruption in the air, so we need a model in reference point which we can all look at to make those adoptions." ***RP11***

A reference point is a key to helping the stakeholder access the benefits to adopt Blockchain technology, particularly when the business case can solve an oil and gas supply chain problem. Then the Blockchain will get the necessary acceptance:

"I will like for a model to be created as a reference point, the model must not necessarily have to pick all the problems in the oil and gas industry or all the supply chain problems, but by the time we see a practical model working, and it solves a problem, provide a solution to a problem, then adoption will be easy, you will realise that at that point a lot of suggestions will come on how to improve the system in the oil and gas industry such that you will get full acceptance that adoption will just be in working, so we need a model." ***RP18***

The industry leaders recognised some trials with the industry as not a viable option. Therefore, a working solution outside the sector will serve as a possible model to replicate. According to one of the interviewees:

"Well, there is a concern across the industry on transparency generally in the way we do business, but I think probably we don't know the readiness of the participants, and all those oil companies that operate in the community they have a lot of dealing with local people, in such environment adopting Blockchain within require the level of transparency but viable business case is essential not trial on us." ***RP20***

"I think if having a business value model, maybe detail the story of where it has been successful and some of the thing it will be able to resolve." ***RP21***

Although the findings revealed that the business model should provide a reference point of where it has worked rather than being a trial in the context of the industry, it is a fundamental pillar that is regarded as a perceived factor that will influence Blockchain adoption in the oil and gas supply chain by the interviewees. The findings' business model theme and important aspects that support the aspect of business development align with the UTAUT construct of performance expectancy, and it is the belief that technology adoption will support organisations in achieving a critical objective. Having a business model that aligns with the industry is a critical driver of adoption, and the ability to design the model aids in persuading stakeholders of the relevance of Blockchain to their supply chain context and how it solves existing challenges. Lee, Kriscenski and Lim, (2019) investigated user acceptance through the UTAUT model to address the predictability of Blockchain technology; the study is unrelated to supply chain but emphasises the importance of business models in the acceptance and development of Blockchain technology.

6.2.3.1 Practical Blockchain application

The interviewees identified practical application as an integral component of the business model. For Blockchain to gain widespread acceptance, its business model must be practical and valuable. Before testing Blockchain, many industry participants are eager to see a practical application; they argue that model design promises are not sufficient to drive adoption:

> *"If you cannot show an oil and gas something, they will not believe you. If you cannot show them, they will never believe you, the smaller people that hold small scale may wish to take. Because Blockchain is promising them efficiency, you are a small stakeholder your margins are tiny if something can make you maximise your margin, that is fine. But for the big players, you must tell them the above theory that is working out there. I think that is key."* ***RP05***

Another interviewee stated that the deployment and adoption would be facilitated by the practical application. In this case, the technology must demonstrate practical value beyond its technical merits before its adoption can be justified. Professionals in the industry must attest to the practical demonstration and utility of the technology. For instance, RP03 was of the opinion:

> *"So a lot of work needs to be done to mobilise professional opinion around recognising the value of Blockchain in tandem with the actual deployment of Blockchain to demonstrate the value. So you have to have a clue that is why I emphasised in tandem, you cannot tell people all the good stuff about the Blockchain, and they can read all the books about Blockchain, but if they casually don't implement it, then that knowledge is only peripheral is not embedded."* ***RP03***

A working model that is tested and proven to show significant value is an influential factor that will enable the adoption. Some of the participants show optimism about the potential of the technology, but lack of a tested model is detrimental to the adoption within the supply chain:

> *"Right now, I will say No, even without doing sort of formal testing, and the reason I say no*

is that until we have a working model that delivers value that people can point on and say so and so companies, this is how Blockchain is working, the understanding of it beyond just a book knowledge will continue to be limited." ***RP06***

The industry has not yet tested any form of Blockchain for the supply chain. The interviewees confirmed that some of the companies are doing some exploration to understand the technology but not in Nigeria:

"So, in terms of testing it, I don't think we are there yet. I think there's a whole lot of discussion around it. Some companies and corporations are doing some practical exploration of Blockchain technology but not in Nigeria, and that is the only one I am aware of. But in terms of mainstreaming and coming together to use it, I think we are still in the rudimentary stage right now in Nigeria." ***RP17***

The lack of tested Blockchain solutions affects the technology's adoption as the industry is inclined to practical solutions before application. Scalability of the Blockchain technology is the primary reason for the untested technology.

"I know here is where I sit, which is part of my job for doing strategy in any potential solution that will help my company, Blockchain has been reached to all our stakeholders here, they know that it's something we are looking at. So that's a very compelling reason for us to ask people to come into the Blockchain to help us all together, but until when we can prove the scalability on tested business premises." ***RP18***

The quotes illustrated the perceived impact of untested technology on the practical application of Blockchain for the oil and gas supply chain, given the preceding findings. Thus, even though stakeholders are aware of the development of the technology, the perceived factor is to observe practical applications that solve a problem similar to theirs in nature. In addition to the relevance of the business model to the findings, the practical business model demonstrated the relevance of the UTAUT constructs of performance expectancy and effort expectancy, both of which are related to the belief that the technology will help in problem-solving, and the ease of adoption and use associated with the technology. Review of the UTAUT application by (Venkatesh, James Y.L. Thong and Xu, (2016) reveals the combination of two or more constructs in a single context. It is not surprising that both the performance expectancy and effort expectancy constructs align with the practical business model's influence on the adoption of Blockchain in the oil and gas supply chain.

6.2.3.2 Procurement business model

According to the research findings, procurement is a crucial component of the business model that can address a variety of industry-wide challenges. The research identifies the procurement model as a crucial aspect of the business model that can help organisations individually and collectively. Significant interviewees were aware of the advantages of a tailored Blockchain business case for

procurement. RP03 highlighted the value that would be maximised if a customised procurement solution was provided:

> *"What will motivate them is value maximisation how it solves my procurement problems and the value proposition. Because the supply chain is ongoing the supply chain in the oil and gas is huge, procurement is huge we procure items a lot and many things. Is a major cost driver in the business that is procurement? So, cost what will be value and the cost of doing that, if they are able to understand that I think they will be able to drive the adoption of the use of the technology. As I said, the cost is a major driver in the business, and the value is important."* ***RP03***

If incorporated into the business model, procurement-to-payment is regarded as a perceived enabler that can impact adoption. Intriguingly, a number of interviewees emphasised the necessity of configuring Blockchain to provide payment system solutions for end-to-end procurement. Specifically, one of the interviewees said:

> *"For me, because we are narrowing down to supply chain what I will consider as successful when we can do procurement to payment (p2p) and influence Blockchain into procuring up until the payment is made and the relevant and the necessary participants in that change are using the Blockchain."* ***RP02***

Sustainable procurement is gaining increasing attention among industry companies. Many of the interviewees recognise the potential to accelerate the adoption of Blockchain if sustainable procurement is integrated into the technology's selling lines. The result indicates that interviewees understand how Blockchain can facilitate the pursuit of a sustainable and ethical procurement and supply chain:

> *"Not just profit or cost but you can also look at it in terms of the triple bottom line, if it can solve a problem of sustainable procurement, if it can solve a problem of ethical procurement, then, of course, is what to adopt... profit is a good one, cost-saving is a good one, and also companies are now increasing levies sensitive to sustainable and ethical procurement."* ***RP09***

The findings shed light on an interesting aspect of the significance of speed in procurement processes, namely the reduction of the contract life cycle and time spent managing purchases. These results suggest that the Blockchain's potential to increase speed will drive its adoption within organisations. RP12 was of the opinion that:

> *"I can tell you this Blockchain will finish this things like maybe ten days vs six months like one month vs twelve months. So that actually is a compelling reason, because then supplies can do many of their business, instead of waiting to do a deal for twelve months, you can do a one-month deal and do it six times a year."* ***RP12***

> *"The supply chain in Nigerian oil and gas we all know is saddled with some challenges, chief of which is the cycle time, the procurement cycle time from initiation to completion of a supply chain activity is unacceptably too long. I'm certain that Blockchain will bring speed*

into this and would be able to trigger people's desire." ***RP17***

Both RP12 and RP17 highlighted digitalising procurement function as the potential area that the oil and gas will benefit from the Blockchain, primarily by increasing visibility. It is interestingly pointed out that most supply chain stakeholders that can influence the adoption are familiar with the need to digitise their supply chain and address challenges of lack of visibility:

> *"I believe the Blockchain will help in digitalising procurement. It will also help us to trace how we operate, because one of the problems we have in the oil and gas industry is actually visibility of our operations and expenditures both in capital expenditure CAPEX and operational expenditure OPEX."* ***RP18***

The interviewees also outlined asset's traceability in procurement function as a critical component of the business procurement model that will help in adoption and influence the decision to adopt:

> *"It will also help in our procurement. The procurement, the way we do our procurement, sometimes you won't even know the kind of asset we have and or the asset we need, but with Blockchain you will know, visibility of the assets, you will have to know how the asset has been used and the rest so it will help you in planning and also increase your operational efficiency."* ***RP18***

In conclusion, the findings presented above demonstrate the component of the procurement function that can be incorporated into the business model and how the components of procurement made possible by Blockchain technology were perceived to be an influential factor in the adoption of the technology. In addition, the findings have highlighted critical areas of interest to organisations across the industry on the significance of procurement in the supply chain made possible by Blockchain technology. The literature has highlighted the potential of Blockchain to transform procurement and supply chain, the findings have demonstrated consistency with the literature and how previous studies proposed Blockchain application within procurement and supply (Banerjee, 2018).

6.2.3.3 Consortium and collaboration

The findings have piqued the interest of the people in the decision to adopt and who will drive the adoption. Several interviewees, however, mentioned collaboration as a perceived influential factor that will guide the adoption and design business model that the company can come up with in accordance with their unique strategies. According to one of the interviewees, the idea that the government should drive Blockchain innovation is not the solution. RP 22 pointed out an interesting perspective that:

> *"Some people will think the government should be the driver of this innovation. Still, the truth is that government is not good at this kind of things, so for me, the stakeholder that will influence the adoption is a general consensus between the industry leaders and players across all segments."* ***RP22***

Others' views were mainly on the consensus of the stakeholders to drive successful adoption that would benefit the entire industry. Many interviewees identified the industry-wide application as the most suitable possible scenario for the industry to benefit from the broader opportunities of the Blockchain instead of individual companies working on a particular application:

> *"Ok, to get it right, there should be an industry-wide decision to explore the technology, build the competency and get the right steps in the areas where the technology can help. So, I would say we need a form of consortium that can lead the discussion. I believe that will be an accelerator to the adoption."* ***RP18***

One of the interviewees highlighted the reasons for the need to develop a consortium and companywide policies that will help in designing a suitable and efficient business model:

> *"The present practice in the industry that we have in Nigeria, corruption is a big problem, so what the stakeholders can do is have a transparent system which is what the Blockchain offers, plugging into a Blockchain system; if the stakeholders like vessel companies, the players in the industry, the buyers and sellers, and the government can have a consortium system which is like a kind of consortium Blockchain system where everybody is plugged into, that will help the adoption of Blockchain system because if one participant/ stakeholders decide to create a solution, other stakeholders might not really want to get involved because it is not their thing."* ***RP10***

As stated above, the interviewees perceived collaboration as an influencing driver for the supply chain adoption of the Blockchain. Furthermore, the interviewees perceived collaboration as the only influential factor that can make the adoption of the Blockchain successful. RP22 is of the view that:

> *"So, if knowing fully that this technology can help us all at the industry level, I will not just influence my partner but work collaboratively to see the smooth adoption."* ***RP22***

Collaboration and working together within the companies at the industry level were highly regarded as influential but success factors to Blockchain and any technology of this nature. Many interviewees related the consortium and collaboration as an aspect that the business model should be integrated and communicated to the relevant parties:

> *"If they are using, if I'm using the technology, I will like my other partner also to use similar technology so that we can have a simple handshake in terms of our operations, and we will also be on the same level. So, if I'm using SAP, I will like the other people to use SAP for easier integration, rather than having you know, let me say any interface that will translate what the other technology is doing to bring them to my technology."* ***RP18***

In summary, the business model perceived by the stakeholder as a perceived driver should focus on developing a collaborative consortium model that can easily scale to more comprehensive industry applications than individual efforts. The findings from the business model divulge specific aspects that are perceived to be the enabling factors for the business model to be accepted: the

practical Blockchain application, procurement model, consortium, and collaboration. They are all consistent with previous Blockchain research that posited the benefits of tailored Blockchain solution (Nofer *et al.*, 2017; Nowiński and Kozma, 2017a).

6.2.4 Level of commitment to adoption

The level of commitment to adoption is the final theme under the organisational category. The findings in this theme are related to the factors that demonstrates the level of commitment to Blockchain adoption in the oil and gas supply chain. The level of commitment to adoption aligns with the UTAUT construct of facilitating condition, which is the belief that the necessary support from management and capability are available to support technology adoption and use. The impact of available management support, investment, and commitment from organisations to adopt Blockchain for their supply chain has been demonstrated by research as an influential factor. Blockchain projects, investments, and funding, as well as industry-wide adoption of Blockchain, fall under the level of commitment to adoption. This theme was as a result of the critical drivers for that will demonstrate the level of adoption.

6.2.4.1 Blockchain projects

The findings identified the ability of industry organisations to start a Blockchain project as a demonstration of commitment to adoption. The ability to champion a Blockchain project can occur only when there is a genuine commitment to adopt Blockchain and change the way things are done. While stakeholders appreciated the level of discussion on Blockchain projects within the industry, it was clear that no organisation within the industry had made a commitment to try it. As stated by RP06:

> *"While there are a lot of discussions in Nigeria about Blockchain and we are yet to see any industry or sector specifically commit to trying it out even at some level to see how it works and then on that basis to sell the successful experience to the players within that sector or industry segment."* ***RP06***

It was further revealed that the slow interest in starting Blockchain projects is a factor that could affect the adoption. The industry's lack of Blockchain projects shows how the organisations' commitment is insufficient to drive the adoption. RP07 mentioned that:

> *"In Nigeria, the adoption of Blockchain has not really started; it is not to the maximum even if other industries have adopted that, my opinion. But as compared to the developed countries, maybe for now in Nigeria, it needs input from the industry selling it and starting with some projects that will likely scale. So, for me, I have not seen or heard of any company utilising it."* ***RP07***

Other interviewees pointed out a recent development on a Blockchain project that started within the oil and gas industry in Nigeria that most of the interviewees were not aware of:

"My involvement as a co-founder in vessel trust is not as a result of me being an active player in the oil and gas sector but as a result of seeing how to marry the solution that the technology offers as an active participant that is trading in oil and gas. Through Blockchain technology in the supply chain or the area we are creating an easy market for the producers/sellers to get buyers easily. And to able to track their sales, e-venture etc. for easy documentation the good from one person to the other. Then reduction in the cost." ***RP10***

Blockchain projects may become more prominent within the industry in the next five years. The potential of the technology and the ability of the technology to solve some pressing issues in the sector pose those opportunities to drive Blockchain projects across the several aspects of the supply chain. Another interviewee stated that:

"As I said, the awareness I am not too sure of the extent, but I know that I can say the pace at which things are going in the next five years but not even full adoption. So likely we can see that from the industry, there is some adoption level." ***RP21***

Based on the above statements, the Blockchain project was identified as a critical driver to the commitment to adoption based on the scope of Blockchain projects to be considered. Although the interviewees indicated that the project has not yet begun within the supply chain, the commitment to adoption is evident from discussions among leading companies and their executives. The UTAUT construct of facilitating condition aligns with the belief that Blockchain projects can demonstrate commitment to adoption. As a result, the importance of having Blockchain projects demonstrates the level of commitment that stakeholders believe will influence the technology's adoption.

6.2.4.2 Investment and funding

Investment and funding are critical aspects of the level of commitment to the adoption. Unfortunately, the level of funding and investment available to support Blockchain within the supply chain in the industry in Nigeria is not commensurate with the yearnings of the players in the technology space. One of the interviewees was referring to the provision of funding as a perceived influential factor that will drive the adoption:

"If you can provide funding, then the adoption can be influenced, especially at a time like this when the industry is struggling." ***RP23***

The interviewees elaborated further by explaining that once the industry recovers from the global turmoil caused by low prices and uncertainties, the industry will make significant investments into the supply chain for potential Blockchain projects:

"I predict – very soon. When the oil price improves, companies will invest in the Blockchain for SCM activities. If it is an investment in production-related projects, I believe it will fly faster. So, the technology developers should be cantered on how it will bring our operating cost lower, increase revenue and certainly make the industry competitive." ***RP21***

Specifically, some of the interviewees mentioned funding should come from the regulatory bodies because they set standards, and the technology can help in achieving those standards and increase compliance:

> *"When the management [and] regulatory bodies buy into the vision, fund it, train the staff and the staff use the technology."* ***RP21***

On the contrary, the organisation that champions the adoption of Blockchain projects should source funds for the projects as it was designed to support them achieve their organisational goals. RP11 was noticeably clear that:

> *"In terms of support for that fund to Blockchain projects, there is a need for mapping and identifying from others who will need to provide budget support, including the organisation's leadership."* ***RP11***

> *"Today we say yes technology is an enabler, several businesses have a database, invest in the database, but with Blockchain technology, it requires initial investment and beyond that has to come with the huge commitment from the supply chain stakeholders."* ***RP13***

Stakeholders have the potential to play a significant role in the development of Blockchain projects by contributing the necessary funding and investing in the projects themselves. Consequently, the investments and finances make it possible for Blockchain initiatives to scale and assist organisations in realising the maximum benefits that Blockchain can bring. This is made possible by the fact that Blockchain initiatives can now scale. The factor that falls under the level of commitment can only be achieved after the necessary funding and investment have been located and put into action across the industry and by organisations. The previous statement makes it abundantly clear that investments and findings are one of the important factors that contribute to the facilitating conditions necessary for the implementation of Blockchain technology in the oil and gas supply chain. According to the findings, the level of commitment to the adoption is a significant factor that the stakeholders considered to be one of the most important factors that would help to facilitate the adoption of Blockchain (Queiroz and Fosso Wamba, 2019 ; Saberi *et al.*, 2019).

6.2.4.3 Mass adoption of Blockchain

The commitment to adoption can be perceived when widespread adoption is achieved across the industry's supply chain. The stage at which commitment, finance, and investment are available to support enormous projects across several sectors of the oil and gas industry is known as mass adoption. Many interviewees anticipated that significant adoption would be the next stage of adoption in the next five to ten years. One of the responders, for example, stated:

> *"So, in my view, over the next 5-10 years, we could likely see mass adoption at the industry level. However, other small-scale adoption by maybe IOCs can be a little earlier than anticipated."* ***RP22***

Increasingly, the interviewee perceived the opportunity for high-scale adoption because of the nature of innovation the Nigerian oil and gas companies are going through most recently, and stakeholders across the industry are sensitive to the lack of adoption of innovations. Therefore, some interviewees commented on the global industry's innovation and why companies are working to catch up with their peers in other industries. RP19 put together that:

> *"Nigerians are speedy adoption; I do not see a problem in adoption once there is the desire the massive adoption will happen in a concise period of time."* ***RP19***

As discussed above, the responses demonstrated the potential of mass adoption as a significant driver toward the commitment to the full potential of Blockchain across organisations, despite the fact that the period for Blockchain to be fully adopted was projected to be between five and ten years.

Based on the perceptions of the interviewees, the ability to pinpoint a specific stage at which Blockchain technology will be implemented indicates a commitment to adoption. Many interviewees provided a time frame for when they expect technology adoption to begin, while others mentioned processes that must be completed prior to adoption. According to RP15, a discussion is currently underway among key industry stakeholders, which is a significant step forward in the adoption process:

> *"I have a discussion, we just have an idea about it, and we will explore what it means for the industry and beyond. But internally, we are not doing anything about Blockchain."* ***RP15***

> *"Right now, like I said, we are still monitoring, we have not seen much of it, the only resemblance of that is the NIPEX system that has a traditional way of managing procurement and contracting and is enabled by the exchange, this is what can be entirely disguised in Blockchain, and that's what we are looking at, but I think we still trying to get there."* ***RP16***

The above also corroborates the view that the internal part of adoption commitment is lacking, as most firms are aware of the technology but need to build a strategy for adoption before making any decisions:

> *"My view is we are still at the study stage. I do not think we've grabbed that opportunity yet. I think we are still looking and a whole lot of things though people are talking about it. We are accessing and looking for an area of use cases that we can use."* ***RP17***

> *"We do not see much of it, as I said earlier. What we see is on the pages of dailies and, of course, influencers talking about it. The industry is geared toward innovation, and Blockchain has the ability if the necessary technicalities are effective."* ***RP17***

The current stage at the organisational level is that no adoption decision was taken as most of the companies are monitoring how the technology will evolve in the coming times:

"I am not sure whether there is any, I mean adoption. Not to my knowledge, I do not know that any company particularly has really gone out to say that, ok, we are adopting Blockchain. I know that we have technology adoptions in terms of, you know, SAP, alternating some processes using an in the house or sometimes external, you know, software technology but, for Blockchain, I'm not sure if any company has adopted it." ***RP18***

Because the oil and gas industry rely on the value proposition, a considerable number of interviewees believe that when the technological discovery stage transitions to the adoption stage, the number of adopters will be high. Adoption will be effortless once the understanding is achieved:

"I have this at times, a lot of things started and when it started everybody is taking unaware, the way Blockchain is going is a revolution that today in the past a lot of people think it will not stand the test of time, but now we are talking of adoption in big corporations including the oil and gas. So, it is not a surprise the chances are very slim, but with the level of awareness that is on stream globally, going forward, I think the adoption in the oil and gas will be a success. So, I see some of the levels of success in the long run of the adoption of Blockchain in the oil and gas supply chain." ***RP21***

In terms of when that will happen from the assertion above, one of the interviewees gave his option that between 5-10 years, there will be significant levels of adoption:

"May in the next 5-10 years, we may be able to go ahead with adoption. There was a time we were in a meeting I heard one of the top managements mentioning Blockchain technology. I was actually impressed that it is a topic within the management so likely within the next five years the Nigerian oil and gas industry will see the light of adoption." ***RP07***

Based on the findings above, the adoption stage is exploratory, as many firms are aware of the technology's development but want to see how it evolves over the next 5-10 years. As a result, while the study discovered that some level of commitment based on potential had been recognised, it is still in its early stages. As most projects are in the early stages of adoption, the scale of Blockchain adoption has not yet reached the required level to demonstrate the technology's scalability. The significance of the findings on mass adoption as a level of commitment indicated that the level of commitment from the industry will drive massive adoption, and that was believed to be a facilitating condition that will drive the adoption of Blockchain in the oil and gas supply chain.

6.3 Institutional

This section discusses the findings from the themes classified as institutional. These themes were classified as institutional based on their relevance to institutional influences and how they affect the adoption of Blockchain technology in the oil and gas supply chain. The Nigerian oil and gas industry is governed by strong institutions, which have a significant impact on the industry's technological future. Institutional themes are related to the findings that related to the specific

influential factors that cut across the institutions. These include industry dynamics, influence and control, and institutional collaboration. The themes' findings are critical to the influence of Blockchain adoption from the UTAUT perspective; it recognises the significance of influence and collaboration from the constructs of social influence and performance expectancy (Venkatesh and Davis, 2000).

6.3.1 Industry dynamics

The interviewees perceived industry dynamics as being a critical aspect determining Blockchain technology adoption. The industry dynamic is essential to the adoption, particularly for the oil and gas industry, considering how things change or are affected by uncertainties surrounding how the industry operates, finance projects, comply with the standard and the global ecosystem. Therefore, this means the industry's dynamic is regarded as a critical constraint to the adoption of Blockchain technology for the oil and gas supply chain. Most interviewees stated the industry's dynamic as a factor and how it affects or influences the adoption. For instance, RP05 perceived that:

> *"Nigeria's oil and gas industry is dynamic in nature due to some stringent laws and operating model now the implication is that the technology cannot be adopted when the laws or the premises in which the businesses are done do not support such innovations. Mostly the reverse is the case, and it is important to consider industry dynamics as a factor that will facilitate the adoption of Blockchain."* ***RP05***

The nature of the oil and gas trading business in Nigeria is peculiar to a specific context. Things could be unpredicted in the industry and the consequences is that it will affect the changes in behaviours of the industry actors. For example,

> *"Because we had people paid to have uptakes their crude instead of having people pay you to take your crude, now you are expecting them to take your crude, so if so happens that you will need Blockchain when people see the dynamics, the perception will change. For me, it is just the industry dynamic that will determine, especially that people have seen the reality of how bad things are, we do not need a lot to convince people to adopt."* ***RP04***

The findings show that the industry is facing significant challenges, with some firms asking their oil trading partners to take their product at no cost. The reality of how things change in the industry will determine the technology's acceptance. The laws governing industry practises, such as the public procurement act, make no provision for adopting technology. Some of these challenges make Blockchain adoption dependent on industry dynamics. RP09 suggests that:

> *"You see when we have law governing procurement, especially in the public organisations, for instance, we have the bureau public procurement which is enforcing the public procurement (2007) and we have the Nigerian content management board which enforces the NOGIC act 2010, and we have a number of other laws but these are the main laws that affect procurement in Nigeria, so if we have an owned government organisation and they are*

subjected to that particular law and in that law there is no place or any provision with respect to applying this kind of technologies, it will be difficult for companies especially in the public domain to be able to implement it." ***RP09***

The interviewee stated that some laws prevent the adoption of innovations like Blockchain technology. They perceived the restriction or lack of support in the industrial setting would affect many aspects of the adoption of Blockchain technology. He further gave an example of the kind of hurdles that the technology will face due to the dynamics of the industry:

"Let me give you an example; by law if any company is selling outbid, all the responses to that bid must come in hard copies by law. So now even if you want to go for e-copies having an e-platform for your bid management, because they do not require hard copies you cannot implement e-procurement effectively because the law is the law, you cannot change it unless by an act of parliament, even if you are willing as a body organisation to implement or to prevail difficult that impossible without changing its policies and in this case the laws governing the procurement in the country." ***RP09***

It is clear from the findings that the limitations in compliance with the regulations governing the sector may result in a more robust adoption of Blockchain technology because it is a highly regulated industry. At the moment, the laws are seen as limiting adoption. The dynamics of the industry have an impact on the ability of any technology to grow; unless the industry takes the necessary steps as an institution, there will be a lack of significant adoption of any innovation, such as Blockchain technology. The combination of the rate at which things evolve and changes are resisted is critical to how the industry is dynamic in nature, and this has influenced the adoption of Blockchain technology from both acceptance and rejection. According to the research findings, some of the critical aspects that shape the industry's dynamics are the level of competition, unethical practises, resistance to change, and manual processes in supply chain and crude oil trading. There was no evidence that the UTAUT model construct aligns within the above findings, but it is critical to present the finding under the under the industry dynamics to demonstrate the significance of the impact of industry dynamics on the adoption of Blockchain technology.

6.3.1.1 Level of competition

Industry competition was frequently cited as a reason for the adoption of Blockchain technology in the industry dynamics. The interviewees stated that the level of competition is a factor in the industry's adoption of Blockchain technology because the players are competitive to some institutionalised advancement. Due to the level of competition, which most players engage in to stay ahead of the competition and establish themselves as leaders, businesses may adopt blockchain technology:

"Well like I said earlier, it is competition and industry dynamics, these things will make them to adopt Blockchain for their supply chain." ***RP04***

Another interviewee added that:

> *"One may be in the form of competition maybe if one sector or industry player is using it, it will be a big factor to influence others to start using it. Leadership acceptability will play a key role as a factor as well as government/political will."* ***RP07***

> *"Maybe a form of competition, if one industry is still using the Blockchain."* ***RP08***

> *"You will be able to be in line with competition because most of the product we do in oil and gas industry is international, if we are not competitive, we are going to be out of the market; the only way you can be competitive is to have your unit operating cost per barrel at a global level."* ***RP19***

The competition can be influenced even at the external level, and competition is done with external partners from other industries – for example, a company's tendency to examine what their competitor is doing and adopt something different. In the context of the adoption of Blockchain, technology competition can trigger the adoption. According to RP09:

> *"So, we have that tendency in organisations to be competitive, and if your competitor is doing something difficult, you might want to check that out and also be able to do it just in case a competitor should not [out] smart you. Competition is not among company but among supply chain; if other companies start adopting it, everybody will start considering it."* ***RP09***

One of the reasons for impulse competition from some of the interviewees' perspectives is the lack of interference from the government-controlled organisations:

> *"The reason is today the government has control over the entire value chain because the government interferes, the various players are not open to compete because there is no competition, and mind you competition brings an increase in productivity, triggers everyone to want to deliver to his customers' value as a reduce cost, today entire value chain is controlled by NNPC."* ***RP13***

Despite acknowledging the government's interference, some of the interviewees make the environment hostile to competition. Nevertheless, there are chances that in the near future, there is going to be some growth in Blockchain technology adoption based on the ability of the technology to solve the industry's supply chain challenges:

> *"In the next 10 years, you will see the massive growth of the technology industry. But, because of competition, once the government hands off and introduces competition, the enterprise will now look inward on how best to offer value, the same value as to reduce cost by improving the internal workings, processes to drive efficiency, automating a lot of things, and investing in initiatives of enablers that will make that happen which is where Blockchain comes in, then they will be able to appreciate and quantify the return on investment for each of this initiatives."* ***RP13***

The competition can bring innovative and investment solutions to the industry and can serve as an enabler to the adoption of the Blockchain. Although some interviewees faulted that the technology

itself is not competitive, that is primarily due to the extent of knowledge and understanding. The more there is competition in the space, the more companies will explore and adopt:

> *"If we look at Blockchain, it is not competitive, for now, the level of knowledge and understanding is very poor and low, I am not sure every company that is running a Blockchain technology is driving with their supply chain. So, for now, the adoption of technology is very low, and I think if I am not mistaken, I'm not sure there is any in Nigeria."* ***RP15***

The above emphasised how competition can drive the adoption of Blockchain technology and the form of competition both at the internal and external level, as well as the way they affect the influence on the adoption of the technology. This is based on the perceived industry dynamics and how proactive the stakeholders accept Blockchain as something that can provide them with the solutions to their supply chain.

6.3.1.2 Unethical practices

Unethical practises have been identified as a factor facilitated by industry dynamics that has a negative impact on the scalability of any innovation with the potential to bring different practises among supply chain functions. Most participants cited unethical practises among partners in the pursuit of an opportunity, particularly on the public side of industry management. One interviewee, for example, mentioned:

> *"Before that full adoption and implementation, I am thinking that the parties that are actually into that will use it to their advantage basically to either get an edge or fall into the wrong hand, it can capitalise on exploitation before it then becomes common."* ***RP05***

Early adopters and drivers of technology, according to the interviewees, take unfair advantage, which can lead to exploitative behaviour and unethical practises. One interviewee agreed with the findings that procurement is threatened by various types of unethical practises such as fraud, corruption, and exploitation. The identification and demonstrated vulnerability of the procurement process, people, and process can have an impact on Blockchain technology adoption:

> *"The chances of a procurement person to be fraudulent is very high because we are dealing with money, we are dealing with contracts, we are dealing with people, and we are dealing with policies. You imagine the pre-tension of a company when you discover that they are sourcing from an unethical source may be child labour is used in the process, maybe is coming from the war zone or somebody is being exploited while he will source for the item, so at least with this technology you can be able to maintain that ethical nature of a job and also be able to fulfil some of the measures [and] concerns that we have in terms of sourcing worldwide (global sourcing), since the world is now a global village."* ***RP09***

> *"Civil society organisation to see us could also be a pressure group because when they begin to prove into some of these issues especially sustainability and unethical procurement practices of course component of the cause to open their records and to show what they are*

doing to protect the environment and some of these technologies we all know are meant to do exactly that for instance Blockchain." ***RP12***

The findings of the interviewees identified a vulnerability in the supply chain and how the desire to overcome unethical behaviour can lead to the influence of Blockchain technology adoption. Furthermore, the findings necessitate a strong push from various stakeholders, primarily external, such as civil society groups. As a result, the responses above demonstrate how the supply chain is vulnerable to unethical behaviour and how these challenges may influence external stakeholders' adoption of Blockchain. Institutions across the oil and gas industry in Nigeria are responsible for setting standards and ensuring that they are strictly adhered to; however, the industry's dynamic has revealed that even the institutions responsible are not adhering to the standards. The industry's commitment to combating unethical behaviour is a strong move, and the industry's commitment to combating that could influence the adoption of Blockchain because it can increase trust and transparency in every operation. The UTAUT construct was not specific to how context-specific factors support technology adoption, particularly dynamic associated factors related to the industry.

6.3.1.3 Resistance to change

The research demonstrates that institutions evolve dynamically because of things that affect norms and practises in a dynamic business-like oil and gas. The adoption of breakthroughs like Blockchain technology is hampered by resistance to embracing and adopting those changes, according to research. The interviewees provided the following collection of responses:

"We have some level of professionalism in the way we handle new events, like the technology but what I do not guarantee is the change mode to get used to it." ***RP18***

"I want to tell you that sometimes you have to sanction some segments to make them use a certain technology, remember the [Treasury Single Account] *TSA how it all started, so getting them to change the local way of doing things can be challenging."* ***RP10***

"We need to set standards to show how we are moving, which will minimise the resistance. If we wait for it to happen on its own it will be more difficult and will not work impact." ***RP05***

"I have seen a scenario where we deploy technologies and the staff refuses to use them or there is an issue, there is resistance, and it all becomes a waste of resources at the end of the day." ***RP09***

From a change management standpoint, the statements above emphasised the reluctance to use and accept new technology. For Blockchain technology adoption, the amount of resistance to change is affecting adoption and use from diverse segments across the industry. Despite the fact that one of the respondents stated that an unconventional way must be utilised in order for anything new to be adopted, RP03 pointed out the relevance of value addition to reduce the adoption resistance:

"Is a technology, is something new for some industries, so as a new tech but since it is

something that is not widely used, so, there would be some king of resistance in terms of usage, so the company will want to see this has been use in terms of benefits from using the Blockchain."

RP03

Because the sector is notorious for its reluctance to change, the relevance of testing the technology and demonstrating that it works elsewhere is important to acceptance. Typically, unorthodox tactics here necessitate understanding the dynamic character of the industry and assembling persuasive factors to get the technology adopted. The presentation has demonstrated how tough it is to use a new technology solution in the replies above. However, as assessed by the respondents, the ability to identify this and apply innovative ways to fix the problem will expedite adoption. Another angle on the discovery is the change management method used to manage change and technology uptake. It is vital to highlight the relevant part that incorporates people, process, and policy to create change as a result of the success of Blockchain technology adoption. These findings do not align with the UTAUT construct since there is no clear approach that demonstrates the effect of institutional resistance to change on technology adoption.

6.3.1.4 Manual process in the supply chain

The oil and gas supply chain has been recognised as having manual processes in supply chain operations. That has affected the level of the adoption of Blockchain technology because it relies on existing technologies. The industry's manual process level has made it possible in practice to resist any possible changes. Manual processes in the industry's supply chain have been identified as part of the industry dynamics that has continuously taken back the acceptance and adoption of new technology regardless of the efforts put together to provide those innovative solutions. One interviewee stated:

"There is a challenge in the process, especially when you are dealing with a manual process, then there is the time lag between when you initiate a transaction to when you end it. But with Blockchain, we are talking about things happening in less than a second that has to be the elimination of the time lag and the fact that you are operating a distributed ledger technology meaning everyone is holding the same data making it difficult for any inaccuracy." ***RP06***

Interestingly, this shows that the interviewees are expectant that the time lag in the procurement process due to the manual process will be eliminated when Blockchain is adopted. The level of how manual process has become compounded to the challenges would help in giving Blockchain technology the selling point:

"Where you are also looking to minimise manual interventions that create the opportunities for things to go wrong, I see that Blockchain must be something that needs to be embraced. Perhaps even faster than anywhere else in the world. So the opportunities are there. I know

the value in doing that and within the oil and gas, the opportunity is huge to deploy Blockchain to manage transactions." ***RP05***

"There is a challenge with the transparency, as long as you are dealing with manual processing, there is always some time lag between the time you initiate the transaction and the time it is completed." ***RP06***

The supply chain transactions end to end suffers from the obstacles and delays of the manual processes in the supply chain and as a result, it affects the integrity of the supply chain process. When process and transactions are manual, it affects the transparency of the whole supply chain. Further, if the manual process affect integrity of transaction as unethical behaviours could take place in the process. RP06 mentioned that:

"Second is integrity through limiting manual intervention, so by limiting manual intervention you enhance the integrity of the process then people will then have a lot of confidence in the transactions and hopefully, that will generate fewer difficulties or challenges around the accuracy of these transactions. There is also the opportunity to completely make supply chain efficient by moving all the transactions from previously manual into the Blockchain space and by so doing, you can actually relieve manpower that was previously assigned to that labour-intensive manual process and clearing of transactions so that the cost per transaction will also be significantly reduced as well." ***RP06***

As expected, the research findings showed the relevance of Blockchain to tackle the manual process and increase transparency as one interviewee admitted that the Blockchain will help reduce paperwork due to the manual process and lack of visibility that current hampered efficiency and transparency:

"The advantage in procurement and supply chain will reduce paperwork and admin cost. It will improve the supply chain's visibility, especially when all supply chain is on the same technology with us. So, it means it has two supply chain-wide adoption." ***RP23***

"A successful adoption is when there is a paperless environment, paperless transaction and all of the information have been captured online, for me that is a success in the adoption." ***RP08***

In another development, one of the interviewees highlighted that the adoption would be successful when the supply chain is paperless. However, a lack of integrity has been identified by the interviewees, who perceived a potential increase in the integrity of supply chains when manual processes are replaced:

"Integrity to limiting manual intervention, by limiting manual intervention, you enhance the process and people will then have more confidence in the transaction. There is also the opportunity to make this completely more efficient by moving all the transaction process that was previously manual into the Blockchain space." ***RP11***

The above conclusions have formed the basis for leveraging the manual process in the supply chain and the possibilities of the Blockchain. The manual procedure would be eliminated, increasing the

likelihood of technological adoption. Supply chain challenges become opportunities to transform industry behaviour. One of the industry's dynamics is the ability to make changes even when they are not anticipated. However, resistance to change has an impact on several potentials to improve the industry. UTAUT has not expressly harnessed difficulties such as manual process and its dynamic in the industry to drive technology adoption. However, the studies highlighted the impact of industry dynamics on technology adoption. There is no evidence from the literature to indicate the effect of industry dynamics and manual processes in the supply chain on Blockchain adoption. Regardless, the findings provided a major context-specific perspective to the adoption of Blockchain in the oil and gas supply chain.

6.3.1.5 Crude oil trading

The most critical resource in the Nigerian economy is the crude oil that the country exports and generates revenues. The critical product that drives the dynamic of the industry is the supply chain of oil and gas trading in Nigeria. The ability of Blockchain technology to provide crude oil transaction history from the first barrel to consumption will make a huge difference and that was perceived to be a factor that will lead to the adoption of Blockchain technology across the industry:

> *"To be able to track, you know from the first barrel that comes out and how that barrel comes out, let me say consumed or something like that is actually mixed. So, what the Blockchain will help us is to digitalise this operation to have an end-to-end visibility of our operations, and also to be able to trace all what is actually produced and how it ended up and also to be able to find, I mean to have the resources you know, part of the things we are suffering in Nigeria is actually the debt. You know, people are stealing the crude, and you know, operators are producing more, but they will say they are producing less all this kind of things, so, when you have the Blockchain actually in the supply chain it will help with that."* ***RP18***

Interviewee RP18 mentioned that crude oil theft is a significant problem in the industry's supply chain. The key point discussed is that the technology's ability to track and trace the crude oil transaction will influence the adoption. RP20 was optimistic that if Blockchain can help with creating value in oil trading through a transparent platform of transactions that will influence the adoption:

> *"So we are optimistic on any technology that will help cut cost and create value to our system in crude trading, I think it should help us create [a] transparent transaction platform for the industry player and the people of Nigeria we account for."* ***RP20***

One interviewee's view was on integrating the digital currency in the joint venture contracting process. Integrating Blockchain technology into that will mean a new powerful tool to trade crude oil globally with no intermediaries:

> *"This crypto technology can help build trust among participating partners especially in contractual arrangement from a joint venture to cash calls to even direct sales - direct*

purchases of crude to petroleum products supply chain. So we expect to see a lot of changes when this technology scale to oil and gas operations in this part of the world." ***RP16***

The findings above highlight an important facet of the oil and gas dynamics: crude oil trade. The speed and efficiency with which the product may be traded and delivered is a critical part of the oil and gas supply chain. The above-mentioned observed opinions highlighted the extent to which Blockchain technology can be integrated into crude oil trading to benefit the industry and its stakeholders. From the foregoing, it can be observed that crude trade is an important aspect of the supply chain that catches the attention of industry players when it comes to the influential Blockchain factors. Adoption of Blockchain in the context of crude oil trading aligns with performance expectations. For example, when oil and gas stakeholders identified the critical nature of crude trading, it could be interpreted as a belief that Blockchain technology will support in trading and transaction accuracy as a result of the adoption of Blockchain technology.

6.3.2 Influence and control

Institutional influence and control were found to be a factors in the adoption of Blockchain due to the nature of the business, actors, and complexity of operation throughout the supply chain. The interviewees recognised that influence and control are significant perceived factors in determining the extent and limitations of Blockchain acceptability in the sector. For example, one of the industry's big companies is controlled by the government, and interviewees admitted that in order to influence specific partners, it is necessary to embrace it, which would give them confidence in adopting the technology:

"If the public organisation we cannot really influence our partners to have Blockchain technology because we are not using it, maybe when we have the capacity and at industry level, we can be able to influence others to adopt the technology." ***RP08***

When technology reaches the level of industry acceptance by the actors, some of the industry's large controllers will be able to influence their industry partners. However, some of the partners are not open to competition, and as a result, the participants will be less willing to accept the influence of others:

"The various players are not open to compete because there is no competition, and mind you competition brings an increase in productivity, triggers everyone to want to deliver to his customers' value as a reduced cost, today [the] entire value chain is controlled by NNPC and Nigerian government which means there is an opportunity for me to improve my internal process at the micro-level, until the government hands-off and allow the private sectors to play just like what happened to the telecommunication industry." ***RP13***

The extent of government control has influenced the possibility of increasing competition since competition promotes progress, creativity, and correct thinking. According to another interviewee:

"The fact that you know it is something that you will be comfortable that a certain group of individuals cannot influence or control it. For me, that decentralisation makes it and gives, I would think stakeholders that confidence that ok whatever that is the commitment or other every term we agree on will be enforced. So it removes that headache of you trying to checkmate or things going the way they should be." ***RP04***

The responses above confirm that the degree of impact of technology is affected by the control of a few key individuals. However, adoption will be strong if technology can provide a solution to decentralisation and control. As a result, influencing partners, external stakeholders, international firms, and stakeholder management is another sub-theme of the data-driven influence and control idea. The assumption that someone influential will persuade others to adopt technology is referred to as social influence (Venkatesh, James Y.L. Thong and Xu, 2016). There are critical stakeholders with influence in the industry, and the influence of those stakeholders in control of resources, finance, field development, or regulation believes to play a significant role in influencing the general adoption of Blockchain in the industry, particularly in the supply chain. The findings on stakeholders and control are consistent with the influence of stakeholders in regulating the level of acceptance in the context of Blockchain adoption in the supply chain.

6.3.2.1 Influencing partners

Some stakeholders would impact the approach to Blockchain adoption more than others in exhibiting the extent of authority and control across institutions. Some of the interviewees express a readiness to urge other partners to embrace the technology. Influence on adoption is a critical component of the adoption choice. Because the level of control exercised by some partners has various ramifications for the deployment of new innovative solutions, institutional influence is important to the adoption of Blockchain technology in Nigeria's oil and gas business. For example, one of the interviewees mentioned:

"If I see the advantage, I will encourage my supply chain partners, it is not enough about what will be and what should be, but the technology is like I can... Why not? I will use that idea internally and externally to my company and our colleagues in the industry; people need to adjust this expected system of operation." ***RP14***

Based on technical understanding, another interviewee believed the following significant partners should use Blockchain technology. As previously stated, some stakeholders have greater influence, resources, and control over the adoption of new innovation:

"Yes, as a long-time practising professional with the knowledge of technology and its impacts on the supply chain, I will influence others to adopt Blockchain because of the potential advantages. But top management of that partner decides to access me on points and see the benefit beyond what we could imagine." ***RP23***

Public sector organisations have limitations on influencing their partners to adopt Blockchain due to their status. Although the interviewee stated that it is because they are also not using the technology so it will be challenging for them to influence others:

> *"One of the sectors being a public organisation that we have now, we cannot only influence our partner to adopt Blockchain because even we are not used to it or using it. So it can be neutral for one to influence someone for something you do not have to start using".* ***RP07***

> *"I believe there is just this type of things they just need, it needs a spark for fire to ignite, I think the spark is there, it is just for the fire now to build and become bigger, I have done that, I think it is something that is worth trying."* ***RP09***

Furthermore, the technology potential has shown to be robust enough that other stakeholders would feel comfortable influencing their partners; the rewards are there; all that remains is for the players to embrace the right-thinking mechanism:

> *"telling the benefit that is actually going to bring to them. In terms of the technology having notes and order that might really not be necessary for the players, what they just need to do is to have a way of doing business that can be easy and transparent for them."* ***RP10***

> *"So I will encourage others you know, supply chain partners to really adopt the technology."* ***RP18***

Despite the fact that Blockchain technology has demonstrated the specific value it can give to their organisations, several interviewees are still unwilling to urge their partners to utilise it. One interviewee stated that they would not be able to enter the Blockchain market rapidly:

> *"It is likely difficult for me to influence anyone to do that. I need to see what is happening in that space to at least influence its adoption. I am not interested in rushing into that, especially the fluctuation in adoption is a big concern—the probability of doing that I will say not certain at least at the moment."* ***RP21***

The comments above emphasised interviewees' perceptions on where, when, and how the extent of Blockchain adoption among partners may be changed. Even though many interviewees recognise the possibility to influence their partners, some are still hesitant to accept and connect with their partners. The findings on the partners and how perception varies are thus important to the UTAUT construct of social influence, however on this point, the impact of the findings reveals the dynamics of influence and control among partners.

6.3.2.2 External partners

The function of external partners was discovered to be part of the influence and control on the industry's adoption of Blockchain. These external partners are seen as stakeholders, with a role to play in the industry's adoption of Blockchain. Many interviewees acknowledged the role of external partners and the overall impact they might have on adoption. RP06 and RP12 stated that:

"Getting all the external parties who will be impacted and who might need to make input to one form or the other and also take benefit for that implementation and getting them all aligned. In our industry, this includes all the regulators, key supply chain partners, financial institutions, and intermediaries." ***RP06***

"I know the National oil company (NOC) will be a major stockholder. Then the IOC which plays a major role in this market then the indigenous oil company that is required to be a player especially a number of them managing marginal field as operators." ***RP12***

Other respondents emphasise the significance of international firms in influencing and managing Blockchain adoption. The major actors in the industry are global oil companies. Because of their global outlook and attempts to promote technology. Interviewees perceive them as critical important partners on the outside:

"So the international companies are more likely to be ready to adopt Blockchain and ahead of the local companies simply because in their footprint elsewhere around the world, they may be adopting Blockchain technology. So it is just to copy for their Nigeria operations." ***RP06***

International companies have critical exposure due to their capability and resources, and their level of commitment will be greater than that of local companies. In sum up, interviewers perceive them as the most important partners in promoting adoption before any other stakeholder:

"The international companies are more likely to be ready and for Blockchain implementation ahead of the local companies." ***RP11***

According to the interviewees, despite the fact that national firms own 50% of international oil firms in Nigeria, they believe they have the ability to make things happen correctly, making them more important partners in the adoption cycle:

"So, the ease of adoption will be [there], because anyway the operation of the oil and gas is highly dominated by international companies in Nigeria, with the role of the national company and other indigenous producers [being] really very low. And you see that the international oil companies are really the people that can really put straight forward. And in the national oil company and other companies are also big stakeholder's especially national oil company because the national oil company has the largest share in all the operations of the companies. So, I feel that you know, the great stakeholders are the international oil companies, the national oil company and the regulator because the regulator has to approve every technology adoption and a new procedure for carrying out things." ***RP18***

In summary, the interviewees' statements demonstrated a finding on the external stakeholders and the strong influence and drive they hold to the adoption of Blockchain technology than other stakeholders not categorically identified. However, interviewees clearly identified that international players in the industry will be more impactful to the adoption, owing to their amount of access to resources and improve innovation. The UTAUT construct of facilitating condition

denotes the influence of resources and management support on technology adoption. A study conducted by (Malik et al., 2021) revealed the clear role of top management support as a factor in the adoption of Blockchain in an organisation through top-level decision makers. Identifying the relevant stakeholders who will drive Blockchain adoption is a critical finding for Blockchain adoption is consequential to the development and acceptance of Blockchain for the oil and gas supply chain.

6.3.2.3 Stakeholder management

Interviewees mentioned the function of stakeholder management at the institutional level to manage the influence and control among partners and stakeholders. For example, one of the responses notes that in every section of the market, there are varied stakeholders and for Blockchain technology to be adopted, stakeholder management is required:

> *"In every industry segment relating to your study's context, we have diverse stakeholders even within the supply chain. I mean that stakeholder management will make the solution to scale through instead of having a single element to dictate to others".* ***RP22***

The interviewee further added that engagement and openness among stakeholders are essential to give the necessary acceptance to the technology. No stakeholder management without effective and collaborative engagements and transparency of information, ideas and strategic plan. RP22 posited that the:

> *"… industry has to brainstorm first and identify areas that this technology can make better, be it cost savings, efficiency and even transparency. The key enabling factor is engagement, openness, and the benefit it can offer if clearly understood."* ***RP22***

> *"I will suggest the need for more education, enlightenment and engagement with more stakeholders to understand and evaluate the powers of the Blockchain technology. In doing so, many interests can be developed, and we will see massive-scale adoption."* ***RP22***

Institutions responsible for developing industry policy and frameworks are being identified as the focal point of stakeholder management. As a result, stakeholder engagement goes hand in hand with policy formation, so that industry stakeholders and players can contribute to the design of the framework for adoption:

> *"The keyword here is regulating but don't [create complexities] because sometimes regulator comes with a big hammer to kill a fly, and it doesn't work that way. The need to have stakeholder engagement in policy formation input from the industry participants in the rulemaking process is a regulatory framework that will be extremely important if the regulators will succeed in their quest to regulate the industry."* ***RP01***

Another interviewee stated that the stakeholders are the organisational decision-makers and, as such, they need to be on the same page before making any decision:

"The key stakeholders and organisational decision-makers need to be on board, anyone who can make decisions needs to be aware of Blockchain, then provide infrastructures, the knowledge and information, the education need to be an enabler … we need to split up, people need to be fully aware of it." ***RP15***

Another interviewee identified a key to the successful adoption as relating to if the big players can support the proper stakeholder management and provide the necessary support to all players by providing a platform for the awareness and addressing their concerns:

"I am sure that if the concerns are addressed, there will be a successful adoption in the oil and gas industry with the right support and with the right you know, example, especially by the big oil and gas players. So, in my view, if this is addressed, the big players adopt it and there is support from the stakeholders, so there will be a successful adoption." ***RP18***

Stakeholder management was perceived from the standpoint of getting the participants to appreciate the benefit of the technology, providing all the support that Blockchain technology adoption requires, and fostering open conversation to resolve any stakeholder concerns about the technology. Findings show that the interviewees emphasised the importance of stakeholder participation in Blockchain adoption within the industry. In general, the role of influence and control lies within the UTAUT construct of social influence. Other findings under the theme show the effect of facilitating condition of external partner due to the consideration of the role the partners could play when adopting and influencing other stakeholders on the adoption of Blockchain in the oil and gas supply chain.

6.3.3 Institutional collaboration

Institutional collaboration was regarded as an acceleration driver to the specific aspects that provide some significant potential for the adoption of Blockchain in the supply chain based on the interviewee's responses. The perceived adoption's accelerated drivers are drawn from the aspect that has proven to work in the industry when adopting industry-wide innovation. Institutionally, there should be outreach and collaboration. Generally, responses across the interviewees indicated critical elements of the supply chain optimisation and improvements as the force to that will bring the institution together and accelerate the adoption of Blockchain technology. In the words of two of the interviewees, the policy direction research and development are drivers for the acceleration of innovation and technological advancement in the industry, yet working together at institutional level is the influence on the adoption of Blockchain technology:

"Policy direction from all the parties involved in the adoption of Blockchain, areas of application that has meaningful values, especially the transparency, cost-saving, building stakeholder confidence and so on. For that reason, institutions must work together." ***RP01***

"In the corporation today, we have a research and development institute that are using their

platform to drive the adoption of such technologies, the research institute is looking for scanning the environment to see what the best way is to do our business, the most optimal way and most importantly is to impact on our bottom-line and add more value to it. Things like this will bring collaboration and working together across industry line." ***RP03***

Another interviewee added that anything to do with cost optimisation could accelerate the institutions to work together toward adoption. However, RP03 mentioned cost benefits as an incentive to bring stakeholders to work together:

"If the cost of sourcing of vendors in the Blockchain technology should be lower than the way we are doing it now. Then the information can easily be circulated or transferred from one company to another. So, I believe the sourcing of vendors may be used to accelerate the adoption at institutional level." ***RP07***

"If it is our platform, we are already working on a Blockchain solution for the industry itself, I will say we are ready, but the players are not yet ready until they see a solution that makes their trading activity easy and then reduce the cost of their trading activity, to make them more money and the ease of trading. I think we will get more people involved." ***RP10***

The ability to bring the stakeholders together and show leadership by employing the technology adoption policy can accelerate the adoption. RP19 perceived the global desire for excellence in the industry as the acceleration driver to adopt the Blockchain technology:

"I think there is some level of knowledge to kick start adoption, and I think it is incremental, but the first thing is to sell the benefit to stakeholders, if you do this, it will impact your business, and once they adopt that easily they can upgrade. The global desire for excellence will accelerate Blockchain technologies and quick adoption in Nigeria." ***RP19***

A significant number of the interviewees have shown the importance of organisational alignment in any innovation across institutions and players in the industry. In the case of Blockchain technology, most participants are poised that they are keen to adopt the technology because it has aligned with their continuous improvement system. For example, RP03 stated that:

"We are very much ready to use it, this company is about quality management system continuous improvement, anything that will help the corporation to continuously improve the bottom-line, efficiency and add more value to our business for the benefit of our shareholders and stakeholders we are more than 100% available to adopt that. I would say we are very ready for that, what we just need is someone to champion and to tell us what the cost-benefit of this technology is, we are open to innovation." ***RP03***

Many interviewees agreed on the alignment at the institutional level when all the stakeholders' visions were aligned with the output of the technology:

"Getting those entire groups together aligning all their interest and what they want to see in the implementation of Blockchain is the requirement to enable effective role out of Blockchain. In a word, you must have stakeholder's alignment." ***RP11***

Because the market is so competitive, technology innovation is a top priority. Every company wants to run as efficiently as possible, and they think Blockchain technology can help with that. Even the government is encouraging operators to try new things, which led to the licences of inefficient operators being taken away and given to those who want to add value, according to RP19:

> *"…to remain an active player and efficient operator, and if they see that the only way to become an efficient operator is to adopt Blockchain technology, they will do it because that's the reason why we are here; and why is that an important thing is because the government is giving them the* [licences], *is taking away* [operational Licenses] *from people who are less efficient, that's why we have marginal field operators."*
>
> ***RP19***

Further, the alignment of people, the organisation, and the stakeholders with the output of the technology will increasingly help scale the adoption, according to one of the interviewees RP07:

> *"I think it is the willingness to accept the system and its perceived usefulness will give it the necessary scalability so that the impact will be achieved. In public, the staff have to be in alignment with the use of technology and build understanding to help and pass their own demands for growths— so top-level buying and staff willingness to adopt and regulatory agencies to guidance as well."* ***RP07***

According to the findings above, the level of activities resulting from institutional collaboration is what the oil and gas industry can do to accelerate adoption. The perspectives of the interviewees indicated what can bring organisations together and achieve the best results from adopting Blockchain technology. The role of actors in technology adoption is critical to its success, but for Blockchain to work in the supply chain environment, the entire network of supply chain actors must be on board (Kshetri, 2018). The UTAUT constructs do not specify the role of collaboration in technology adoption; however, previous studies have shown the effect of collaboration in technology adoption, such as Gurtu and Johny (2019), who stated that the diverse stakeholders in the supply chain are the main determinants of Blockchain adoption in supply chain, due to the constraints that every player has some level of capability that can affect competitiveness of one another.

6.3.3.1 Automation and autonomous decision

An interviewee discussed the ability to automate the supply chain and have a self-decision mechanism for the adoption of the Blockchain in the supply chain. The extent to which the technology will support automation was mentioned as the acceleration factors, particularly when the ease of use of the technology can be justified:

> *"I think the regulators should make the ease of using Blockchain a requirement. So, one if you must use it, make it easy for people to use it, and they have to put in place parameters to check and ensure that this requirement has been complied with".* ***RP02***

"Blockchain can also assist in helping system make decision on critical components of the oil and gas supply chain operation. The advantages are numerous." ***RP05***

The interviewees saw opportunities for integrating Blockchain into autonomous decision making in situations where human intervention could be limited. This discovery is critical for addressing the complexities of trust and transparency in the oil and gas supply chain. The findings show that if the supply chain can become autonomous, it can help accelerate adoption because of the benefits the interviewees saw in eliminating third parties in their supply chain. Many interviewees identified a decision-making feature that, in their opinion, can improve efficiency and reduce payment fraud:

"If we are looking at human-operated systems, I think we will do just fine, because what we only need, is to build bridges, APIs, middleware and then the Blockchain brings its data in, the middle ware interprets it to what the existing system can do, logic can be applied, and decisions taken. But if we are looking at going to automation, it may be a bit difficult, we will not be able to have an autonomous system, but we should be able to integrate seamlessly into human management and control systems." ***RP05***

Additional interesting finding was stated by one interviewee that having a paperless built solution supply chain environment will be a dramatic acceleration driver and influence the adoption:

"To consider successful adoption is when there is a paperless environment built on supply chain based Blockchain solution, and when the industry can drive the needed value from the adopted technology promises. So the introduction of Blockchain can only be successfully adopted when all the key stakeholders have a key in from upstream to midstream and downstream." ***RP07***

"I also see the opportunities of time that into artificial analytics intelligence as the digital data continues to grow that accumulate could be drive in Blockchain to get quality analysis and decisions relating to supply chain management transaction that can then informed decision making and value extractions for the industry." ***RP06***

The industry was some discussions at the highest level to automate supply chain activities and Blockchain was perceived to be a platform that can facilitate the automation:

"I have participated in many high-profile industry discussions on how the industry can benefit from Blockchain technology, specifically automation, increase transparency and efficiency in the day-to-day activities of the industry." ***RP16***

The findings presented above have highlighted perceived factors related to institutional-led themes, with a focus on the role of industry dynamics, influence and control, and factors that led to the acceleration drivers for Blockchain adoption. The institutional findings have a significant impact on emerging factors that will influence industry-wide adoption beyond individual company initiatives. The UTAUT construct recognises the importance of the belief that the decision to adopt technology was triggered by the belief that the technology will help achieve the objective. The findings under institutional collaboration and automation are critical to influencing Blockchain

adoption among supply chain stakeholders across institutions in the industry, but it could also mean that the UTAUT model's performance expectancy aligns with the participants' belief that Blockchain was viewed as an option to automate supply chain in the industry.

6.4 Technological

The section presents the findings from the technological classification themes. In this research, the technological category includes all relevant factors and findings related to technology views on the adoption of Blockchain technology in the oil and gas supply chain. This category contains the themes internet, infrastructure and connectivity, data security, implementation cost, and technology user acceptance. The themes describe how the findings demonstrate the relevance of the UTAUT construct of effort expectancy and facilitating condition as a factor in Blockchain adoption in the oil and gas supply chain. All analysis of these themes is based on the participants' responses to provide an outcome and its significance in this research.

6.4.1 Internet, infrastructure, and connectivity

The technological component of categorising the themes is critical to understanding the view of Blockchain technology's adoption in the oil and gas supply chain. Internet, infrastructure, and connectivity are important topics to discuss because they are critical to the development of any technology. Internet connectivity, compatibility and integration, cloud infrastructure and the 5G network, and power supply stability. The sub-themes listed demonstrate the importance of the technology category in the adoption of Blockchain technology, as well as the interviewees' belief in the importance of internet, infrastructure, and connectivity. The interviewees shared their perspectives on the internet and connectivity; for example, one stated that the sector is not digitally creative:

> *"I think we have talked about infrastructure requirements earlier. Nevertheless, that is another aspect that, in my opinion, will be a barrier to adoption. Apart from the national oil company and the international oil companies (IOCs), most local companies are not digitally innovative. The local players are critical because they have a lot of the top end supply chain activities. So, for the industry to be fully embraced with Blockchain-based solutions, there is a need for massive infrastructure to accelerate the adoption."* ***RP22***

> *"We are not in control of the entire infrastructure, within the industry, we can control but once you give it to service providers it is outside the core oil and gas companies to manage you will begin to have challenges."* ***RP05***

The interviewee stated that the industry has no control over the infrastructure to develop the technology sector, many of the policy related to technology are handled by the IT regulator and the

digital economy Ministry. However, RP07 confirmed even the level of innovation and the capacity to develop IT enabled solutions are not available within the industry:

> *"The infrastructure, IT might be there to make it easy to for many companies not only the oil and gas.* [So to make it simple] *with the right skills, knowledge transfer the technology will be easy to adopt and use by companies."* ***RP07***

> *"IT might not be there for now, which also will have taken to some other industries in Nigeria."* ***RP08***

> *"Basic infrastructure is lacking, and within organisation Blockchain technology you are not isolated by yourself, you have to relieve with somebody, all the various stakeholders need to be at the same time developing hand in hand."* ***RP19***

The view of the interviewees is the industry is lacking technical capacity to drive the adoption of Blockchain technology. The findings recognises that it is due to the lack of IT capacity internally, the technical infrastructure and access to the internet are lacking:

> *"The technical infrastructure having internet access and enable to have a digital transaction, and if you look at what is going on at the Fintech space in Nigeria, it suggests that; that can only grow and infrastructure can only become more robust to support processes and technologies like Blockchain, that's what I see coming down."* ***RP11***

The findings revealed the effect of lack of infrastructure to the adoption technology. The uniqueness of Nigeria and the difficulty in technological advancement has put many innovations on hold. According to RP09:

> *"I will say it is going to be very difficult in a short time and because the reason is that Nigeria is a unique environment if I want to say very unique environment in terms of technology adoption because even the main areas adoption is difficult like for instance doing electronic business and all that is a bit of a challenge because of infrastructure."* ***RP09***

While several interviewees highlighted the constraints of capacity of the technology, one interviewee argued that infrastructure reform can be a form of an enabler:

> *"I think we need total infrastructure transformation, so that could be a big disadvantage in terms of cost, time and technicalities."* ***RP16***

> *"The other thing I said is the existing infrastructure that we have which will also help you know, is an enabling factor in adopting it."* ***RP18***

The interviewees have shown the opportunity that telecommunication infrastructure can make in the adoption of the Blockchain:

> *"Infrastructure, telecommunication infrastructure, energy infrastructure, and the market's desire, because the market is desirous for optimal efficiency, that desire remains and the infrastructure."* ***RP18***

The previous responses have provided knowledge of the state of infrastructure for Blockchain adoption. It has also enabled the research to reach a conclusion about the importance of infrastructure in the adoption of Blockchain in the oil and gas supply chain. The findings fall within the construct of the UTAUT model of facilitating condition, even though the infrastructure is not available to drive Blockchain adoption in the industry. It is critical to provide the necessary infrastructure and ensure that the level of infrastructure is adequate for the standard of Blockchain application. As a result of the stakeholders' belief that the infrastructure, when available, will support the adoption of Blockchain in the industry, the findings could also be viewed from the perspective of performance expectancy.

6.4.1.1 Internet connectivity

Internet accessibility and connectivity are the backbones of any technological development. The means of connectivity is critical to the success of any technology. The interviewees have posited that the internet and connectivity as an influential factor both as an enabler and barrier to Blockchain technology in the oil and gas industry. The interviewees positioned Nigeria as one of the best destinations for effective internet and showed optimism that Blockchain will work with the current internet connectivity:

> *"Well, Blockchain thrives on top of web technology. Currently, we have reasonably ok internet penetration so to speak, but then we also need to work on the connectivity to make them stronger and make bandwidth available so that you know seamless communication and transfer of data can actually work better."* ***RP01***

> *"In Nigeria, IT, internet I think that apart from the IT is there, Nigeria has a wonderful backbone of fibre networks that is used by all the telecoms and service provider that will serve, guess what I think that Nigeria will easily adapt this and it will easily work because they are company, for example our banks works seamless, you can do a banking almost any time of the day without any problems. So, the backbone is available."* ***RP02***

The extent of internet availability was recognised as an enabler that can support the adoption of Blockchain technology in the industry, as mentioned by the interviewees. However, one interviewee was specific on the advancement of the internet infrastructure in the industry and his observation that alone can support the adoption:

> *"Well since it is technology-driven, I think the industry has come a very long way in terms of infrastructural strong in terms of IT, so since we are running SAP and other IT solution so I believe the existing infrastructure should carry the basic requirement for the Blockchain to thrive and as I said it all about being cost effective if using the Blockchain will make us to spend more on infrastructure without a proportionate benefit using that. It may be a factor not to invest but if it is another way round that you do not need to invest more than just small upgrade but the benefit outburst the cost, we can do that. So, I believe if we use that the current baseline infrastructure we have Blockchain today will be able to thrive but if there*

is any need for upgrade it will be costly for the industry." ***RP03***

The interviewee pointed out that the extent of the availability of the internet has supported the adoption of SAP system in the past. Similarly, the call for more investment into the ICT infrastructure that will enable internet penetration will influence the adoption of Blockchain today. Another interviewee added that the availability of internet can influence the adoption of innovation and accelerate adoption:

> *"Well, like I mentioned, we already have a good internet quality in Nigeria, it is not restricted like in other countries, the cost will also be a factor to look at giving all these dimensions, if all these are put in place, we will ensure that data and information to Blockchain technology are secured if the technology is affordable and not overly expensive."* ***RP14***

Despite this positive outlook in terms of the quality of the internet in Nigeria, other interviewees argued that the infrastructure that enables the internet connectively is not yet there and that will affect the adoption of Blockchain technology:

> *"At present, the instability in internet and data connectivity could be a problem to Blockchain adoption in the oil and gas and power supply."* ***RP20***

> *"That is where the challenge is because the infrastructure has to be there. The internet must be effective for Blockchain to thrive in this industry. The infrastructure has to be there."* ***RP22***

The findings reiterated the extent of internet connectivity in the Nigerian oil and gas sector, in addition to how the availability of existing internet connectivity can benefit or hinder adoption. Other interviewees, however, indicated that a lack of greater internet and connectivity would impede adoption. Currently, there is no internet connection available to facilitate the adoption of Blockchain technology. The UTAUT construct recognises the impact of technology support and how the availability of support influences behaviour to adopt and use technology.

6.4.1.2 Compatibility and integration

Compatibility and integration with existing systems is a critical step in the adoption of Blockchain technology. RP02 mentioned that they were optimistic Blockchain will be compatible with the current system in operations in the industry. Blockchain is not a standalone technology and the ability of the technology to integrate and complement existing systems is critical to the adoption decision.

> *"Ok well, based on that I think I am sure it will not be such a big deal; integration is one very huge thing that is happening in the world, all the technology is becoming seamlessly compatible. I think it can be highly compatible they can work together."* ***RP02***

According to the interviewees, technology is becoming seamless to integrate with any other technology, and the compatibility will not be a problem when the industry is ready to adopt

Blockchain for supply chain. Furthermore, the industry currently uses the SAP system, so the integration of the SAP with Blockchain can be done effectively with RP03 and RP09 stating:

> *"Currently, we use SAP system application product, and I am not an IT person, but I believe their whole lot of technology integration along that so they should be able to integrate with SAP easily. That is if Blockchain is that user-friendly and so on. It is a new technology the SAP is robust, then they should be handshake."* ***RP03***

> *"Yes, it can be compatible because for now, the level of effective ICT adaptation of ERP system, system application and products are becoming compatible with other technologies, so with that already in place and considering the huge investment, the developers of Blockchain will not expect companies to leave their system and go for Blockchain but instead find a way to integrate Blockchain."* ***RP07***

> *"I think if Blockchain can work, SAP, for instance, came in, the only thing that was done was to develop a network, the network now integrates with all party application."* ***RP09***

New investment infrastructure due to advances from the legacy system is another aspect that one of the interviewees highlighted. At this moment, it will be early to see where the Blockchain system can be compatible with the existing system but when the decision to adopt Blockchain comes into play, the industry might need to consider the technology readiness level to check the maturity of individual technology and the collective infrastructure to determine the extent of compatibility and integration or investment required:

> *"I want us to digest where the industry is at the moment. Yes, we have had so many technology-driven initiatives over the years, are they compatible with the existing system they met? Not really in some instances. So, for me, Blockchain technology should be consistent with our legacy systems to scale through. That will make it more buyable to the companies because they will not have to invest in another infrastructure or hardware set. Based on my knowledge, I cannot give you an account of where the Blockchain solution would be compatible with our legacy system. Still, from what I know, all modern innovations come with improvements to what we used to have to meet the exact compatibility we are discussing."* ***RP22***

RP13 has a contradictory argument that compatibility will be one of the issues of adoption of Blockchain technology in the industry based on previous technology adopted. The compatibility to extend poses some risk to the adoption according to RP22 and RP13:

> *"I say alignment, compatibility could be one of the issues we have to deal with, with the adoption of Blockchain, if you want to bring any technology compatibility is always an issue, and for Blockchain, I think it is going to be an issue with how it is compatible with the existing systems. So with the little I know about Blockchain, I think Blockchain is next after the internet to disrupt the internet there is no alignment with the current framework, I do not believe, so compatibility will be a big issue."* ***RP13***

> *"Well, compatibility, I don't see any problem with compatibility. Because the world is a global village. IT system now is unified across the globe. Whatever we use, there is the*

unification of technology and application. Aside from availability issue and standard in terms of what is available to us here in this market is almost unified." ***RP12***

There are two opposing viewpoints on compatibility with the existing system. The importance of compatibility to the deployment of Blockchain in the oil and gas supply chain is vital to the discovery. No business will invest in new technology while ignoring existing technology. However, if the current system can be readily integrated into the new technology, Blockchain has a good possibility of becoming a technology that will persuade other parties to use it. RP06 stated the significance of system integration:

"On the interface with other systems and database usage, I am sure that will be less of a problem, due to how user-friendly application and database are becoming over time, Blockchain will not be different." ***RP06***

"Like I said, you know the process content the oil and gas system has gone through several cycles of the introduction of technology and Blockchain will be just one. Apart from the technical management of the transition to new technology within the oil and gas. What is then remains is how to align other stakeholders who will be impacted i.e., the supply chain partners, the financial institutions and all others in that chain. I think that once that can be project managed, the offtake of Blockchain should not be more difficult for instance, than the ERP systems in the past so that is my take on the compatibility." ***RP06***

The element involving people and process is critical to technology integration, and the success of technology adoption is defined by how successfully the integration occurs between people and process. To achieve success, interviewee RP17 stated the seamless integration of people, processes, and policy with Blockchain implementation. According to the research, one of the obstacles of Blockchain is cultural resistance based on established company processes and models, as well as people's attitude toward technology innovations (Patel et al., 2017; Wang et al., 2017). As a result, aligning people's processes with technology, influences their decision to accept the technology. In addition to the point above by RP06, RP17 emphasised the compatibility with other technologies taking into account people, process and policy:

"A successful adoption is when we create the smooth running of this solution seamlessly. Blockchain solutions can only be successful if full integration between people, process, policy and technology handshakes seamlessly. We have witnessed other solution that has not met up to the above expectation, so we cannot consider it as successful." ***RP17***

The compatibility and integration of the Blockchain-based solution have been identified as a factor that to the adoption Blockchain technology, and the element of compatibility with other technologies has been recognised as the most critical part of the influence to the adoption by the stakeholders in the industry. Although participants have typically witnessed less integration with other parts of the system they used or currently in use, other views emphasises that integration should go beyond the system to the system by taking people, processes, and policy. UTAUT

constructs of effort expectancy put in to account the ease of use and adoption of technology. The compatibility and integration forms part of the ease of adoption due to the opportunity to utilise existing technology base. The literature evaluated demonstrated real solutions that provide provenance through the integration of IoT and Blockchain-enabled systems (Mathijsen and Sadouskaya, 2017; Kim *et al.*, 2018; Vinay Reddy, 2019). Another review result is the integration of Blockchain with Enterprise Resource Planning (ERP), which is one of the prospective technology-based systems that is widely accepted and used for supply chain management across many functions (Banerjee, 2018).

6.4.1.3 Cloud infrastructure and 5G network

Cloud infrastructure and the fifth-generation network was found to be among the factors that enables the adoption of Blockchain in the oil and gas supply chain. The interviewees mentioned cloud infrastructure as an enabler with the internet, infrastructure, and connectivity. In addition, some interviewees stated that they have cloud infrastructure that can enable the application and adoption of Blockchain. The extent of identifying cloud as a significant factor to the adoption show that the industry has the ability to host Blockchain solution, as many of the solution are cloud based.

> *"The major one is the cloud infrastructure that we now have. that is now available very much everywhere. Cloud infrastructure has made this something that is possible. It might be able to reduce the capital outlay that that is needed to start or kick-start it."* ***RP12***

The interviewee further suggested that the use of cloud solutions for Blockchain will enable the industry to adoption because it could reduce cost of adoption since on cloud you pay as a service for facilities utilised. An interviewee provided an example that if cloud was to be adopted the industry can easily adopt Blockchain technology:

> *"In terms of infrastructure, if we adopt the cloud, we are on the run, we can go ahead that is an enabler for the Blockchain adoption."* ***RP12***

As mentioned by RP12, another interviewee added that cloud infrastructure would be a significant facilitating condition. While RP16 and RP17 posited on the cost benefits of a cloud solution and how that would influence the adoption of Blockchain:

> *"The major facilitating one is the cloud infrastructure that we now have, that is now available everywhere the cloud infrastructure made it something that is possible, it might be able to reduce the capital if that is needed for us to start this."* ***RP16***

> *"The facilitating one, the major one is the cloud infrastructure that we now have, that is available pretty much everywhere. The cloud infrastructure has made this something that is possible, and it might be able to reduce the capital outlay that is needed for us too."* ***RP17***

However, the role of role of internet connectivity and speed is critical to the adoption of new technology. The 5G network, was captured by the interviewees in influencing the adoption of Blockchain:

> *"Let us look at it this way, what do we have on the infrastructures other than the internet platform, all the internet service providers and all part of the stakeholders are all there to reach what they have gained, legal infrastructure, financial infrastructure to me am not sure the infrastructure is a challenge to the adoption of Blockchain. Government can decide to roll out 5G just to get the Blockchain scale through."* ***RP15***

Despite the technology having an unpleasant experience from the beginning when it was initially piloted, the interviewees perceived the implementation of 5G network as a driver that will enable the scale through of the Blockchain technology:

> *"It's just like the experience we had in the 5G in Nigeria. You know, because stakeholders are also, there is a conspiracy theory that is related to or is being to 5G, you can see that in Nigeria some stakeholders are frowning at 5G and what you see is other African countries are adopting 5G, but in Nigeria, we are not because there is no support from the stakeholders. The regulator even came out to say that we are not giving any licence for 5G, so that from their every effort for 5G is going to be killed. So, the point is if the regulator and these key stakeholders are mentioned accept it and support it, it will see the light of the day."* ***RP18***

Even though just the interviewees mentioned it, 5G is significant in terms of Blockchain adoption given the current condition of internet connectivity in Nigeria. It will aid in providing the necessary high-speed transactions, which will aid in connectivity. Cloud infrastructure and 5G demonstrate the importance of connectivity as a driving force in adoption. The UTAUT concept of facilitating conditions highlighted the need of available technical and management support in technology adoption. The availability of cloud and 5G support adoption from the standpoint of UTAUT, and as technical support to drive Blockchain adoption.

6.4.1.4 Stability of power supply

The stability of the power supply has been a problem in the county for an extended period. The interviewees mentioned the stability of power as a perceived factor to be considered in relation to the internet, infrastructure, and connectivity. The lack of power supply will have huge cost and technology scalability across the industry. For example, RP05 clearly stated the lack of stable power supply as a setback to the adoption of Blockchain:

> *"I think we have sufficient computing power; we have sufficient bandwidth requirements. The one more thing that may not be there would be power (electricity) and the knowledge and maybe possibility a workable or a practical business model because doing the thing is one thing but doing it the right way is another thing."* ***RP05***

> *"Business moves, systems understand their needs, but the infrastructure required to achieve*

that power, the systems need the power to run." ***RP05***

Despite the massive potential of Blockchain and other related technology solutions, the power supply stability may be considered to be a potential challenge that needs to be overcome to achieve the technology adoption:

> *"I like your emphasis "in Nigeria" because in Nigeria there is what they are doing now that is called Digital Oil Field Operation, but in Nigeria, there are a number of challenges I can see, it is a country with huge potential, but power and energy in terms of even an ordinary power is a challenge, we are low in a power outage that's one challenge."* ***RP19***

Lack of power supply has wasted investment in IT and telecommunication in Nigeria according to RP10 and RP20:

> *"Power, if there is no power, is a waste of time, telecommunication infrastructure in Nigeria, most of the failures around the things we do in the industry, is the inability of you to communicate with the various stakeholders"* ***RP10***

> *"Most of the companies are running on alternative power like a generator and it is not even 24/7, so you can imagine for a technology like a Blockchain to go completely off power".* ***RP20***

A Blockchain implementation cannot operate with a lack of power supply and stability, and the interviewees' perception is that power must be available if Blockchain should scale through the industry. The influence of power means that the device will require other energy sources, which could add to the system's maintenance costs. One of the interviewees mentioned how they use generators as an alternate power source, which will not lead to more adoption of Blockchain systems. Power supply has been a vital phase in the enabling condition since without power, the system cannot function, which may result in adoption failure.

6.4.2 Data security

The potential security breach and data risks are something that was captured within the themes of internet and connectivity. Data security has been mentioned by the interviewees when outlining the adoption of the Blockchain within the industry. The interviewees stated that they still anticipate risks associated with their data. Blockchain offers secured data storage and transaction system, the solution was considered as secure due to its decentralisation nature, yet the interviewees are reserved to the aspect of data security. For instance, RP22 mentioned:

> *"We could still anticipate some potential risk if you like that could potentially be a disadvantage, data security, so the notion that it is open and transparent we have to be careful with our sensitive data probably should there be any chance of compromise from the system."* ***RP22***

The genesis of data security is the ownership and protection of data. The findings show that data protection is essential when it comes to the adoption of Blockchain in the oil and gas industry. The industry has records of protecting data and perceives data as the most valuable asset, so the analogy of the decentralised data will create the opportunity to drive data security if that is guaranteed. RP17 and RP09 pointed out that:

> *"The other part is, we know that in the industry, a whole lot of companies and even nations try to protect their data in terms of how it is being used, what do you call it now, intellectual properties and things like their differentiation, what differentiate them from others. So you will see this protection reason will be eroded if it is left open in the Blockchain open and transparent operation like Blockchain."* ***RP17***

> *"You know IT platforms are hard, and the data for us is key, and in most cases, we protect it with all we have, so when we threw a data out there, many people are going to be using the decentralised system that doesn't have control, it is a bit difficult scenario and it's a good chance that might be exposed, the company might be disclosed in the process."* ***RP09***

The disadvantage of the Blockchain in these early days is the perception of the people and how scared they are of the security even though it has the potential to protect data:

> *"The issue of disadvantage; people have been scared, we have the issue of fraudster online, scamming, hackers. Nigeria is top on the lines of cybersecurity threats; that can be a disadvantage to our collective efforts."* ***RP15***

The interviewees mentioned hacking, manipulation, and fraud as top security challenges associated with Blockchain technology. For example, RP15 posited that:

> *"Because of hacking, internet manipulation and fraud start with the lack of expertise because any mistake in the cause of transaction can run the money into another platform, evident from the bitcoin transactions so far. It can cause a loss; I mean a very serious one. If it is implemented vigorously, I would say yes it will help us across the industry in more significant information transformation within the supply chain."* ***RP21***

The protection and control of data is essential for the adoption of Blockchain. As part of data security, the interviewees mentioned data ownership and control also known as sovereignty as a factor in the adoption. RP12 said the industry is concerned about data sovereignty and any technology that exports its data will not succeed at the industry level:

> *"I know that nations are concerned about data sovereignty and how data is being guarded in terms of data that are critical to the nation. For us in this industry in Nigeria, I know that there is data sovereignty issue that we need to contain if you want to go full-blown into the cloud. So that is the only thing."* ***RP12***

RP16 further confirms that data sovereignty is an issue within the industry:

> *"I know that nations are concerned about data sovereignty and how data has been guarded, for us in this industry in Nigeria, I know there is data sovereignty issue that we need to specify*

with if we want to go fully to the cloud, so that is the only thing I think if we adopt the cloud is an enabler." ***RP16***

The aspect of data control and sovereignty is an essential and perceived factor that can hinder the adoption of the Blockchain. Unfortunately, no interviewee highlighted this aspect, but it is crucial in the adoption of Blockchain technology and assessing data security. Data protection, control, and security fall under the perceived influence associated with effort expectancy and facilitating condition. The aspect of effort expectancy shows that the stakeholder believes that data protection and control are critical to the adoption of Blockchain, and thus it serves as an ease associated with the technology's acceptance. Data control and sovereignty could be derived from the assumption that if the technology provides control, stakeholders will perceive it as important in supporting the technology's adoption. The Blockchain has been determined to be adaptable due to the potential it holds for improving supply chain efficiency and reducing fraudulent and manipulative behaviours. Data security is one of the benefits of adopting Blockchain. Many initiatives are currently emerging to be implemented for various reasons in supply chains. For example, in the United States, logistics operations are embracing Blockchain to increase supply chain transparency and digitalisation of operations (Werbach, 2018).

6.4.3 Implementation cost

The adoption of Blockchain technology comes with a significant expectation from adopters in relation to the technology cost and what is the relative implementation cost of the technology compared to other solutions. While the industry is passionate about the solution that will add value to the supply chain process, the technology should have a low cost of implementation. The interviewees were precise that the cost must be low because switching or upgrading a system requires a lot of investment, but competitive cost is a driver to the adoption:

"People who want to sell Blockchain-based solutions to the oil and gas and supply chain industry must sell the advantage that a little or low cost, low transactions charges, faster ways of processing documents." ***RP01***

Another interviewee added that the cost of adopting new technology is very high, so for the Blockchain to be implemented the cost should be relatively low and affordable:

"The cost of adopting the technology will be very high, you know some companies are using ERP platform, so adopting this Blockchain will be very expensive for them, try to bring all the infrastructure to put this to the ground will be a very big challenge and the issue of security, and the issue of the regulating framework, the industry is complex in nature." ***RP15***

Another group of interviewees cited the limited investment in the new project as a result of the low selling price of crude oil, whereas Blockchain has the ability to reduce operating expenses.

However, in order for the industry to implement Blockchain, cost sensitivity must be considered. The emphasis is on the cost-benefit of adoption from the cost of implementing Blockchain against alternative technologies, as well as the solution's affordability:

> *"I was actually appointed as the vice president of number one indigenous company looking at oil and gas cost reduction, unit operating cost; in other words, what does it cost us to produce hydrocarbon today par barrel, and Mr president who you have seen his picture here is a minister of petroleum, and he has given a mandate that we must reduce the unit of operating cost, so at this company that am the vice president strategy and commercialisation is focusing on how to reduce unit operating cost and our whole theory is under pain while using Blockchain technology which is quite interesting. But the technology should also be sensitive to cost for anyone to adoption within this industry, I know."* ***RP19***

> *"The high cost of the technology discourages adoption."* ***RP02***

> *"There was one proposal to introduce IoT into our logistics process, but we realized the cost of system upgrade and the request to change the current system we are using discourages our management from looking into it as an option".* ***RP23***

> *"Affordability of the technology because the oil and gas industry as much as they spend a lot the smaller company that can easily use this might not afford it."* ***RP02***

According to RP03 the ability to leverage existing infrastructure can save costs and make the cost of the technology solution cheaper. Because they believe they have the underlying infrastructure to support the adoption:

> *"So since we are running SAP and other IT solution so I believe the existing infrastructure should carry the basic requirement for the Blockchain to thrive and as I said it is all about being cost-effective if using the Blockchain will make us to spend more on infrastructure without a proportionate benefit using that. It may be a factor not to invest but if it is another way around that you do not need to invest more than just a small upgrade but the benefit outburst the cost, we can do that. So, I believe if we use that the current baseline infrastructure, we have Blockchain today will be able to thrive but if there is any need for upgrade it will be costly for the industry."* ***RP03***

According to RP14, the whole cost of implementation should be affordable, which is critical for assessing the commercial viability of the technology:

> *"Not a lot of people in Nigeria are IT driven, people struggling with basic IT that we have available in Nigeria such as Email, ERP, using a new system such as Blockchain technology could be... a lot of company are thinking of applying cost, the cost of applying the technology will be so much, the cost of training the personnel will be so much, looking at the commercial around Blockchain technology."* ***RP14***

When the commercial viability is there, and the cost of implementation is competitive, and the benefits are obvious then the cost factors influences the adoption:

> *"..we already have a good internet quality in Nigeria, it is not restricted like in other*

countries, the cost will also be a factor to look at giving all these dimensions, if all these are put in place, we will ensure that data and information to Blockchain technology are secured if the technology is affordable and not overly expensive." ***RP19***

The above summarised the perception of the stakeholders in the industry on the cost implication associated with the adoption of the technology and why low implementation costs will enable industry adoption. Therefore, the interviewee considers the cost sensitivity of the industry and investment in technology as a factor to the adoption of the technology. If the implementation cost is high then it may discourage many stakeholders to consider the adoption. Furthermore, the interviewees focused on how the competitive component of the implementation cost was centred on the potential of the technology to lower operational costs rather than the one-time cost of implementation. The oil and gas business are motivated by cost-cutting and operating cost reduction. The importance of cost reduction in technology adoption was highlighted by the interviewees. One interviewee, for example, remarked that:

"Cost is a motivator in the industry, anything that can save cost is a go or anything that can generate more revenue is also a go area. So companies and supply chain actors can easily be motivated when the technology can offer cost savings and improve revenue generation." ***RP22***

The Blockchain should demonstrate how the industry can save cost by adopting it, and they believe the cost aspect is not just enabling but a motivator for the adoption. RP23 added that if the cost reduction associated with the technology can be practically implemented, then that will motivate the stakeholder to adopting without hesitation:

"Any innovation that can drive efficiency, reduce cost etc., is a welcome development. The potential benefits and see other companies that have successfully adopted Blockchain in their operations. If the technology shows how cost can be saved and practically implemented, I am sure it will motivate others to adopt without any hesitation." ***RP23***

Supply chain actors want to bring the cost down and the fact that Blockchain can enable that will help accelerate the adoption:

"I feel if they see the benefit, especially the cost benefits the fact that it helps you reduce cost; we all want to bring down cost and increase profitability. That will be a huge factor that will push for it. NNPC is trying to be profitable." ***RP02***

"I mention that everybody will be happy to adopt it because right now, the industry is looking for a way to increase efficiency or save cost. And if anyone will translate, if you do any of the two, it will translate into increased profitability, especially in this low oil price region." ***RP18***

Regulatory bodies are also keen on the solution of Blockchain and how the technology can bring the cost of operation to a lower level so that government can earn more in revenue and royalties, as mentioned by RP03:

"Because cost is our major issue in the industry, the oil price is now below 40 USD space as and industry we need to see how we can drive cost low, so that our unit cost should be low. So, if the Blockchain can provide cost optimisation in the supply chain I think the regulatory commission will see that benefit and play the role the buying in to it and make it more of see how they can sale it to other operators and then see how also they can enjoy the economy of scale, like buying in bulk and things like that. So that we can synergise and enhance the and improve the usage in terms of usability of the technology." ***RP03***

The government is also interested in driving the cost down to the best minimum cost of production through the supply chain, so RP12 perceived the opportunity of adopting Blockchain to bring the cost of operation down:

"I think the contribution will be that those who understand the Blockchain technology coming together articulating these games that will be described. I know our principal; the government is highly interested in how the oil cost is driven down to the barest minimum given the current situation we have in terms of the coronavirus and the oil price globally. So, it drives to ensure that the cost of the oil comes drastically down is there. The highest contribution to the cost is actually the supply chain." ***RP12***

One interviewee introduced the potential for digital transformation and the opportunity to cut cost and drive efficiency using Blockchain by enabling speed in data process and supply chain visibility:

"In that case, digital transformation is a key innovative requirement that will drive us. The Blockchain-based supply chain solution can help us drive costs down. Efficiency in the operations and reduction in operating costs. When we see the benefits – lower costs, reduction in time for processing data, data availability, supply chain visibility etc." ***RP22***

The viewpoint of RP11 was on the end-to-end rollout of the technology and how the automation of manual processes can effectively increase speed and reduce delays in the transaction and cost-related transactions:

"Where this Blockchain is a roll-out end to end, and you clear the manual processes that pre-existing, and you can demonstrate the value in terms of reduction in transaction cost and speed of processing of transactions, and you can also demonstrate that there is a framework, higher satisfaction which you can pull in terms of an actual matrix, and also in terms of perceptions." ***RP11***

The findings revealed interviewees' perceptions of the significance of cost of implementation and cost reduction in the sector and how Blockchain adoption may enable cost reduction in the supply chain instead of just the implications of the implementation cost. Although several interviewees were optimistic about the possibilities of Blockchain based on the technology's capacity to reduce costs, practical implementation and its associated cost will convince stakeholders to expedite adoption. The UTAUT construct of facilitating condition enables the identification of resources available to support the adoption of technology. Cost of implementation and cost benefit could drive the opportunity for resources available to influence the adoption. The literature posited that

despite various advantages of the technology, it was discovered that practical problems exist at the time, such as enterprises lacking an established ecosystem to scale this technology, employee training, governance, privacy, and a high cost of implementation (Koteska *et al.*, 2017).

6.4.4 Technology user acceptance

The interviews perceived technology acceptance as a critical factor to the adoption of Blockchain in the supply chain. It indicates the views of the amount of acceptance of the technology based on its technical characteristics, such as simplicity of adoption or adaptability. UTAUT construct effort expectations were regarded as the ease of technology adoption and utilisation. In this instance, the themes provide crucial results regarding the perspectives of stakeholders towards the adoption of Blockchain technology. For instance, the research revealed that operations and supply chains were designed to be complex even when no technology has been used. RP22 believed that with a cautious approach to what Blockchain has to offer, it would not be complicated. The findings indicate that the judgement concerning complexity is influenced by the solutions and how easy it is to address the issues:

> *"I believe the future of any transaction is the Blockchain, the oil and gas operations and supply chain is deliberately made to look complex but with a clear and organised system, it is not as complicated as it is believed to be. So Blockchain technology can enhance the industry's operations by creating an ecosystem that every aspect of the industry can interact with each other and make the process less complex, as the case might be."* ***RP22***

Surprisingly, RP02 stated that Blockchain will be complex in the industry, and that in the past, other technologies were not used due to the complexity, though this was attributed to other causes associated with the human decision to use or not use the technology:

> *"I think the greatest setback or drawback would be the complexity of the Blockchain or the perception of the Blockchain as a tool that enhances transparency. I have been here for 13 years. Rather a simple process or simple technology that has been introduced, there is always a huge unwillingness to accept and adopt it, so that would be a big-time issue."* ***RP02***

The assertion of RP22 agreed that the future of any transaction is the Blockchain, and the oil and gas supply chain was deliberately made to look complex and attest that Blockchain technology will enhance the industry's operations. Conversely, RP02 alluded that the complexity is only related to the perception of the Blockchain but insisted that the problem is on the willingness of the industry to accept any technology at this time. Interestingly the interviewee above expressed the belief that the technology is not complex. Still, the complexity is in the adoption and the perception of acceptance to use and follow all requirements related to its full potential.

> *"If they can be able to sell that it will drive the management toward the change management approach, it is about bringing people up to speed and to be able to see and own the*

technology. If we can drive it from leadership, we can cascade the adoption down to the system without any complexity." ***RP03***

"I know I have read about it a couple of times but to say you are bringing something better because we all know there is already a system that is running, it's not the change alone, we want people to know what we are bringing will be better for them and can lead to solving more complexities in the way we tackle technology adoption." ***RP20***

Findings revealed that the industry wants to have things done better and have a system in place, but the bottom line is the change management needed to solve the complexity in the adoption process. The complexity and change management shows the factor of currency fluctuation, it is the understanding of the interviewees that it is a factor that will lead to increased complexity to the adoption if the lack of stability in currency (foreign currency) as forex is a key determinant of many technologies, finance, and development within the industry. Some interviewees even went to the extent of the fluctuation should the industry consider digital currency as a means of exchange in the supply chain based on the principle of the flow of finance.

"The Blockchain will reduce the over-reliance in trade exchange rates fluctuation and normalisation, account officer approvals and another process up to the central bank that we spend a lot of time, hence solving the above complex situation will make Blockchain acceptance." ***RP21***

"The Blockchain has some instability like you have a value difference in the fluctuation of the value for bitcoin can affect many transactions. So, in terms of gains and losses, the purchaser and the supplier can be losses at either end. If Blockchain is managed to the point of stability, then gradual adoption is a go, but if the contracts imperfections, the value of whatever is your bitcoin today, there will be a lot of challenges I mean just like the downfall in oil price." ***RP04***

The interviewees' views, considering the option of digital currency as a factor for the adoption and simplifying the user acceptance, is a vital point from the perceived factors for the technological considerations. Moreover, it gives an opinion as to what aspect of the Blockchain will be technologically tricky or easier to be accepted across the industry. The findings here also indicate the extent of innovative solutions that internally, the stakeholders would prefer Blockchain to offer to the industry.

6.4.4.1 Perceived usage difficulty

Interviewees discussed the challenges of using Blockchain as a complicated technology. The perceived difficulty was stated based on the various application areas of Blockchain technology that affect the supply chain and stakeholders. The subsequent comment from RP02 emphasised this point even more:

"I believe even within companies in Nigeria, the private entities would accept it and run with it and maybe make use of it, or the largest companies or government, in most companies the

ease of use will be very complex due to the nature of process and procedures involved."

RP02

The view of this interviewee confirms that some companies would not experience difficulty in the adoption of the Blockchain. However, for some companies, it could be difficult due to their transaction and partners' complex processes and procedures. RP06 pointed out that there is nothing easy about technology in the industry, particularly the technical aspect. That is believed to make it complex when adopting:

"I believe the Blockchain will not be easy, especially the requirement of the technology and the advancement in dealing with computer languages, consensus protocol and so on. So you do not expect the technical aspect to be easy for many in an industry like the oil and gas while factoring Nigeria." ***RP06***

It is apparent from the responses above that the difficulty of the use of Blockchain technology is a perceived factor that would determine the complexity of the adoption. In addition, many interviewees pointed out that a lack of familiarity with the technology will add to the complexity of adoption. RP19 stated:

"The fear of the unknown, people do not know what Blockchain can do for them, the fear of not knowing is a thing that we need to work on to eradicate the complexity in adoption. The stakeholders need to be given adequate orientations. We need to do continuous education to get people really involved." ***RP19***

In another part, interviewees revealed that untested technology is naturally complex and difficult regardless of where it comes from, not necessarily the oil and gas supply chain. For example, an untested technology, and the reason is untested technology contributes to the complexity and complex adoption. At the same time, there is this notion that what has not been tested cannot work. RP09 commented that:

"And another thing I also want to point out is that oil and gas industry is even more complex in adopting technology. In the scale of scenario and their unique nature is that they are risk-averse, so it is difficult for oil and gas to start using an untested technology immediately."

RP09

While Blockchain for supply chain could be considered to be in the early stage of development, the untested nature will make the adoption with oil and gas supply chain complex until demonstrable cases are available within the industry. Untested technologies can be disruptive because some potential solutions could look promising but may not deliver when tested. In such scenarios, the adoption could be as complex and compelling as expected. RP09 and RP20 stated:

"Looking at the risk of untested technology, we have all these nice-looking scenarios as a solution to help our businesses. When we deploy them, we realise that our operations are turned more complicated and may not be able to adequately cover whole operations, there

is also what we are afraid of in terms of the rise of intrusions." ***RP09***

"Personally, I always feel that in terms of technologies like we saw what happened with the blackberry servers and the social media are mostly controlled by Western countries so in the adoption of something like Blockchain we don't know the level of transparency of the technology itself and we are mindful about our back-end data." ***RP20***

The foregoing findings emphasised the significance of user experience and how perceived difficulties in adoption will be addressed from both a technology and a user perspective. The findings revealed that because the technology has not been assessed, determining its acceptability and user expectations and experiences will be difficult. However, the findings also revealed that the oil and gas industry adoption of Blockchain is determined by the ability to solve the problems associated with the technology; once this is applicable to the context, the complexity of the adoption can be solved, and users will not find it difficult to use and accept. UTAUT expressly addresses the complexity of technology and the expectation that for the behaviour to accept the technology, the technology should be simple to adopt and operate under the performance expectancy. It addresses the complexity of adoption as a result of perceived untested technology and a lack of a defined change management approach to delivering innovative and disruptive technologies and solutions that originate outside the industry or country.

6.5 Operational environment

In this section, themes under the operational environment category are presented. Like the previous sections, the current section focuses on the factors that are found to be within the adoption of Blockchain technology from the operational environment in the oil and gas industry. However, the environment here does not mean the climate-related factors but the factors relating to the Nigerian operational environment that involve policy, regulations, and government-specific involvement. The themes under the operational environment category are: emerging trends; government policy and support; and, regulation and regulatory framework.

6.5.1 Emerging Trends

Emerging trends reflect the current focus of the industry in relation to technology and the discussions around the latest development that will shape the industry and support the adoption of the Blockchain. However, the dynamics of how things change within the global space in the industry were factors that can lead to the adoption of Blockchain or otherwise.

The oil and gas industry has been the primary source of revenue for the government of Nigeria. Despite the recent economic challenges and the industry's low revenue drive, the government is keen on revenue protection. The interviewees indicated that the interest of the government is

protecting revenue with any opportunity available. As such, if Blockchain can offer that revenue protection, the industry will embrace the technology and lead the way to adoption. RP04, for example, stated that:

> *"If there are other opportunities for generating revenue if they are quick wins, for instance, you already have the required data there is something you can easily do with less effort, you can be able to generate revenue from that I mean that will accelerate the adoption of Blockchain."* ***RP04***

The interviewees identified the opportunity of leveraging existing sets of data and applying Blockchain to increase revenue generation. Those beliefs were perceived to incrementally support the oil and gas environment in embracing and accelerating the adoption of Blockchain technology. RP15 posited that:

> *"If we can easily track our revenue, that is where we are having major issues in the supply chain from upstream to downstream... and all that, so the industry is vulnerable to risk and fraud, so we need a better way to handle this going forward."* ***RP15***

Revenue tracking will eliminate fraud in the oil and gas supply chain and the trend was to minimise fraud and protect revenue in the industry (K. Mark et al., 2017). The industry is vulnerable and the risk of fraud in the supply chain and these challenges are encouraged to be fixed with the role of Blockchain technology. RP16 provided an example of how the government can decide to deploy Blockchain technology to track revenue generation and indicated perceived factors for the adoption:

> *"Let me give you an example, the government of Nigeria can decide to deploy a Blockchain-based solution to track revenue generation in the oil and gas – so that will be a key motivation for the implementing body knowing very well what they will benefit in terms of revenue generation or cost savings."* ***RP16***

> *"So, companies and supply chain actors can easily be motivated when the technology can offer cost savings and improve revenue generation."* ***RP22***

Tracking revenue is an important trend with the industry as the revenue coming from oil and gas is low, and the potential of Blockchain technology to keep a clean record of revenues with no involvement of third part is an interesting aspect the research has found. The point of RP05 were centred on the challenges that lead to the lack of transparency and how that is affecting revenue generation:

> *"The advantages are obvious you cannot keep secret anymore because things used to be with secretive around the oil and gas industry in Nigeria. In the context of it [being] opaque, you only need to know things are coded in terms of revenue, it is not easy to know where the revenues are made, going to and the final number given as profile. The amount of revenue going to the federation account is opaque because the public doesn't have idea, the industry is complex. People look at our production."* ***RP05***

"So, if Blockchain is introduced, you cannot hide transaction, you cannot say you spend x amount in this operation whereas the people assume you spend less, if you asked all parties involved in the supply chain of that sector, they can all confirm that competitive price. But as it is now when you mentioned figures, people that are not familiar with the industry come up with all kinds of plans so to help with no secret and transparency will increase." ***RP05***

Enhanced transparency in the oil and gas supply chain can lead to increase revenue and the elimination of taxation-related challenges facing the industry. RP06 was keen to see the tax authorities leveraging Blockchain to block revenue leakages:

"I also imagine that regulatory authorities like the tax authorities will be interested in what is going on is that space and therefore need to be comfortable both for the technology and how it will be implemented to make sure they are able to keep pace with that development and be able to carry out their strategic function as well." ***RP06***

The tax authorities oversee collecting and recording taxes generated by all industries, including oil and gas. This aspect has highlighted the areas of Blockchain that could assist tax authorities. RP22 also stated that the enhanced data visibility would be the area of interest to tax authorities:

"In areas of regulation, it will ensure smooth compliance with the laws and regulatory framework in the industry through enhanced data visibility. That is something that is not obtainable, we always have inconsistency in our reporting system from different segments of the industry. I also talk about in some authorities like tax organisations may also be interested in that whole implementation of Blockchain." ***RP22***

The general economy benefiting from adopting the technology will make the stakeholder adopt the technology. Therefore, solving the burning issues of revenue generation is of the utmost priority:

"Government is for them to see the benefit in terms of the general economy, general wellbeing of the country, safeguarding the law of a country. If everybody sees things from a different perspective, if I am a government, what I will be thinking is this Blockchain can make this pipeline vandalism stop vandalising my pipelines across the country. If you can solve a burning problem that will be an enabling factor." ***RP09***

The above responses provide detail of the emerging trends in the industry for Blockchain implementation. The role of revenue generation, protection and blocking of leakages are all perceived to play a crucial role in the operational environment in which the oil and gas industries operate to adopt Blockchain technology. The findings are fundamental to the entire oil and gas sector as the government of Nigeria has significant control over the revenue and the main source of revenue to the people of Nigeria. The aspect of taxation and the role of authorities in the sector to influence and benefit from Blockchain when adopted is a significant step perceived to influence the adoption.

6.5.1.1 Innovation and efficiency of the system

Despite the industry's supply chain challenges, the operational environment encourages innovation to drive efficiency. Many of the interviewees perceived that the efficiency of their supply chain system is the focus, and as leaders, this will help the business environment to thrive. In addition, most of the interviewees recognised the potential of Blockchain technology to drive efficiency:

> *"As I said, the benefit will be much, one, efficiency in terms of what you are procuring what will be in your inventory, what is your stock level and so on. So again, in addition to the efficiency, it will help optimise the contracting cycle. If it increases efficiency and reduces the contracting cycle, you will increase your revenue, which means more profitability and value and create time for other things. By this, you should be able to see things from a one-stop shop without interfacing with many people. I mean this is the key measure of success."* ***RP03***

> *"I think the advantage will be efficiency and effectiveness of the system together will be able to achieve optimum productivity using technology".* ***RP14***

Reduction in contract lifecycle means the opportunity to speed up transactions within the contracting management. The cost efficiency, quality and process will further benefit from the adoption of the Blockchain according to RP02:

> *"For me based on what I think it is, Blockchain is going to push efficiency of [the] system which is a very huge problem in the country, it will also push transparency so that will be more savings and our hope will be more savings, it will prove efficiency that is one of the responsibilities I have, both, cost, quality, process and all of that is also going further increase."* ***RP02***

Another perspective on reducing human interference through automating the process and the intervention by adopting Blockchain technology is the opportunity to generate efficiency and accuracy in the system. Supply chain managers are exploring areas where the application will help minimise human interferences and stop the possibility of fraud and corruption which is critical to protecting revenues and stopping any form of leakages. RP11 further stated that:

> *"To minimise human intervention, and to generate efficiency and accuracy, and to lower the transaction cost and make that process seamless from end to end, and to create a very smooth interface for all the regulators who need to interrogate those transactions from time to time."* ***RP11***

Responses show that the oil and gas companies are alarmed by the growth of innovation in the operational environment. As a result, the industry is equally exploring ways to innovate and be part of the trends:

> *"I think it will be a very good one, what keeps industry going is innovation, if there is an innovative way of trying to solve some issues, I think it is a welcome development, as is said there earlier there is still some issues as supply chain is one of the challenges the industry is*

facing in terms of cost the entire supply chain management system." ***RP03***

The ability of the industry to be innovative will influence the adoption of Blockchain technology. One of the interviewees perceived that they have no problem trying new concepts that means the willingness to innovate is there and Blockchain due to its promising capabilities will be an innovation that the industry will consider:

> *"I think we want to be able to be innovative, and I see no harm in trying. We already have a unit in our organisation that is an IT unit, and I believe... I had conversations with some of the people over there, and I show them that it is something that is worth looking at and I share some of my ideas to them and they find it also interesting."* ***RP09***

The interviewees emphasised the level of innovation as the industry has followed through different technology transformations, and Blockchain technology will not be an exception due to the level of commitment to innovation that is driving the industry. RP18 and RP22 gave examples of previous technology adoption and the readiness to explore Blockchain technology:

> *"Another thing that I will say is the fact that we have also used, or we are using other technology like the adoption of robotics and the adoption of other similar application or technology in the oil and gas industry."* ***RP18***

> *"My view of the adoption of Blockchain is we are not yet there but the industry is open to innovation and Blockchain will undoubtedly help us and we will be more than happy to embrace it."* ***RP22***

It can be deduced that the industry is not yet there on the adoption of Blockchain. Still, the commitment to adopt the technology has received significant attention due to the level of innovation in the industry. The findings have revealed the participants' willingness to innovate and increase efficiency. This is significant due to the trends in Nigeria on innovation and the digital economy. The country has made digital innovation investments and created an ecosystem that is a key foundation to all major sectors of the economy.

6.5.1.2 Transparency and visibility

Another trend with the operational environment is the desire for transparency and visibility as a perceived factor for the adoption of Blockchain technology. The stakeholders mentioned transparency and visibility as enablers to the adoption of the Blockchain within their supply chain.

> *"Based on my perception of Blockchain, I feel that it is only further going to enhance transparency in the system, I know they are some certain systems but what I think about Blockchain is a system that cannot be easily tampered with it will enhance transparency."* ***RP02***

> *"The Blockchain I think it will substantially enhance transparency within the business, however, driving the business itself, I would need to know what how and how Blockchain works help to further drive the business, for example, drilling and other activities that are*

directly with the oil and gas operation." ***RP02***

Another perspective to the transparency, is the transaction and the opportunity for the distributed ledger to provide visibility as mentioned:

> *"I think the first is the transparency of transactions, so once you then deal with that from the distributed ledger system. If the party to the transaction can have access to the same records, that will then be extremely difficult to alter and so the dispute to exceed about the transaction. Blockchain can address the dispute."* ***RP06***

The transparency in the transaction will eliminate any potential dispute which happens across the industry, according to RP06. Transparency across the movement of vessels is regarded as an area that the industry will benefit from when Blockchain is adopted. The current system does not offer a solution to the lack of visibility in vessel movements and port operations:

> *"There are lots of trading things going on. For example; a vessel being moved from the government holding, and the government don't even know where their vessels are or who is paying for such truth in itself, whereby a vessel has been sold and is moving to its expected port while moving the vessel is being resold, then a buyer can confirm that this vessel has been sold from another seller, with the Blockchain system actually the government can easily track the vessel movement, for the one that independent marketers or any party is selling because it is transparent."* ***RP10***

> *"The use of Blockchain will ease transparency both from the side of government to the side of players, I see lots of potential in terms of vessel and logistics happening easily between everyone that is involved in the industry".* ***RP10***

> *"As people desire, but we know the chief of transparency, there is nowhere to hide, so transparency will be enhanced."* ***RP12***

> *"We know the transparency is a big problem, you know there is nowhere to hide when you now use Blockchain. So, transparency will be enhanced and also in terms of integrity."* ***RP17***

Furthermore, RP05 posited that when the industry embraced the adoption of the Blockchain, there will be no way to keep it secret, the interviewee elaborated on the reasons why transparency is essential to the industry based on the current level of practice:

> *"In the context of it [being] opaque you only need to know things are coded in terms of revenue, it is not easy to know where the revenues are made, going to and the final number given as profile. The amount of proceed going to the federation account is opaque because the public don't have idea, the industry is complex. People look at our production. So if Blockchain is introduced, you cannot hide transactions, you cannot say you spend x amount in this operation, whereas the people assume you spend less if you asked all parties involved in the supply chain of that sector, they can all confirm that competitive price."* ***RP05***

The benefits of openness are critical to income generation; with the low cost of selling oil, transparency was seen to be a driver for cost protection and delivering value to stakeholders. To confirm the reason for the transparency being an emerging trend in the industry, RP12 stated:

> *"Externally, we have things pushing us and that why we have low oil cost and low oil cost will get that if our supply chain is one cycle time is reached, we can have transparency of the operation of this supply chain and we are able to compete and get the best price or whatever we are doing. So, we can cut cost, so that is the very compelling reason for us, to ask people to come into the Blockchain to facilitate cheap cost for us."* ***RP12***

Another interviewee emphasised that visibility, together with transparency, will make the supply chain better:

> *"The adoption of that Blockchain in the supply chain, you can begin to monitor your industry level in any location you have... if Blockchain can help us, that is a good measurement of success."* ***RP15***

Some of the interviewees believe that, in general, the adoption will enhance supplier relationship management, build trust and create a more transparent and consistent establishment. Trust is a critical element when many parties are involved in a transaction, in the oil and gas industry, the diversity of stakeholders could be subjected to trust building and maintaining effective relationships. The finding shows that with the ability of Blockchain to embed trust into transaction that will drive the adoption within the operational environment:

> *"Yes, I truly believe it will enhance the oil and gas operation in Nigeria at least on contract management, supplier relationship management and building trust among parties that we transact. The industry is so complex and especially the inconsistency that we have with players are mainly issues of trust even between the corporation and the public."* ***RP07***

The outcome from the interviewees above highlighted the significance of transparency and visibility in the oil and gas transaction and the stakeholder's perception of how the role of transparency and visibility is a trend within the operational environment. The whole industry is facing transformation and the aspect of Blockchain technology could be integrated into the transformation and add value to revenue protection, generation and savings of operational costs.

6.5.2 Government policy and support

In Nigeria's oil and gas business, the government is responsible for driving policy and the implementation of programmes and projects through the national oil company and the private sector. Interviewees emphasised the distinction of government policy and support as a vital contributor that may be distinct from other industries and nations. Interviewees described the role and duties of government policy and assistance in promoting the implementation of Blockchain technology inside the industry's supply chain:

"The government putting in place the right policy, there is no policy in place to guide such adoption then it might never really happen, so is there a policy formed that will mandate the regulators in the industry currently to create a platform that all the players will be mandated to be primarily involved in the platform." ***RP10***

RP10 discussed the government's role in increasing adoption by establishing a policy and mandating regulators to execute it. And for the regulators to ensure and assess the level of compliance. The interviewees provided the role of the government by owning the process, development and dissemination of the technology according to RP21:

"Again, it has to come from the government if they see it visible, they can now create a process to manage Blockchain in the country so when they have done that they can involve other stakeholders, because of nature of business in the industry, and then introduce the benefits in terms of the merits and any challenges and look at the risk that is associated and then eventually give their own position. Most of the ball is in the court of the government, major regulators in the oil and gas here are the Department of Petroleum Resources (DPR) and then the Ministry of Petroleum Resources." ***RP21***

Another interviewee emphasised the significance of the government through the ability to promote the technology and provide an avenue for support from the technical to the implementation level. The role of government has been thoroughly covered in Chapter 3, which indicated the government's powers to set norms and policies; thus, the findings emphasise the extent to which the government might drive adoption. RP06 addressed the responsibilities associated with technical participation:

"I expect that they would have to provide technical endorsement for technology like that to take off and define the rules and parameters and so on. To make sure as minimum someone is doing an audit of transaction that happens in that space and that it doesn't become a black box that is not accessible to government and to others who might need to view and confirm certain transactions." ***RP06***

"Of course, the government institutions like the national treasury, tax authorities and the regulators etc., these are the people that can influence the adoption of Blockchain in the oil and gas in Nigeria generally." ***RP15***

"If in a public organisation, maybe the likes of NNPC, PPRA, PEF, the supervisory agencies can influence the government's policy. So, I believe they are critical stakeholders." ***RP07***

"We are not ready, the reason as I said that is we are a government organisation and owned by the Nigerian entity and unless there is already a statement from the government, we are not even thinking of it." ***RP08***

"For us in the government, we are open to new challenging opportunities that will enhance our processes and make our industry a better place for all stakeholders." ***RP15***

Based on the responses provided, it appears that the interviewees believe that the adoption of blockchain technology in the Nigerian oil and gas industry would necessitate technical endorsement

and oversight, and that government institutions and agencies would play a significant role in influencing and potentially implementing this technology. It also emerges that certain government institutions may be reticent to utilise blockchain technology until the government issues a statement or decree signalling support for its usage. However, at least one interviewee seemed to believe that the government is open to new prospects that may enhance processes and benefit all sector players:

> *"Policy direction from all the parties involved in the adoption of Blockchain, areas of application that has meaningful values, especially the transparency, cost-saving, building stakeholder confidence and so on."* ***RP01***

In the words of RP12, the government should be transparent about the policy and procedures and convey to the people about the intention to use Blockchain for supply chain while involving the relevant organisation to accelerate the adoption:

> *"Then in terms of regulation and ensuring that we have a way of implementing and regulation are standard. It's a policy, and people need to believe in the structure that is created to enable this in terms of governance in terms of the processes and procedure for addressing issues and resolution."* ***RP12***

The interviewee further added that the procedures of the policy direction should assign the roles and responsibilities of the government agencies in the Blockchain technology space:

> *"What are the policy and the procedure of each of the participating agency's bodies to have a strong role to play in that space, and in terms of formulating standard process and policy that influence and assure the gain we are potentially proposing."* ***RP12***

In terms of the policy and procedure, some interviewees stated that the current role of the government in the implementation of the technology aligned with the recently created digital economy ministry. Nigeria has created a new ministry of digital economy and developed the National Digital Economy Policy and Strategy to digitise Nigeria. The findings show that the industry is aware of the digital economy potential and how the adoption of Blockchain aligns with the digital economy sectors. However, RP20 mentioned a point that has been affecting the industry to be efficient which is the Petroleum Industry Bill, the bill can capture the adoption of technology as a policy:

> *"But once the government understood the importance and the benefit of the technology, it can lead and make a policy on that. For example, this government has considered the digital economy as a ministry, so you could see the passion they have for making things better and believe the digital economy itself is part of the Blockchain adoption."* ***RP15***

> *"Well for us obviously here maybe I know Petroleum Industry Bill (PIB) is coming, if that one is written, that one is already in motion probably there will be little input, even though there is going to be stakeholder's forum, all the participants will be given in their input and review, probably at that stage, it became part of the policy document."* ***RP20***

There is an opportunity to extract the technology's potential and build implementation-guiding rules for the broader sector. The greatest way to incorporate innovation into the policy side of the Petroleum Industry Bill is to include new and disruptive technology provisions. Based on further responses, the policy and governance could not be executed without the confidence of the stakeholders. The government and its agencies are responsible for fostering confidence RP01:

> *"I think Blockchain technology will add value in the supply chain in the oil and gas in Nigeria because the supply chain industry like every other aspect of our existence in Nigeria, is broken and there are far more opaque than anyone else can imagine. The power of Blockchain can be transformative in the nature of the operation. It can change the status quo in the oil and gas sector. Improve governance and build the confidence of all stakeholders."*
>
> ***RP01***

Since the present system is dysfunctional and Blockchain can solve it, the government and regulators must demonstrate how the technology can effectively help the supply chain. Therefore, the appropriate authorities should provide stakeholders with the confidence while deploying the technology:

> *"It is also their responsibility as the policing agency to build the confidence of every business entity within the industry, it is not just about enforcement but collaborative culture for successful adoption. If they come up with a robust framework so that people will not abuse the system."* ***RP15***
>
> *"Let's say a step at a time, convincing the stakeholders at the regulatory end to adopt the system just happened to motivate others to come on board but today one step at a time. First, you can get the stakeholder at the upper edge to come on board and see how it goes. Impressive enough, the government now is more serious about increasing the path of confidence in the industry."* ***RP21***

Governance, confidence, and policy and process are essential components of the government's policy drive and support. Government and regulatory requirements do not restrict any environment. Regulation and the government's involvement in providing required support are essential for the widespread adoption of Blockchain technology. Blockchain technology suffers from a lack of regulatory standards, and several authorities in the sector are tasked with developing regulations and guidelines. Participants believed that the government's responsibility is to support the process and instil confidence in the adoption process, processes, and templates among the stakeholders.

6.5.3 Regulation and regulatory framework

The operational environment of the oil and gas industry were impacted by legislation and the regulatory framework. According to interviewees, regulation is a crucial part of every aspect of the oil and gas industry in Nigeria, the laws, acts and frameworks governs the conduct of every aspect of the industry. Therefore, compliance with regulatory standards is a vital function that operations,

operators and business conduct takes responsibly and seriously. The interviewees identified regulators would have a crucial role in the adoption of Blockchain technology and the influence of regulators to drive the adoption. For example, RP06 stated that the regulators would benefit from the technology in terms of delivering their tasks, so the technology is not about the operations in the industry but how the regulators can achieve their objectives:

> *"Make a whole lot of process seamless from end to end, and also to create a very smooth interface for all the regulators who need to interrogate all the transaction from time to time, so that way you are creating value for all those who will be impacted by the technology and taking work off their hand and returning value to them in the form of transparency and integrity of the transaction and so on. I think that is the value for promoting Blockchain adoption."* ***RP06***

Adoption of Blockchain will benefit the industry as a whole in terms of transparency and integrity, and the role of regulators in the use of Blockchain will support in achieving the objectives that cut across the operational environment. The regulators, as providers of guidance to the operators, could ask the operators to secure their system through setting standards for the adoption of Blockchain according to RP14. It further provides the insights that regulators have the full authority to ask operators to secure their transactions using the Blockchain. That will be one of the advantages of having the regulators in the adoption process:

> *"Regulator can actually express the needs of operators to secure their systems so that they are able to settle... across the world, because the regulators also work together with the oil majors of the company."* ***RP14***

> *"So, regulators have a major role to play to guide the use of Blockchain technology in the industry, not only enforcement."* ***RP14***

> *"The regulator decides to make it a key performance indicator, so organisation have no choice but to adopt, it is kind of put things in perspective, organisation and stakeholders can influence the adoption, for me, that is what they are going to be doing; make deliberate plans, deliberate change management process that can be used to manage resistance."* ***RP09***

In encouraging the adoption, instead of enforcement, the adoption of technology could be part of performance enhancement and indicators for the industry RP09. Once the guide is provided and the industry begins to adopt the technology, the regulators see the benefits, they can trigger enforcement to non-adopters because the law has empowered them to act in the interest of the industry. RP09 stated:

> *"I think regulators are the key guides here, if they can now begin to enforce or create these rules and enforce them, there will be no choice but to follow."* ***RP09***

> *"The role that they can play in this sector will be mandating the players to sign up to a solution that involves the use of Blockchain, that solution could be a decentralised platform/ system that is open to everybody and regulatory agencies to see what is happening in the*

industry, also to see production level, and to see what sellers are actually lifting and selling to off-takers." ***RP09***

"The regulatory bodies have a big role to play to ensure compliance with the adoption, especially if they clearly see benefits relating to the enforcement of the laws of the industry." ***RP16***

Conversely, one interviewee mentioned the negative aspect of the regulators, which if they decide they can refuse to commit to the technology, so, the regulator can affect the adoption if it lacks their support:

"The regulator has the power to implement and refuse the implementation depending on their reasons, so it very serious business dealing with the regulators, and they have the key influencing factor. So we all work according to their judgements." ***RP20***

The role of regulators is to comprehend the technology and find a reason to adopt it; if this is not possible, it may be difficult for them to give it the necessary attention. Once there is consensus on the adoption among regulators, the compelling reason is for the stakeholders to follow the guidelines of the regulators. Regulatory uncertainty was identified as a factor that could affect the adoption, for instance, the regulators are many from upstream, mid to downstream, any fraction between the regulators affect the overall goal to adopt Blockchain in supply chain. RP01 stated that:

"My view is that in as much as we are still having regulator uncertainty and zero policy statement on it, it is still a very unarguably tool that can disrupt and definitely change the way the supply chain is operating in Nigeria." ***RP01***

The regulatory uncertainty could stem from an inability to decide on the technology or a lack of a framework to guide the use case and how the industry will benefit from the technology, affecting the technology's viability and adoption.

However, once the consensus is achieved and the policy and regulation align with the benefit of the technology to the industry, the aspect of regulatory framework comes into consideration. The findings show that regulatory framework is an additional compelling component of regulatory agencies to influence the adoption of Blockchain. Lack of regulatory guidance through regulatory framework on the adoption of the Blockchain from the operational environment's point of view, the adoption will be ineffective and lack the backing of the government and collective central point that enable sharing of data and information. Consequently, the interviewees viewed the regulatory environment as having a role in the scalability of Blockchain use within the oil and gas supply chain. The oil and gas industry is a highly regulated industry to begin with, which is why many interviewees stressed the impact of the regulatory environment on technology adoption. According

to RP01, the government should develop a detailed regulatory framework for the adoption and interact with stakeholders to raise awareness of the framework:

> *"I think policy, precise policy direction from the government agencies that regulate the industry where Blockchain is applied, and proper regulatory framework which will comprise rule books that participant must follow this will be the prime math that must be lead because any significant adoption talk less of mass adoption can be seen in the industry."* ***RP01***

There are two dimensions to the regulatory framework guidance and enforcement for Blockchain adoption to be successful, It is the responsibility to create standard guidelines of the requirements and the need for the adoption, interest of the industry stakeholder and the appropriate internal consideration that are contextual to extant laws in Nigeria:

> *"I think that regulatory agencies have two roles, first, is that they should make it absolutely a requirement if we are able to identify the numerous or the outstanding advantages of Blockchain to the oil and gas industry and they are also going to accept it then the regulatory agencies should make the use of Blockchain a requirement for anyone that wants to do business in the oil and gas [sector]."* ***RP02***

The interviewees perceived the distinction of identifying the right people to drive the regulatory framework and standard for the industry as a critical success path:

> *"I think we must have the right people with the right mind-set driving the Blockchain from the onset. We should look at also regulation and so on, the government has to come into play if not by the time they just allow the technology and every start play later government start to say you are entrenching on this and that."* ***RP04***

In order to encourage adoption, it was determined that a regulatory framework would be beneficial; however, the resolution will only be effective if the proper level of monitoring and compliance is maintained across the operational environment. RP22 stated that the standards, monitoring compliance should drive the framework and once the players agree with that, the regulators will enforce the adoption:

> *"Setting standards, monitoring compliance once the framework for adoption is there, and the players agree on it or the other way the law recognises the solution as a law, we will enforce it as the regulator."* ***RP22***

> *"Regulatory agencies have a big role to play because some of the concerns of parties will be if we adopt this, what are the governance arrangement to ensure parties abide by what we have looked at, where are the institutions that guide and ensuring people abide by what they put there."* ***RP16***

RP16 posited that the integral part of the regulatory framework centred on who is responsible for regulation and the potential misuse of unregulated technology:

> *"The question is who regulates how people come into that market and guarantee the authenticity of what each party is bringing into that scheme, how do we settle those disputes,*

and what are the policies and procedures for each of the participating agency bodies. They have a strong role to play in that space and in terms of disseminating standard process policy that influence." ***RP16***

There was an emphasis on the level of risks when evaluating the adoption from a regulatory perspective, and some interviewees reiterated that the regulatory framework should drive the adoption commitment, which includes developing risk assessment criteria and determining how risks can be mitigated:

"The role they can play, because they have to accept and they have to approve a lot of things regarding it, so the role they can play is actually to be able to look at the idea, go through it and see what are the risks you know, involved in adopting this Blockchain and how can those risks be mitigated whether Nigerian operation is matured to adopt that kind of technology and the rest." ***RP18***

The findings have an impact on the operational environment because legislation is a critical enabler for the widespread adoption of Blockchain technology as the regulators control and set standards. It is the responsibility of regulators to take the initiative and indicate the path for adoption, as well as to ensure that the rules are clearly stated and made available to all stakeholders for compliance. Furthermore, regulators' impact is to ensure that the technology's potential to address the industry's complex supply chain difficulties is not hampered. If authorities are not appeased, the industry's acceptance and development of the Blockchain solution may be jeopardised. Facilitating condition is a construct of UTAUT that influences the adoption of technology based on the resources available. The findings on the role of the regulatory framework and how the regulators will support the adoption of Blockchain in the oil and gas supply chain were considered as resources that could influence the adoption. The regulatory framework and the role of regulators have been identified as important perceived factors in the oil and gas industry's adoption of the technology. Because the oil and gas industry are regulated, regulatory bodies are critical in developing standards and guidelines, as well as monitoring compliance and adherence to processes. As a result, the regulators' tasks and responsibilities play a role in developing a distinct standard that is compatible with Nigeria's oil and gas industry. According to the interviewees, the regulators' active participation at this point may aid Blockchain in finding a home and gaining acceptance due to its ability to address supply chain concerns that affect all stakeholders. These studies also revealed the industry's unique regulatory nature, which must be followed if Blockchain is to be considered.

6.6 Summary

These thematic sections provide a detailed analysis and interpretation of data collected in this research. The interpretation and presentation presented the significance of the research results supported with quotes from research interviewees. The key objective of the research process is to

investigate the perception of the adoption of Blockchain in Nigeria's oil and gas supply chain. The data was gathered via semi-structured in-depth interviews with stakeholders from Nigeria's oil and gas industry. This research discovered several intriguing findings among the perceived determinants for Blockchain adoption in Nigeria's oil and gas supply chain.

The researcher discovered critical findings from four categories of organisational, institutional, technological and operational environment. The findings show the following are the factors that would influence the adoption of Blockchain technology included leadership and senior management, awareness and knowledge, business model, and commitment to adoption are all perceived factors under the organisational category. Second, industry dynamics, influence and control, and institutional collaboration constitute the second set of perceived institutional category. Third, the internet, infrastructure and connectivity, data security, cost driver, and technology user acceptance are all under the technological category. Finally, the operational environment includes emerging trends, government policy and support, and regulation and regulatory framework. The next chapter is the presentation of the UTAUT embedded analysis.

7 UTAUT embedded analysis

This chapter presents the UTAUT embedded analysis. This chapter is based on the objective that it will establish the relevance of the thematic findings within the UTAUT constructs and will serve as the theoretical basis for the research validation. The UTAUT model is an important theoretical lens that has been used to explain, interpret, and predict the behaviours of technology adoption. The constructs within the UTAUT model were analysed in the context of the outcome of the thematic analysis in Chapter 6, Section 6.1 and the literature review conducted in Chapter 2. The first part of this chapter covers the process of the UTAUT embedded analysis, followed by a presentation of the UTAUT embedded analysis prepared according to the theory's four components of performance expectancy, effort expectancy, social influence, and facilitating condition. According to the research findings, an additional construct was identified and should be considered when implementing Blockchain technology in the oil and gas supply chain. This construct was defined as "industry dynamics". The results of the validation of the findings are also presented in this chapter, and the chapter ends with a summary.

7.1 The process of the UTAUT embedded analysis

In the context of this research, the UTAUT model has been used to predict the perceptions of the adoption of Blockchain technology within the Nigerian oil and gas supply chain. Therefore, the application of the thematic analysis to the UTAUT construct is appropriate to reflect the findings on the critical constructs as presented in Chapter 6. This research focused on the relevant constructs of performance expectancy, effort expectancy, social influence and facilitating condition (see Chapter 6) for a detailed discussion of the constructs (Venkatesh et al., 2016b). The first step to identifying the relevance of the outcome to the construct of the theory is the nature of the findings from the thematic analysis. In this research, the themes were categorised into four dimensions: organisational; institutional; technological; and operational environment (see chapter 6).

The UTAUT embedded analysis process relies on inputs in stage one, from the thematic analysis (themes and sub-themes), the literature review in Chapter 2 and the constructs of the UTAUT model discussed in Chapter 4. As previously adopted by research, the process has allowed the identification of consistencies, inconsistencies and findings that the literature and theory have not discovered (Venkatesh, James Y L Thong and Xu, 2016; Francisco and Swanson, 2018). The process began with familiarisation with the thematic findings through the lens of the UTAUT theory, the general application of the UTAUT theory centred on the influence of the four primary constructs on the adoption of Blockchain technology (Venkatesh, James Y L Thong and Xu, 2016). However, this did not mean that other factors were not considered to be influential factors in the

adoption of the technology. Previous research has utilised the UTAUT model to make assumptions as to how technology can be adopted. For example, Salem and Ali, (2019) proposed a model that integrated new constructs of perceived risk and trust. However, the UTAUT embedded analysis process focused on matching based on the interpretation of the themes and the relevant UTAUT construct as well as the literature on similar findings. Figure 7-1 adopted from (Becker, Kolbeck, Matt, and Hess, 2017) below provides an illustration of the UTAUT embedded process using within this research.

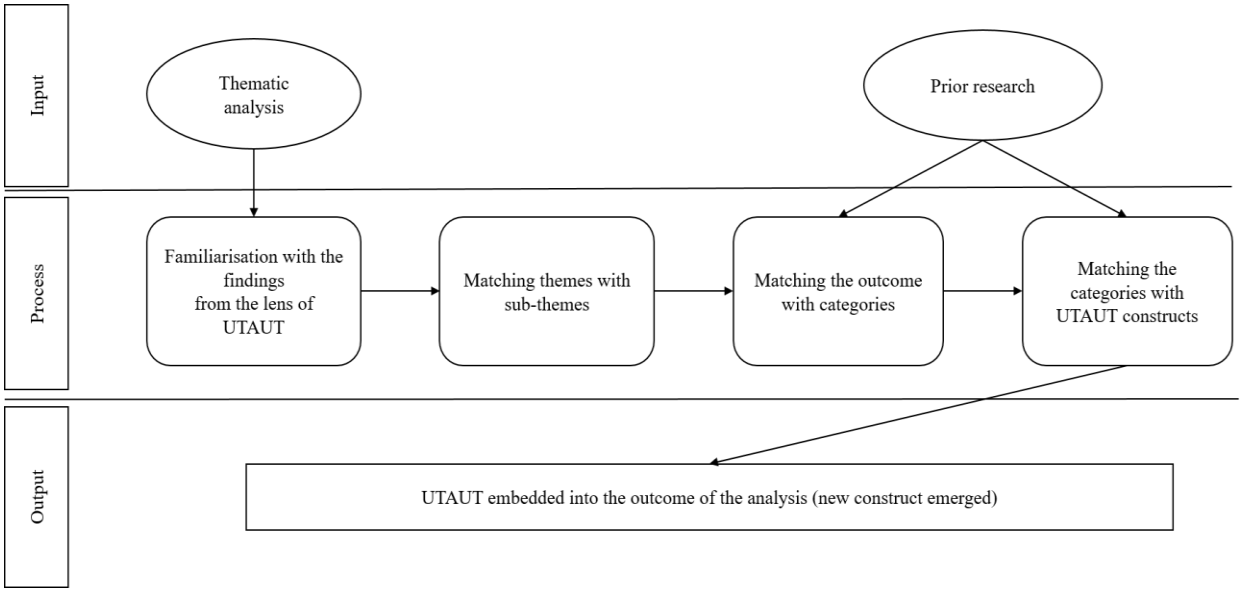

Figure 7-1 UTAUT embedded analysis process adopted (Becker et al., 2017)

The last part of the process is the output, at this stage, the analysis conducted through the process followed in the figure above uses the literature and UTAUT model lens to arrive at the output as an embedded analysis for presentation. For example, the thematic analysis in Section 6.3.1 revealed the relevance of the interpretation to the UTAUT construct of social influence. This process helps to explain the findings and how they fit into the existing or new areas in relation to the theory within the technology adoption and Blockchain technology. And as previously indicated the importance of new knowledge on the factors that affect Blockchain adoption by (Alkhwaldi and Aldhmour 2022; Knoblock-Hahn and LeRouge 2014; Venkatesh, Thong and Xu, 2016; Nordhoff et al. 2020). The processes are consistent with previous studies that employed the UTAUT model to interpret findings, and the approach has resulted in significant theoretical and practical contributions (Bhatiasevi, 2015; Tarhini *et al.*, 2016; Thongsri *et al.*, 2018). Therefore, embedding UTAUT into the thematic analysis enables the researcher to draw conclusions on the suitability of the UTAUT model in achieving the research objectives (Gruzd, Staves, and Wilk, 2012). The UTAUT-embedded analysis of the thematic chapter has addressed the research aims. The significance of the UTAUT analysis in addressing the research aims and answering the question around the perception

of Blockchain adoption within the oil and gas supply chain is through leveraging the thematic findings, the combination of the theoretical constructs in UTAUT to communicate the findings, and how that will affect the adoption of Blockchain technology. This chapter is critical to addressing the research aims and expanding the boundaries of knowledge in the field of Blockchain and supply chain.

The UTAUT model was first developed by (Venkatesh and Davis, 2000) as an extension of the Technology Acceptance Model 2 and was a result of the synthesis of eight theories. UTAUT model has been applied to investigate technology adoption and predict acceptance and use of technology within different contexts, mainly the individual factors for using and accepting technology (Magsamen-Conrad *et al.*, 2015; Alabdullah *et al.*, 2020). However, the constructs that predict the acceptance and use of technology are performance expectancy, effort expectancy, social influence, and facilitating conditions. The theory also considered two outcomes based on the four constructs: behavioural intention and use behaviour, that are moderated by four variables: gender, age, experience, and, voluntariness of use (Venkatesh and Davis, 2000; Venkatesh and Zhang, 2010).

Based on the above illustration of the embedded UTAUT model in Figure 7.1, the significance of the finding is now drawn from the perspective of the UTAUT constructs. Performance expectancy is consistent with themes of business mode (§6.2.3), institutional collaboration (§6.3.3), and emerging trends (§6.5.1). Effort expectancy is consistent with the themes of awareness and knowledge (§6.2.2), data security (§6.4.2), and technology user acceptance (§6.4.4). Social influence is consistent with the themes of leadership and senior management (§6.2.1) and influence and control (§6.3.2). Facilitating conditions is consistent with the themes of commitment to adoption (§ 6.2.4), internet infrastructure and connectivity (§6.4.1), implementation cost (§ 6.4.3), government policy and support (§6.5.2), regulation, and regulatory framework (§6.5.33). Industry dynamics (§6.3.1) is the only theme that is inconsistent with the existing constructs, the research identified that industry dynamics should be considered as an extension of the theory.

For this research, as evaluated in Chapter 4 and for the purpose of the UTAUT embedded analysis, only the four constructs of the UTAUT model are found relevant to analyse of the perception of stakeholders on the adoption of Blockchain technology. Furthermore, the analysis relates the findings to the existing literature in order to identify consistency, inconsistency and new knowledge that previous research has not addressed. Figure 7-2 illustrates the outcome of the UTAUT embedded analysis and its impact on the adoption of Blockchain in the oil and gas supply chain.

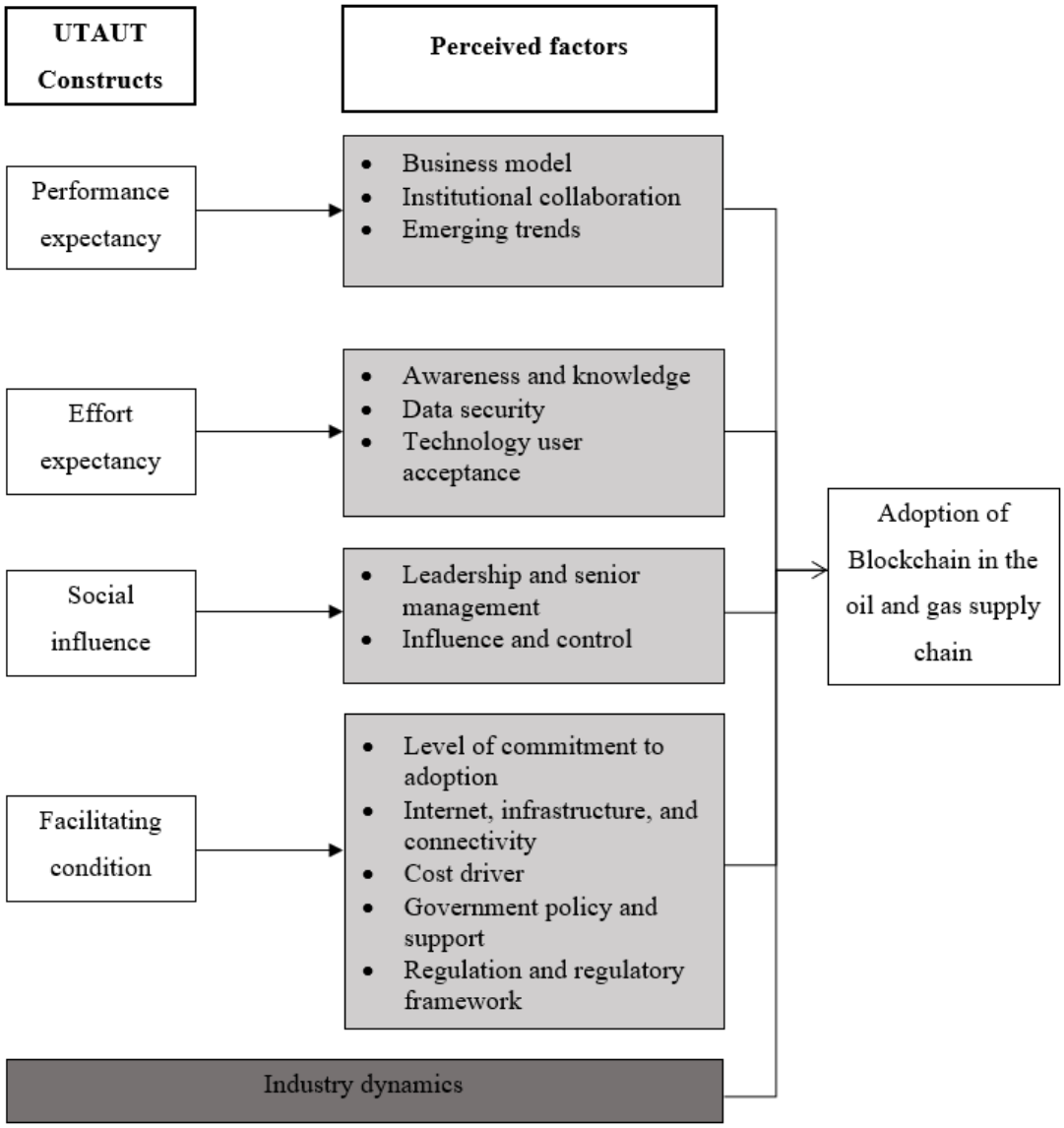

Figure 7-2 the summary of the research outcome source

Figure 7-2 illustrates the procedure used to analyse the research outcome from the perspective of the UTAUT model that is also referred to as the UTAUT embedded analysis. The following sections present the analysis based on the illustration in Figure 7-2from the impact of the UTAUT model on the factors for the adoption as demonstrated. This embedded analysis provides empirical evidence on the perceived factors for the adoption and the relevance of the outcome on Blockchain technology within the Nigerian oil and gas supply chain.

7.1.1 Business model, institutional collaboration and emerging trends embedded in the performance expectancy construct

The performance expectancy construct represents the extent to which an individual believes that the adoption of technology will help in achieving a specific objective (Venkatesh, Thong and Xu,

2016). Therefore, the adoption of Blockchain technology is facilitated by the belief that the adoption of the technology will help achieve the objectives of the oil and gas supply chain. This included the adoption of Blockchain in the industry to solve challenges facing the industry and increase its global competitiveness. Based on the embedded analysis, the business model, institutional collaboration, and emerging trends were identified to be the perceived factors that offer the desired expected performance outcome to Nigeria's oil and gas supply chain. Therefore, the themes that fall under the performance expectancy are under the category of organisational, institutional and operational environment. This outcome implies that the stakeholders perceived that having a business model, managing institutional collaboration, and identifying emerging trends across the industry will influence the adoption of Blockchain from the perspective that it will increase performance in the oil and gas supply chain in Nigeria.

The findings from the thematic analysis show the effect of performance expectancy on the adoption of Blockchain technology within the oil and gas supply chain. Performance expectancy is the degree to which one believes this technology can help achieve the objectives. Therefore, the findings from this research align with the view that the adoption of Blockchain can support the oil and gas supply chain to achieve its objectives (Venkatesh, Thong and Xu, 2016). All the themes were interpreted from the perceived factors of the adoption of Blockchain technology based on the constructs of performance expectancy. The findings under the business model in Chapter 6, Section 6.3.3 revealed the relevant areas perceived by the stakeholders as critical cases for a Blockchain business model by identifying unique challenges and providing Blockchain solutions. The findings confirmed that if the Blockchain solution could be tailored to a practical application, a procurement model enabled by consortium and collaboration will help the industry adopt Blockchain. The findings from a previous study by Clohessy and Acton (2019), explored the effect of organisational factors on the adoption of Blockchain technology, and found that business model readiness was a factor in the adoption of Blockchain technology. However, the literature has provided aspects of the specific models and the anticipated effect on the perceived adoption from an organisational or performance expectancy perspective. The findings have provided a guide on the type of business model stakeholders that are interested in Blockchain solutions.

The research findings identified that institution collaboration was an expected performance that would lead to the adoption of Blockchain. The research findings under institutional collaboration revealed the perceived influence of organisational alignment, automation of the process, and self-decision as an enabler for performance in the oil and gas supply chain. The findings align with the perceived expectation that Blockchain will scale across industries through organisational alignment enabled by automation and autonomous capability. Interestingly, the work of Francisco and

Swanson (2018) on Blockchain for supply chain found the effect of organisational trust as a factor in facilitating the adoption of Blockchain technology in the supply chain. Similarly, Gokalp et al. (2020) revealed the influence of inter-organisational trust as a construct that influences the adoption of Blockchain within organisations. Alazab et al. (2021) extended the UTAUT model by integrating organisational alignment as a factor for the adoption of Blockchain technology. However, the aspect of automation has not been studied in the literature and this discovery was identified to be a essential to the adoption of Blockchain and how the automation will happen within the manual process in the supply chain.

Additional findings that were matched to the performance expectancy are the industry's emerging trends as a factor for the adoption of Blockchain technology for the supply chain. Although this was contained within the operational environment category of the thematic analysis, it is relevant to the perceived expected outcome from the Blockchain due to the innovation and efficiency of the system, transparency, and visibility. The thematic analysis demonstrated in Chapter 6, Section 6.6.1 the belief of the stakeholders that the emerging trends, coupled with the desire for innovation and efficiency, can support the industry achieve its supply chain objectives. Also, within the emerging trend theme was identified that transparency and visibility support the trends for the adoption of Blockchain technology. Literature has established the element of Blockchain technology to deliver transparency and visibility for the supply chain; as a result, the perception of the stakeholders on emerging trends as an enabler for achieving supply chain objectives is consistent with previous findings (see Wang *et al.*, 2019; Dutta *et al.*, 2020). These two findings illustrated Blockchain solutions' performance effect on transparency and efficiency. However, there is no consistency in previous findings on innovation, but system efficiency has been found to be a driver for the adoption of Blockchain technology (Nowiński and Kozma, 2017a).

The findings from the study generated a perspective that the previous research had not been adequately researched or lacked empirical evidence. In this aspect, previous literature has been consistent with the findings and where there are inconsistencies, the findings serve as evidence for further exploration. It has revealed the relevance of the business model on any Blockchain solution to the industry and the critical relevance of institutional collaboration to achieve supply chain objectives. Further, findings have shown how emerging industry trends help establish the usefulness of Blockchain technology to be adopted across the oil and gas supply chain environment. Based on the above evidence, the findings have confirmed the relevance of the impact of the UTAUT theory and the construct of performance expectancy in generating new knowledge based on empirical evidence from the research interviewees.

7.1.2 Awareness and knowledge, data security and technology user acceptance embedded in the effort expectancy construct

Effort expectancy is the extent to which ease of adoption is associated with a technology (Venkatesh, Thong and Xu, 2016). Therefore, the adoption of Blockchain technology is perceived based on the factors that will facilitate the ease of adoption in the oil and gas supply chain. The themes in this research that related to the effort expectancy constructs are awareness and knowledge, data security, and technology user acceptance. These themes come under the category of organisational and technological, which demonstrated that the stakeholders perceived these themes to be enablers for ease of adoption. The significant part is in terms of the expectation of the stakeholders on the awareness and knowledge across organisations to ease the adoption. Data security and technology user acceptance are believed to be a factor that will ease the adoption from the technological point of view by offering Blockchain technology the acceptability of the stakeholders to scale through adoption in the industry. It could be deduced that these themes are critical perceived factors that could motivate the oil and gas supply chain stakeholders to adopt Blockchain technology once the ease associated with the adoption is achieved. The second part of the thematic analysis that aligns with effort expectancy are the perceived factors that the stakeholder's believe that adoption of Blockchain technology will be easy if support is available to scale the adoption. According to the UTAUT constructs, effort expectancy is interpreted as the ease of use associated with the adoption of Blockchain technology (Venkatesh, Thong and Xu, 2016). This UTAUT embedded analysis has associated awareness and knowledge, data security and technology user acceptance as the perceived factors associated with organisational and technological categories.

The awareness and knowledge of Blockchain technology in Section 6.3.2 as a critical factor that would enable the adoption of Blockchain technology in the oil and gas supply chain and lack of knowledge and understanding is a perceived factor that affects the adoption even among the committed companies in the industry. Mohammed et al. (2020), when identifying factors that would significantly influence decision-makers to adopt Blockchain, found that awareness of the technology is a critical driver. Khazaeir (2020) also found that when adopting Blockchain technology, the awareness of the technology could provide a positive outcome. The consistency here is that awareness and knowledge of Blockchain technology is a factor that will facilitate the ease of adoption based on the interpretation of the construct of effort expectancy.

It was interesting to note that the findings on data security presented in Section 6.5.2 agree with the effort expectancy construct. This alignment was based on the interviewees' beliefs regarding the level of confidence from the stakeholders as a perceived factor that will help in the protection of data associated with Blockchain solutions. Data is an asset to industry, and any technology that can

protect data is a welcome development that can scale through adoption. Even though the findings show concerns about the control of data, cyber security and hacking, the data control and how Blockchain could facilitate that is a factor that is considered to ease the adoption of the technology. Clohessy and Acton, (2019) are among the first to identify the relationship between data security and acceptance of Blockchain technology and found that large companies are likely to adopt Blockchain based on data security. Consistent with these findings, Shardeo, Patil and Madaan, (2020) identified critical success factors for Blockchain adoption, and identified data security and reliability amongst the top technological factors for the adoption. Additional research validated secured databases as an enabler for Blockchain technology adoption and demonstrated their significant impact on the adoption of the Blockchain (Kamble et al., 2020).

Technology user acceptance in Section 6.5.4 has been identified as a factor to ease the adoption of Blockchain technology in the oil and gas supply chain. The findings revealed that the less complex the technology is designed, the better chance the industry will accept it. It revealed that Blockchain technology should fit into the business process as a way of adding value before adoption, so the technology user acceptance is a practical demonstration that the industry agrees to the value of the technology and is ready to adopt it in the supply chain. It was further found that user difficulty should be eliminated from Blockchain solutions targeting the oil and gas supply chain. This is in addition to the industry's difficulty, so the ease of use in this context relates to demystifying the technology. Blockchain is expected to facilitate ease of adoption and the literature shows elaborated findings with technology user acceptance or experience as an enabler for adoption. The relevant literature in relations to the themes were the work of (Palos-Sanchez, Saura and Ayestaran, 2021; Grover *et al.*, 2019) which generated an interesting perspective on the user acceptance of Blockchain technology or digital transactions. Though it was not within the supply chain, it relates to the ease of use and understand of technology. Therefore, user technology acceptance was found to be a factor for the adoption of Blockchain technology and a strong factor that fits within the social influence construct.

The findings under the export expectancy show that for the industry to embrace the Blockchain technology for the oil and gas supply chain, it is critical for the adoption to focus on organisational awareness and knowledge whilst the technology should maintain consistency of protecting data and securing the industries vulnerable data at the same time ensuring the technology is less complex for user acceptance. The findings have confirmed the relevance of the UTAUT theory and the construct of effort expectancy in generating new knowledge based on empirical evidence from the research interviewees. This approach sits within the Blockchain technology literature as previous

studies have validated this research outcome and where the literature was lacking, it generated a new perspective.

7.1.3 Leadership and senior management, and influence and control embedded in the social influence construct

Social influence is the extent to which an individual believes that someone important will influence their decision to adopt new technology (Venkatesh et al., 2016b). Therefore, the acceptance of Blockchain by socially influential stakeholders impacts adoption in the oil and gas industry. The themes under social influence are leadership and senior management, influence, and control, and they are under the organisational and institutional categories in Section 6.4, respectively. In the analysis of the themes under the social influence constructs of the UTAUT model, the interviewee's perceived that at the organisational level, the leadership and senior management are regarded as the critical stakeholders that will influence the adoption of Blockchain technology. The other important aspect is that the oil and gas institutional influence and control is a significant factor that others will adopt Blockchain technology in the industry. From the thematic analysis, the level of influence and control by institutions in the industry is the social influential factor in the adoption because of the nature of the drivers of the industry, as presented in Section 6.4.2. Therefore, the findings show that the perceived factors of both the leadership and senior management and the influence and control are important factors that others considered to influence the adoption of Blockchain technology for the oil and gas supply chain.

The literature highlights similar findings on the determinants of Blockchain adoption in the supply chain, where top management support is an influential factor though was not viewed from the UTAUT construct perspective (Mali*k et al*, 2021). According to (Malik et al., 2021) top management support is amongst the factors that lead to Blockchain adoption in an organisation. Although this research found specific roles related to leadership and senior management support, such as the role of supply chain partners, major industry players and top-level decision makers, are perceived factors that the leadership and senior management support can influence the adoption of Blockchain in the oil and gas supply chain. The findings revealed that the industry stakeholders are familiar with the role of top management, similar to what was reported in previous literature relating to the adoption of Blockchain (Ma*lik et al*, 2021). The aspects of influence and control have however not received any attention from researchers to date. The role of institutional influence and control being a social influence, demonstrates how Blockchain adoption was viewed by the stakeholders, recognising the specific role of the external partners and overall stakeholder management. However, (Orji *et al*, 2020a) mentioned that stakeholder pressure could be responsible for influencing Blockchain technology in research that examines the influential factors

for adoption, therefore, social influence here relates to internal and external forces that might influence the decision to adopt technology.

The thematic analysis of social influence illustrates its embeddedness to the UTAUT model and provides the justification for explaining the themes of leadership and senior management, and institutional influence and control on the adoption of Blockchain technology in the oil and gas industry. Furthermore, the analysis of the leadership and senior management is consistent with previous studies that individually identified the role of top-level management and the impact on the adoption of Blockchain technology, even though it has not yet been empirically proven nor in the context of the oil and gas supply chain. Furthermore, the UTAUT embedded analysis has confirmed the relevance of UTAUT theory and the construct of social influence in generating new perspectives and knowledge based on empirical evidence from the analysis of the research interviewees.

7.1.4 Level of commitment to adoption, internet, infrastructure and connectivity, government policy and support, regulation and regulatory framework embedded in the facilitating condition construct

The facilitating condition construct represents the extent to which an individual believes that technical and organisational support exists to support the adoption of a technology (Venkatesh, Thong and Xu, 2016). Therefore, the level of organisational and technical support or resources to support Blockchain adoption in the oil and gas supply chain were considered. The themes that are embedded within the facilitating condition construct are the level of commitment to adoption, internet, infrastructure and connectivity, cost driver, government policy and support, regulation and regulatory framework. The above themes were established under the organisational, technological and operational environment categories.

The analysis revealed that stakeholders perceived that the level of commitment from the organisation would be a facilitating condition to adopt Blockchain technology. At the same time, the internet, infrastructure and connectivity are facilitating conditions to the adoption of Blockchain technology. The analysis demonstrated that the cost of the technology would influence and create the enabling condition for the adoption of Blockchain technology. The findings also recognised the role of government policy and support in Section 6.6.2 as facilitating conditions. Another important finding was the regulations and regulatory framework as a facilitating condition for adopting Blockchain technology in the oil and gas supply chain. In line with the categorisation of the themes, the themes affected the category of organisational, technological, and operational environment. Thus, the only category that does not fall under the facilitating conditions is institutional. The findings revealed that the level of commitment to the adoption was a perceived factor that the

stakeholders believed would help to facilitate the adoption (Queiroz and Fosso Wamba, 2019; Saberi *et al.*, 2019). However, the findings in this research revealed that the level of commitment enables the establishment of Blockchain projects for the industry's supply chain through available funding and investments. The consistency of findings under the facilitating consideration is the belief that perceived commitment through projects, investment and funding would be a factor in the adoption.

The thematic analysis identified that the internet, infrastructure, and connectivity in Section 6.5.1 are critical facilitating conditions for Blockchain technology. Previous studies found among the adoption factors for Blockchain technology adoption are the internet and connectivity as critical drivers for adoption (Rejeb, 2018; Figorilli *et al.*, 2018). Connectivity has been found to be a facilitating condition for the adoption of Blockchain technology in the industry based on the findings because Internet accessibility and connectivity are the backbones of any technological development. Though no study has pointed out the direct link between internet connectivity and facilitating condition, research has attributed the success of Blockchain adoption to internet connectivity (Ikumoro and Jawad, 2019). In addition, research has previously found that Blockchain adoption factors include technological fits such as infrastructural facilities (Queiroz et al., 2020a). Among the factors found in this research are compatibility and integration in Section 6.4.1.2. These are factors that Blockchain technology's adoption considered as the facilitating condition available to support compatibility and integration with existing technologies. The findings show that new requirements for investments in infrastructure and discarding existing systems and technologies could have a severe negative impact if Blockchain technology cannot be compatible and integrated with the existing technologies. Blockchain technology's effectiveness in integrating with existing business process management and emphasises the compatibility with existing technologies (Batwa and Norrman, 2020). From the analysis above, the relevant literature highlighted has been demonstrated to be consistent with the current embedded analysis on the significance of the themes embedded to facilitating condition for the adoption of Blockchain in the oil and gas supply chain.

Cloud infrastructure in Section 6.4.1.3 was identified to be a facilitating condition that could help Blockchain technology adoption. It also reveals the importance of IT community as a means of support for the adoption, and resonates with the facilitating condition, as the finding shows that having a community of IT will effectively support the technology adoption and address the existing lack of awareness. However, the literature has not yet demonstrated cloud computing or community support as a facilitating condition for the adoption. Instead, the literature states that the Blockchain technology community is growing and serves as a sector that will increase its presence within

academia and industry (Rosanna, 2019). The findings revealed the 5G network, as one of the facilitating conditions in the adoption of Blockchain technology in industry due to the demand for speed in internet connectivity. However, no literature has capture the relevance of 5G as a facilitating condition to the adoption of Blockchain technology, despite the research that recognised the importance of the 5G network to the usage of Blockchain technology (Chaer, Salah, Lima, Ray, and Sheltami, 2019). Further findings from internet connectivity comprise the stability of power, which is also identified as a facilitating condition to the adoption of Blockchain technology. The stability of power and energy supply is a critical aspect that the research identified from the infrastructure support available.

The findings from the operational environment aspect show that government policy and support in Section 6.5.2 are facilitating conditions for the adoption of Blockchain technology. The belief is that once the government policy is available and government supports the adoption through programmes and policies, there will be adoption within the oil and gas environment. The findings revealed that the government is responsible for driving policies and the implementation of programmes and projects. As a result, the government has a role in ensuring the adoption of Blockchain technology is driven by its policies and programmes. Furthermore, the government provides guidelines on the adoption of Blockchain which stakeholders see as initial support available to drive the adoption. It was further revealed that without government policy and support, critical stakeholders would be less concerned about adopting Blockchain even though it could benefit the entire system. There is a previous relevant finding on the role of government policy and support in the literature: Shardeo, Patil and Madaan, (2020) posited that government support as a factor leading to the adoption of Blockchain technology, while in another finding, government policy was found to influence adoption of Blockchain within organisations (Gökalp, Gökalp, and Çoban, 2020).

The role of regulation and regulatory framework in Section 6.5.3 was found to be a facilitating condition for the adoption of Blockchain technology based on the relevance of regulation and enforcement of technology in the industry. The research findings revealed that for Blockchain technology to be adopted in the oil and gas supply chain, there is a need for legislation and a regulatory framework that will guide and enforce adoption according to the operational environment factors in the industry. The research found the significance of the regulatory framework based on understanding Blockchain technology and what it offers to supply chain management in the industry. The role of regulations as a facilitating condition has been rooted in similar research that investigated the influence of Blockchain in supply chain adoption, and the study found the effect of regulatory support as a perceived enabler (Won*g et al*, 2020). Regulation

has also been found to be a critical part of Blockchain adoption by creating a fair environment for the stakeholders and protecting the exploitation of adoption (Abelseth, 2018).

The above analysis of the embedded facilitating condition revealed critical research findings. The findings above were consistent with similar research in the previous literature, particularly in confirming the findings' relevance to the existing UTAUT theoretical approach. The level of commitment, government support and policy and regulation and regulatory framework are all factors that serve as facilitating conditions for the adoption of Blockchain technology within the organisational and operational environment categories in the research. Furthermore, the findings have confirmed the relevance of the UTAUT theory and the construct of facilitating conditions, as well as in generating new knowledge based on empirical evidence from the research interviewees.

7.1.5 Industry dynamics as a new construct for the UTAUT model for the adoption of Blockchain technology

The significant theoretical implication of the UTAUT embedded analysis has revealed that one of the themes, "industry dynamics", does not align with the performance expectancy, effort expectancy, social influence, or facilitating condition constructs. In this regard, industry dynamics is based on the thematic findings and theorises a new perspective to the adoption of Blockchain technology in the oil and gas supply chain. Despite technological advancement, the oil and gas industry's dynamics in this research were centred on the components that are in line with the unique nature and antecedents of the industry as well as those the interpretation of the findings in the context of the Blockchain adoption. These are the level of competition Section 6.3.1.1, unethical practices in Section 6.3.1.2, resistance to change in Section 6.3.1.3, manual processes in the supply chain Section 6.3.1.3, and crude oil trading in Section 6.3.1.5. The implication of the above findings, is that it can extend the UTAUT to include a construct on industry dynamics; for example, the composition of the industry dynamics from the context of this research is directly constituted to the oil and gas supply chain. Venkatesh, Thong and Xu, (2016) recommended exploring contextual individual and organisational factors to extend the UTAUT theory. The consideration of industry dynamics as a construct that will influence the adoption of Blockchain technology within the oil and gas industry, can be viewed as the role of industry-specific factors that lead to growth, changes, or innovation in an industry. These sets of events can eventually lead the industry to accept and adopt technology, i.e. Blockchain technology in this case (Kryukov and Tokarev, 2018; Dolgui *et al.*, 2020)

On why the oil and gas industry is considered a dynamic industry in the context of this research and generally, is that some factors continuously shape the industry's future, and some affect the industry development that is driven by internal and external factors in most cases, which cannot be

predicted. Therefore, the oil and gas sector has been generally regarded as a dynamic industry even before the technological evolution (Shuen, Feiler and Teece, 2014; Saad, Udin and Hasnan, 2014; Antonakakis *et al.*, 2018; Behmiri, Manera and Nicolini, 2019). However, there has been no standard definition of industry dynamics in the context of the study, nor the literature relating to the adoption of Blockchain technology. Carlsson and Lundvall, (1978), Carlson, (2016) and Kipping, (2021) are among the leading advocates of the concept of industry dynamics and its role in market structure, transformation, technology, and profitability. Their work streamlined industry dynamics into the role of industry changes and its institutional framework conducive to technological progress at the organisational levels. Although the area of industry dynamics as it relates to innovation and technology is emerging, more research is needed to make innovation systems a viable tool for analysing industrial progress and economic growth with a deeper analysis of the dynamic aspects of complex systems adoption (Carlsson, 2016). This research concludes that the theme of industry dynamics is a critical component of the findings that most of the research interviewees emphasise as a factor to the adoption of Blockchain technology. The UTAUT model has four constructs: performance expectancy, effort expectancy, social influence and facilitating condition. Therefore, the UTAUT embedded analysis findings has not found the industry dynamics aligns within the existing constructs, and suggested it as an additional construct to the UTAUT model applicable to this research.

The consequence of the above finding extends the theory and is found to be consistent with the views and recommendations of (Venkatesh, Thong and Xu, 2016) on exploring contextual organisational factors to extend UTAUT. Interestingly, industry dynamics were among the themes that emerged under the institutional category. Many of the interviewees in the study emphasised the role of industry dynamics in the industry's adoption of new technology like Blockchain technology. The industry changes rapidly due to low prices, government policy and globalisation due to the move in energy demand and it comes with developments that the industry can quickly adopt technologies like Blockchain technology or not on the opposing part. The research found that some of the dynamics of the industry are attributed to the level of competition as they continue to change over time. Unethical practices in Section 6.3.1.2 was attributed to the industry's structure, and the institutional practices and resistance to change by key players in the industry are all attributed to factors that are perceived to be determinants of Blockchain technology adoption for the supply chain. By integrating the construct of industry dynamics into the UTAUT model, this research proposes an extension to the UTAUT model based on the evidence of the relevance of industry dynamics as a factor for the adoption of Blockchain technology.

Similarly, the findings revealed that the industries that are accustomed to manual supply chain in Section 6.3.1.4 practices and the nature of how crude oil keeps changing due to its strategic priority to the government. The research found that the oil and gas industry is dynamic and keeps shifting and considering the potential of Blockchain technology to the supply chain will be of strategic advantage to the industry. The literature did not directly highlight the role of industry dynamics in adopting Blockchain technology. However, it has been shown that changing events could lead the industry to accept and adopt Blockchain technology (Kryukov and Tokarev, 2018; Dolgui *et al.*, 2020). Another perspective on the factors that influence Blockchain adoption is the market turbulences, which significantly affect the decision to adopt Blockchain technology in the operational environment context (Orji, Kusi-Sarpong, Huang, and Vazquez-Brust, 2020b). Generally, several studies have proved the dynamics of the oil and gas industry and how its affect new innovation and technology development as a resultant of the impact of policies, regulations and operational environment, and in most case this factors cannot be predicted (Shuen, Feiler and Teece, 2014; Saad, Udin and Hasnan, 2014; Antonakakis *et al.*, 2018; Behmiri, Manera and Nicolini, 2019).

7.2 Research validation

The purpose of research validation is to assess the research's quality, significance, and validation. It proves that the research was carried out correctly and accurately. For this research, validation means whether the findings provide sufficient evidence on the factors influencing the adoption of Blockchain technology in the oil and gas supply chain, and what value the findings will provide in relation to the adoption of Blockchain technology. To validate thematic qualitative research, the process focus was on whether the outcome provided convincing evidence to achieve the research's aims (Edmondson and Mcmanus, 2007; Nowell *et al.*, 2017; *Patton*, 1990; Venkatesh and Brown, 2013; Birt *et al.*, 2016).

Chapter 6 and the current UTAUT embedded analysis was significant to have demonstrated the extent of detailed analysis of the research. However, Pyett, (2003) posited that for qualitative research, the analysis process necessitates constant self-reflection, continuous assessment of subjective responses, intersubjective dynamics, and the research process itself. Therefore, the initial interpretations of the thematic findings were confirmed during analysis by additional scrutiny and verification of quotations, which also includes a look at the meaning-making process and repeatedly going back to the data to check the findings.

In Section 5.4, the research validation process was discussed through the use of a member check. Member check also referred to as interviewee or participant validation, is a method for examining

the veracity of results. Participants received data or results back to verify accuracy and fit with their experiences. Member checking is frequently listed among the validation methods for qualitative thematic analysis (Birt et al., 2016). Further, in order to justify the validation process for this research, it covers the six standards that can be used to ascertain the reliability of thematic analysis research: credibility, transferability, dependability, confirmability, audit trails, and reflexivity (Borrego, Douglas and Amelink, 2009; Nowell *et al.*, 2017). Accordingly, the research conducted a member check examination and validation. The process was designed to achieve the goal of validation through credibility of the findings and was achieved through member check examination, the generalisation of the research outcome, and this was achieved through a broader selection of research participants across the oil and gas industry and across cross-organizations and functions. The dependability was achieved by relating thematic findings to existing literature and the UTAUT model, which has existing findings within an established field of knowledge.

The member check process for this research entailed contacting the initial interviewees to present the findings and determine whether the findings and interpretation accurately represented their views and perspectives on their contributions. For the member check, all twenty-three research respondents for this research were contacted. However, only nine people responded to the calls, and seven of them were members. There were three members from upstream and four from the middle and lower reaches. At the time of the member check, the Nigerian oil and gas industry had been restructured by the passage of the Petroleum Industry Act 2022.

The process began with a 30-minute presentation of the research aim and the thematic findings as well as the UTAUT embedded outcome. The members were asked two questions.

Do the findings represent the views provided during the interview, and how do the finding reflect the authenticities of the factors found in the research within the industry? All the members that participated confirmed that the findings represented their views from the initial interviews, and they were satisfied with the entire outcome and how it will guide the adoption of Blockchain technology in the industry. However, two of the members provided additional comments.

- The industry is facing a transformation with the passage of the Petroleum Industry Bill to the Petroleum Industry Act 2022 and the commitment of the government to commercialise the national oil company and its operational model.
- The development of commercialisation and the PIA would open the transformation and the use of Blockchain technology to commercialise Nigeria's national oil and gas industry.

None of the participants from the member check objected to the findings in this research based on their contribution. However, the findings may be limited to the research's circumstances,

population, and context. Based on the validation, it would apply to similar circumstances, populations, and contexts, particularly for repeatability purposes (*Patton*, 1990; Venkatesh and Brown, 2013). Table 7-1 shows how the research address the validation against the standards of credibility, transferability, dependability and audit trails.

Table 7-1 Research validation against the standards

Validation criteria	Description	How the research addressed it
Credibility	The extent to which the findings accurately reflects the experiences and perspectives of the respondents.	Using NVivo, the thematic was used to ensure that the data was thoroughly examined in order to identify themes and patterns. The member check with the respondents confirms the findings' accuracy and validity.
Transferability	The extent to which the findings can be applied to other settings and context.	The research from different parts of the industry and backgrounds based on their supply chain decision making capabilities has provided a range of perspectives that will be useful to inform future research in similar context. The findings could aid Blockchain adoption throughout the supply chain.
Dependability	The extent to which the findings are consistent and repeatable	The audit trails were kept to document the process, which included selecting respondents, collecting data, and analysing it. The UTAUT embedded analysis ensures consistency in theory application and relevance.
Audit trails	The documentation of the entire research process to ensure that it can be replicated or audited by other researchers	This research has taken into account the details of the process and analysis, which, in accordance with university policy, will be saved for a set period of time, including the data collected, analysis, and interpretation.

7.3 Summary

In this chapter, the research presented several insights that have come about as a result of expanding the research findings and interpreting the research based on the UTAUT model. It has incorporated the findings from the thematic analysis into the constructs of the UTAUT model, and it has established the significance of UTAUT when combined with earlier research taken from the body of published literature. A comprehensive analysis of the data was carried out using the appropriate constructs, and the procedure that was utilised for the UTAUT embedded analysis was described in detail. The findings of the research indicated that UTAUT is of critical importance in interpreting the thematic findings across organisational, institutional, technological, and operational environment. As a consequence of this, it was shown that the critical importance of UTAUT to the

research in the behavioural implication of the adoption of Blockchain based on the factors identified. The implications of the findings could be perceived as a result of the identification of the constructs that align with the themes, whereas industry dynamics that was not aligned with any of the UTAUT constructs. The alignment of the themes to UTAUT helps in predicting how stakeholders in the oil and gas industry will feel about the implementation of blockchain technology within supply chain operations. In addition, the findings of this chapter filled a knowledge gap on the contextual factors for the implementation of blockchain technology in supply chains within the context of developing nations, which demonstrated the significant contribution that the research has made. The discussion of the findings will be presented in the following chapter.

8 Closing remark

The UTAUT embedded analysis was presented in the previous chapter, whilst this chapter is the closing remark. The research was carried out using a qualitative thematic approach. The chapter begins with an overview of the methodology and methods used, as well as the research findings, in order to critically discuss the findings. Then turn to how the qualitative thematic and UTAUT embedded analysis could potentially help achieve the goal of implementing Blockchain technology within the Nigeria oil and gas industry more effectively. This aspect includes a detailed discussion of how the research goal was achieved through reflection on the findings and why this was possible using the qualitative thematic and UTAUT embedded method and analysis. The chapter discusses the significant research contribution, theoretical contributions, methodological contributions, and practical contributions, the managerial implications, the limitations and future research implications, and end with the conclusion of the thesis.

8.1 The research methodology and method

The research investigated the perceptions of Blockchain technology adoption in Nigeria's oil and gas supply chain. The research's main objective was to provide valuable and novel knowledge on Blockchain technology adoption in the oil and gas supply chain context. As a result, the Interpretivism paradigm was chosen as the best fit to provide the research with the ability to evaluate the elicited perspectives of the stakeholders by interpreting the stakeholder's views using thematic analysis and the UTAUT embedded model (Borrego, Douglas and Amelink, 2009; Cao *et al.*, 2021).

To address the sparsity of research on the application of UTAUT to predict technology acceptance and use in the oil and gas supply chain, this research utilised a qualitative research methodology to test the model's appropriateness to the adoption of Blockchain technology. This research employed a thematic inductive approach to identify the factors, and embedded UTAUT to determine the relevance of UTAUT and how it could explain the adoption of Blockchain technology within the oil and gas supply chain. The prominent philosophical queries of what the researcher can learn about Blockchain adoption in the oil and gas industry outside of the Nigerian setting and how valid the statements will be given, are crucial concerns in the researcher's thinking. The interpretivist philosophical approach, which focuses on investigating and creating knowledge by interpreting the interviewees' responses, is further justified due to the relevance of the research, resources, access, the choice of methods, and the depth of valid knowledge that the research can create. The problem was initially investigated through a systematic process and qualitative interview inquiry with stakeholders in the Nigerian oil and gas industry from various backgrounds and organisations. An

embedded UTAUT analysis was conducted and validated by a member review of the overall research outcome to explain further and comprehend the perspective. The choice of qualitative research methodology and methods promotes knowledge and understanding through the experiences, beliefs and perspectives of the interviewees in this research. It is imperative to investigate the adoption of Blockchain technology in the oil and gas supply chain phenomena that is otherwise difficult to quantify quantitatively. The use of qualitative and thematic analysis is well established to create new knowledge about a phenomenon that lacks empirical evidence. The application of the qualitative research methods and the findings from the thematic and UTAUT embedded analyses are consistent with what in-depth qualitative research can offer and has been characterised by the researcher's ability to demonstrate transparency and accountability throughout the research process (see Chapter 5). It provides a comprehensive analytical approach to the above findings from the research (Holloway, 2005:6; Davies and Hughes, 2014).

8.2 The findings of the research

This research has two critical presentations of the findings, the thematic analysis in Chapter 6 and the UTAUT embedded analysis in Chapter 7. This has provided the perspective of the stakeholders on the adoption of Blockchain technology in the oil and gas supply chain in Nigeria. Therefore, the thematic analysis's findings are categorised into organisational, institutional, technological and operational environment. A total of fourteen themes were discovered with organisational having four themes (leadership and senior management, awareness and knowledge, business model, level of commitment to adoption), institutional having three themes (industry dynamics, influence and control, institutional collaboration), the technological having four themes of (internet, infrastructure and connectivity, data security, cost driver, technology user acceptance) and finally, operational environment having three themes of (emerging trends, government policy and support, regulation and regulatory framework). These themes were embedded into the UTAUT model, and the outcome translated into having the themes embedded into the constructs of the UTAUT as follows.

The UTAUT performance expectancy construct was embedded into the themes of business mode, institutional collaboration and merging trends. Effort expectancy was embedded into the themes of awareness and knowledge, data security, and technology user acceptance. Social influence was embedded into the leadership and senior management and influence and control. The facilitating condition construct was embedded into the level of commitment to adoption, internet, infrastructure and connectivity, cost driver, government policy and support, and regulation and regulatory framework. Industry dynamics was identified as having a unique composition that does not fall

under the existing UTAUT constructs and could, therefore, not be regarded as being embedded into the existing UTAUT model.

Consider the implications of the findings for the current challenges in Nigeria's oil and gas industry. The findings demonstrate the potential of Blockchain technology to address issues such as lack of transparency and accountability, revenue leakages, manual processes and downstream operations, and subsidy regimes (Section 3.3). The factors identified in this research span multiple categories that are deemed critical to the adoption of Blockchain technology. The application of these findings in the design, adoption, and use of Blockchain as platforms for sharing data, storing transactions, and eliminating third-party verification will increase trust among supply chain partners while also increasing speed and efficiency in oil and gas supply chain operations. However, the critical players and the national oil company have been identified as critical enablers of Blockchain adoption through leadership, investment, demonstrations of commitment to adoption, and sharing experiences as first adopters. Thus, regulators and the government are identified as critical stakeholders in ensuring that Blockchain is used in the oil and gas supply chain, resulting in revenue leakages being eliminated and subsidy payments being transparent. However, the research indicates that the government must be committed to developing policies that align with Blockchain and using regulators to create an enabling environment and regulate Blockchain practises. The research findings have laid the groundwork for the industry as a whole to form a consortium that will accelerate the adoption of Blockchain for supply chain and create efficient and secure forms of data storage and transaction.

8.3 How the qualitative, thematic and UTAUT embedded analysis achieved the aim of the research

It is important to critically consider how the qualitative thematic and UTAUT-embedded outcomes contributed towards achieving the aim of the research. The research aimed to investigate the stakeholder’s perception of the adoption of Blockchain technology in Nigeria's oil and gas supply. The UTAUT model was used in the research to support the prediction of Blockchain adoption based on the perceived factors identified. As a result, the research data was gathered through in-depth interviews with interviewees based on their knowledge and experience of Blockchain adoption in the supply chain. The qualitative in-depth interviews were thematically analysed, and the outcome were presented into four categories of organisational, institutional, technological and operational environment based on the identified themes. The use of a qualitative approach identified factors that were unknown and not empirically identified in terms of Blockchain adoption.

Furthermore, as part of the UTAUT-embedded findings, the categorisation of the findings identified the effect of the themes on the constructs of the UTAUT model. The UTAUT embedded findings led to the proposition of a new construct of industry dynamics and its impact on Blockchain adoption in the oil and gas supply chain. The consistency of the factors in the literature and the alignment of the factors in the UTAUT constructs indicate the validity of this outcome. Furthermore, the member check performed as a form of validation demonstrated the efficacy of the thematic findings in accurately interpreting the interviewee's experience, knowledge, and views within the context of the research. All the thematic findings were found to be consistent with the perspectives expressed by interviewees during data collection.

This research offered a unique perspective on the adoption of Blockchain technology in the oil and gas supply chain, which can benefit firms, regulators, investment, technology development, and stakeholders at multi-organisational levels. The findings of this research will provide context for addressing the lack of adoption of Blockchain technology, even when the business case has been justified. Based on the nature of the oil and gas supply chain, the complexity of stakeholders' operations in the Nigerian oil and gas industry, government interest, and Nigeria's emphasis on technology and innovation for public goods, the findings in this research have been achieved through providing a source of achieving the desired result of using Blockchain technology to solve supply chain challenges.

The qualitative nature of the research has helped in achieving the aim of the research based on the following findings:

- The findings demonstrate the impact of performance expectancy on Blockchain technology adoption in the oil and gas supply chain. The degree to which one believes technology can help achieve their goals is referred to as performance expectancy. The findings confirmed that if the Blockchain solution can be tailored to a practical application, such as a procurement model enabled by consortium and collaboration, the industry will be able to adopt the technology more quickly. Based on empirical evidence from research interviewees, the findings confirmed the relevance of the UTAUT theory and the construct of performance expectancy in generating new knowledge. It has demonstrated how emerging industry trends influence perceptions of the utility of Blockchain technology in the oil and gas supply chain environment.
- The second part of the findings that achieved the aim of the research is the effort expectancy results from the perceived factors that the stakeholder's belief that adoption of Blockchain technology will be simple if support to scale the adoption is available. Surprisingly, the research discovered that data security and stakeholders' confidence in Blockchain

technology's ability to protect data are viewed as factors that will aid in Blockchain technology adoption. Despite the findings indicating concerns about data control, cyber security, and hacking, data control has shown optimism about adoption and the perception that it will ease the technology's adoption. It was discovered that the industry wants the technology to fit into its business processes and add realistic values before adoption, so technology user acceptance is a practical demonstration that the industry recognises the value of the technology and is ready to implement it in the supply chain. The significance of effort expectancy is another way the research findings achieved the aim. It demonstrates that in order for the industry to embrace Blockchain technology for the oil and gas supply chain, the adoption decision must focus on organisational awareness and knowledge, while technological factors must maintain consistency in protecting data and securing the industry's vulnerable data while also ensuring the technology is less complex for user acceptance.

- When it comes to industry adoption, Blockchain technology demonstrates the impact of social influence. It has been demonstrated that leadership and senior management are perceived as influential parties within organisations, and their role can support and control others in considering the adoption of Blockchain technology in the oil and gas industry supply chain. As captured, UTAUT's social influence fits into the specific role of external partners and overall stakeholder management. Interestingly, the findings address significant insights on how the social influence demonstrates how the industry will embrace Blockchain technology for the oil and gas supply chain. The adoption decision must focus on organisational leadership and senior management while influencing and controlling at the institutional level.
- Another important factor that addresses the research aim is the effect of the facilitating condition, which was discovered to be a perceived factor of adoption. The UTAUT model aided in determining the significance of the findings on the facilitating conditions. The results show that the level of commitment to Blockchain projects for the industry's supply chain through available funding and investments is the most important aspect of facilitating conditions. The findings also addressed the research aim regarding the effect of facilitating conditions on the role of government policy and support in influencing Blockchain adoption within the industry. It has also contributed to the knowledge of the impact of regulation and regulatory framework as a facilitating condition among operational environmental factors.
- Finally, other significant findings on the role of industry dynamics in the context of Blockchain technology adoption achieved the aim of the research. Among these dynamics

is the effect of uncertainty on issues relating to context-specific aspects such as unethical practises attributed to the industry's structure and resistance to change by key industry players, all of which are perceived to be factors in the determinants of Blockchain technology adoption for supply chain. The relevance of embedding the UTAUT model to address the findings in a logical technology adoption model in the context of Nigeria's oil and gas industry also answered the research questions.

Finally, the research aim was achieved by attempting to incorporate the findings into a new construct of industry dynamics to the UTAUT model as an extension of the theory. This research proposes an extension to the UTAUT model based on evidence of the importance of industry dynamics as a factor in Blockchain technology adoption in the oil and gas supply chain. Based on the findings, the research is believed to have adequately achieved the research aim and significantly contributed to Blockchain adoption in the supply chain field as well as the theoretical aspect of the UTAUT model qualitatively and thematically.

8.4 Generalisability of the research

This research was conducted qualitatively; therefore, the concept of generalisability is important. Though, transferability is referring to the generalisability of the enquiry (Tobin and Begley, 2004). Transferability reflects on the extent to which the research findings can be applied to other contexts or settings (Stahl and King, 2020). It is important to address transferability in qualitative research in order to enhance the truthfulness and consistency (Birt et al., 2016). Slevin and Sines, (2000) posited that research can address transferability by providing detailed descriptions of the study setting and participants, using multiple sources of data, and providing detailed descriptions of the findings. They can also triangulate the data and strengthen the validity of the findings by using a variety of data collection methods such as observations, interviews, and document analysis. Furthermore, throughout the research process, researchers should consider and document their own biases, assumptions, and expectations. They should also provide a rich detailed account of their research process in order to make the research understandable to others. Another way to improve transferability is to guide the study and interpret the findings using established theoretical frameworks. This can help others understand how the findings relate to other research in the field by providing a broader context for the study Finally, to provide detailed examples from their data to illustrate key findings and assist readers in understanding the study's meaning.

To address the research's transferability, the semi-structured interviews that were used as a data collection instrument with 23 participants, had detailed participants descriptions including areas of expertise, industry classification, and years of industry experience (see Section 5.3.4). This allowed the readers to appreciate and comprehend the context of the interviews, as well as how the

participants in the industry are related or unrelated to one another. Another aspect of the research is the use of the UTAUT as the theoretical framework. The use of UTAUT as an established theoretical framework had placed the research in the broader context of previous research in the field of technology adoption, making the findings easier to understand and relate to another research. The member check validation was used; the use of the member check is another significant aspect that addressed the transferability of this research. This entails providing participants with a summary of the findings and soliciting their feedback to ensure that the researcher accurately represented their perspectives. It has demonstrated transparency and accuracy in interpreting and sharing the process and outcome with the interviewees, as well as dependability of the outcome. The research structure, chapters and process followed, methodology and coding process were all documented, the account of research process provides a detailed and transparent account of the research, such as how participants were recruited, data was collected, analysed, and themes were identified is believed that this will help in applying the same process and getting compelling results that are accurate to this research and help readers and adopters understand and appreciate.

Based on the empirical evidence presented above, this research offers important perspectives into the factors that influence the adoption of Blockchain technology within the Nigerian oil and gas supply chain. These findings are relevant not only to the Nigerian oil and gas industry, but also to supply chain industries in developing and developed countries that engage in similar activities, such as oil and gas exploration, production, and distribution. This study contributes to a better understanding of how supply chain partners can leverage Blockchain technology to improve their operations and overall performance by examining the factors that drive the adoption of Blockchain technology.

Furthermore, the implications of these findings go beyond Nigeria's oil and gas industry. Because the use of Blockchain technology in the energy sector is still in its early stages around the world, the factors that this research revealed may be useful to any supply chain that plans to use this technology. As a result, the generalisation of this research result has significant implications for the supply chain industry as a whole. This study emphasises the importance of understanding the interplay between technology and supply chain management in today's business environment by focusing on the key factors that influence the behaviour of supply chain partners towards the adoption of Blockchain technology.

The evidenced process and activities carried out in this research to increase its transferability, the research believes that if the same process were followed, the research outcome would be the same in other contexts, and thus provides strong evidence that handled the transferability.

8.5 Research contributions

This research sits within the context of the Nigerian oil and gas industry and the significant contribution is the first to empirically investigate the factors that influences the adoption of Blockchain within the national oil and gas industry. In specific the following significant contribution were captured in Table 8-1 contributions below:

Table 8-1 Research contributions

Research contribution to the adoption of Blockchain in supply chain	
Challenges	Research output
There are no studies that address the factors that influence Blockchain adoption in the oil and gas supply chain with contextual factors	The research identified fourteen themes within the four categories of organisational, institutional, technological, and operational environment that influence the adoption of Blockchain in supply chain.
Lack of theoretical lens that helps predict how Blockchain will be used in the oil and gas industry in Nigeria.	This research investigated at how well the UTAUT model can predict adoption and found a contextual construct of industry dynamics and its effects on the adoption of Blockchain technology in the Nigeria oil and gas industry.
Using Blockchain technology to solve Nigeria's oil and gas industry's complex supply chain problems.	The research contributed by providing the perceived factors on how Blockchain solutions can transform the Nigerian oil and gas supply chain, as member check validation shows that the industry is eager to commercialise and use technology to increase efficiency. The research would allow the Petroleum Technology Development Fund to lead and collaborate with industry leaders on the potential of Blockchain and how it can benefit the oil and gas supply chain. The research could serve as a framework for programmes and projects involving Blockchain technology in the Nigerian oil and gas industry.

Apart from the presentation in the table above, the following are specific theoretical, methodological, and practical contributions of the research:

- The contribution of this research has a theoretical implication, being the first to empirically investigate the perceived factors for the adoption of Blockchain technology in the oil and gas supply chain using UTAUT in Nigeria. It was necessary to conduct the analysis of the appropriateness of the construct in line with their nature and identify whether there is something missing, and instead of focusing on the general application of UTAUT to test the effect of the construct on technology acceptance and use. The steps taken was to review the appropriateness of the findings to the constructs and the nature of them, and investigate it there is anything missing within the UTAUT. Hence, the research took a different approach by utilising a UTAUT-embedded approach to analyse the identified factors to extend the UTAUT constructs.

- The conduct of this research has provided consistent and validated proof for the adoption of Blockchain for the oil and gas supply chain as an approach for research. Furthermore, the research has answered the call for theory-based research that will stimulate academic discussions on the potential of Blockchain technology in the supply chain field by utilising UTAUT embedded approach to analyse the findings (Treiblmaier, 2018; Nowiński and Kozma, 2017).
- Blockchain technology research is lacking a rigorous scientifically qualitative approach to provide empirical evidence beyond the survey and literature reviews. Therefore, methodologically, the existing research in the literature due to the novelty of the research areas focused on conceptual, frameworks and case studies. Another significant gap is the paucity of research employing a qualitative empirical approach. The methodological approach adopted in this research has demonstrated the significance of qualitative in-depth analysis of Blockchain adoption in supply chain. This research has addressed the growing methodology demands for qualitative research in Blockchain technology. The in-depth semi-structured interviews conducted, data analysed and identified the factors for the adoption demonstrate answering the call for research in qualitative methods by(Woodside et al., 2017).
- This research is the first to provide insights on the factors that would enable the application of Blockchain technology in the Nigerian oil and gas supply chain. The research findings have contributed to the adoption of Blockchain based on the factors identified and discussed using the lens of the UTAUT model. These cut across the categories of organisational, institutional, technological and operational environment, something that no research has empirically discovered.

From the research idea to the research contribution, this entire process followed in this research is illustrated in Figure 8-1 Summary of the research work below.

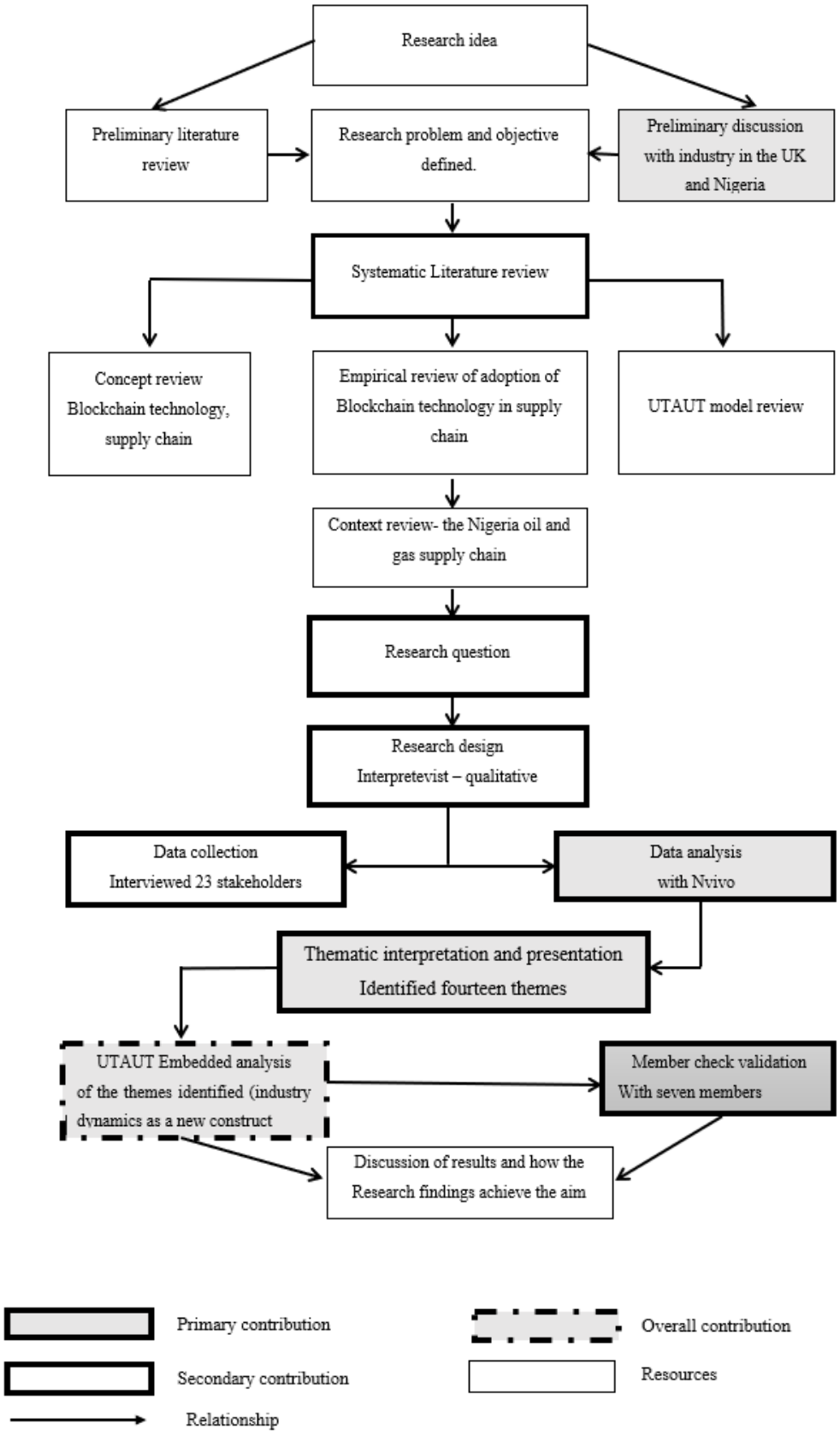

Figure 8-1 Summary of the research work

8.6 Managerial implications

The outcome of this research has several management implications for various aspects of Blockchain adoption in the oil and gas supply chain in Nigeria. This research has provided management with critical findings by identifying the factors for development and practice relating to the adoption of Blockchain technology for their supply chain. Predictably, the industry's major actors bear a more significant share of the responsibility for driving the adoption of Blockchain technology in the supply chain. As a result, this research suggests that international oil companies, national oil companies, and major marketers form a consortium to enable innovation and drive Blockchain technology adoption. The emphasis should be on addressing the concerns of a fit-for-purpose Blockchain business model that aligns with the peculiarities of Nigeria's oil and gas supply chain. Furthermore, in order for the technology to be adopted by the more comprehensive supply chain partners, leaders must raise awareness and provide special training and knowledge development programmes on Blockchain technology. The findings also suggest that, as part of the practice, industry supply chain actors collaborate and demonstrate commitment through funding, leadership, and influence. This will allow all actors to make an informed decision about adoption. Regardless of the industry dynamics, companies and supply chain partners can develop internal strategies on how Blockchain can benefit them based on the potential while identifying challenges associated with an adoption based on early adopters' experiences.

The research identified another implication for policy directions for the use of Blockchain technology in the oil and gas supply chain. It has recognised the importance of government revenue protection from the industry, as well as the role of policy in creating an enabling environment for innovation and transformation. It recommends that the government and regulators develop a policy to encourage the early adoption of Blockchain technology to manage supply chain activities across the industry as one of the policy lines. The policy should include incentives for early adopters and promoters. Another implication for the management is to create a special-purpose vehicle for Blockchain adoption through funding, research, and development of use cases. According to the research, if the government takes this seriously, other players will join in, and technology adoption will be successful. As part of the policy recommendations, industry regulators should encourage and reward compliance with government policy on the adoption of Blockchain technology in the Nigeria oil and gas supply chain.

Finally, the research has implication on the factors that should be considered when implementing Blockchain technology in the oil and gas supply chain. As a result, a thorough examination of the findings will benefit companies, supply chain partners, regulators, researchers, and innovators in

the oil and gas and technology industries in order to promote the use of Blockchain technology in supply chains that the stakeholders will accept.

8.7 Limitations and future research implications

This research has provided a starting point for future discussions on the adoption of Blockchain in supply chain within depth empirical results. However, the research has identified some limitations that are acknowledged and need to be addressed in the future.

Qualitative research is a valuable method for understanding complex social phenomena like the perception of adoption of Blockchain in supply chain. Instead of an inductive research approach, the research mixed inductive and deductive to drive factors induced by the UTAUT theory and the data. Although this provides detailed analysis and outcome to address the perception of the adoption of Blockchain in supply chain. Future research should address this limitation through inductive approach in order to drive findings from the data without the theory constraints. The use of qualitative approach will be useful in future research by developing hypothesis and testing them against the adoption of Blockchain technology in the oil and gas supply chain.

Furthermore, qualitative research can be time-consuming and resource intensive. Data collection and analysis can take a long time, and the process can be influenced by the researcher's personal and professional circumstances. This can result in restricting the scope of the research and therefore limit the opportunity to broaden the research context. In terms of scope, the research focus on the stakeholders in the oil and gas industry in Nigeria based on the researcher's access, resources and supply chain network, the findings may not represent the entire views of the oil and gas industry more broadly, and specifically. Future research could focus on larger samples or use a case study to address the broader or specific scope respectively. The use of larger and more diverse samples could help to ensure that the findings are not limited to a specific group or population. Additionally, future research could leverage on this research to establish a base for building further research and could use pre-existing data or secondary data sources to reduce the time and resources required for data collection.

The research recognised the importance of Nigeria's oil and gas industry in the global context, similar research in other developing countries would help identify other factors that this research context may not have discovered and other comparative cases for investigating perceptions between developed countries.

While qualitative research has limitations, future research can enhance the validity and reliability of the findings by constantly exploring, testing and validating the evolving areas of adoption of

Blockchain technology in supply chain field, particularly by elaborating the transformation of the perceived adoption factors to actual adoption factors and the post-adoption experience as the technology is being used and accepted.

8.8 Conclusion

The aim of the research was to investigate stakeholders' perceptions with respect to the adoption of Blockchain technology in the Nigerian oil and gas supply chain. This aim was aligned with a knowledge gap identified in the systematic literature review in Chapter 2. The research focused on the factors that influence the adoption of Blockchain in Nigeria's oil and gas supply chain through identifying the factors and examining the factors based on the UTAUT model of technology adoption. This was then explored through a preliminary literature review and an industry visit to Nigeria and the United Kingdom in the oil and gas industry. These preliminary findings confirmed the opportunities for Blockchain adoption in the oil and gas supply chain, but with the challenges of a lack of understanding of the technology, a lack of adoption, a lack of commitment to explore the technology, and no practical demonstration of project Blockchain in the supply chain in the industry.

The research continued with a systematic literature review of the use of Blockchain technology in supply chain. This process covered the planning, execution, and reporting of the systematic literature review. The review was conducted using four databases as the main source of relevant sources: Science Direct, Scopus, Web of Science, and IEEE Xplore. The systematic literature review revealed the level of adoption of Blockchain technology and the areas of application within the supply chain. It also allowed the identification of the literature gaps, prompting the research questions: *"What is stakeholders' perception of Blockchain adoption in the oil and gas supply chain?", and "How does the perception affect Blockchain adoption in the oil and gas supply chain using the UTAUT model?"*

The above questions were aligned to the review of the research's context, the Nigeria's oil and gas industry. The review of the Nigerian oil and gas supply chain chapter provided a background of the Nigerian oil and gas industry, the supply chain in the oil and gas industry, and the industry structure. The oil and gas contractual modes which are the defined commercial and technical model in the industry were presented and discussed to create the awareness and conceptualisation of the industry into the supply chain management. The chapter outlined the industry's supply chain challenges, such as a lack of transparency and accountability, revenue leakages, manual process and operational inefficiencies, and downstream and subsidy regimes. In order to connect the industry context with

Blockchain technology, a review of Blockchain in Nigeria was conducted, and the development of the Blockchain industry in Nigeria was presented.

The research conducted a critical theoretical review to identify the theoretical framework and the lens in which this research was conducted. This began with the need for theory in research, followed by technology adoption theories and a review of the UTAUT model. The theoretical chapter also included a review of predicting technology acceptance and use, as well as the basis upon which Blockchain research was viewed through the lens of the UTAUT model. It concluded with a justification for the chosen theoretical framework for the research.

The methodology chapter began with an overview of the research, followed by the research philosophy and a detailed discussion of the research's ontology and epistemology, which provided justification for the chosen approach. The research adopted a qualitative approach due to the nature of the question of why and how and provided a detailed research design through semi-structured interview and the data collection process and procedures. The interview protocol was also discussed, how interviewees were chosen and how the interviews were conducted. The thematic data analysis method was adopted and presented, and the process involved in the thematic process was discussed and presented. The chapter also discussed validation, rigour, and ethical considerations associated with the research.

One key aspect of the research is the presentation of the thematic findings. The chapter began with the background of the research participants, followed by the presentation of the themes that emerged, which were categorised into four: organisational, institutional, technological, and operational environment. The first organisational category contains four themes: leadership and senior management, awareness and knowledge, business model, and level of commitment to adoption. These themes corresponded to the organisational factors associated with the adoption of Blockchain in the oil and gas supply chain.

The institutional category contained three themes: industry dynamics, influence and control, and institutional collaboration. The findings demonstrate that the themes are aligned with the institutional factors influencing the adoption of Blockchain in the oil and gas supply chain. The technological category revealed four themes: internet, infrastructure and connectivity, data security, cost driver, and technology user acceptance. The thematic chapter further revealed three themes in the operational environment category: emerging trends, government policy and support, and regulation and regulatory framework.

In order to create new knowledge from the thematic analysis presented above; the research provided another chapter on UTAUT embedded analysis. The analysis focused on the findings, and

presented the thematic analysis embedded in the UTAUT model. The UTAUT embedded analysis process involves the presentation of the themes, reflection on the analysis of the themes, and reflection on existing literature to find similarities or differences, and then embedding it into UTAUT constructs based on its main objectives. The analysis revealed that the four constructs of the UTAUT model, performance expectancy aligned with the business model, institutional collaboration, and emerging trends all together. The second construct of the UTAUT model is effort expectancy, which incorporates awareness and knowledge, data security, and technology acceptance. The third construct of the UTAUT model's social influence construct includes leadership and senior management, as well as influence and control. The fourth UTAUT construct is the facilitating condition, which consists of the level of commitment to adoption, internet, infrastructure, and connectivity, government policy and support, and regulations and regulatory framework. The UTAUT embedded analysis revealed a significant finding with the industry dynamics as a construct for the adoption of Blockchain in the oil and gas supply chain. The above findings were validated using the member check to ensure the research findings' trustworthiness and the analysis's accuracy.

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Appendix 1: Request for research participation

Dear Sir/Madam

Name of department: Design, manufacturing and Engineering Management Title of the study: "Investigating Stakeholders perception on adoption of Blockchain technology in the oil and gas supply chain in Nigeria: A Unified Theory of Acceptance and Use of Technology approach".

My name is Salisu Alhaji Uba, and I am a PhD researcher at the University of Strathclyde, Glasgow.

For the purpose of my PhD thesis, I am conducting a research on "**Investigating Stakeholders perception on adoption of Blockchain technology in the oil and gas supply chain in Nigeria: A Unified Theory of Acceptance and Use of Technology approach".** The aim of the research is to explore the stakeholder's perception and identify other contextual factors on the adoption of the Blockchain in the oil and gas supply chain in Nigeria using modified UTAUT model.

As an experienced person working within the oil and gas industry in Nigeria, I am inviting you to take part in the study through interview. The interview is expected to last for 45 minutes – 1 hour and mainly your views based on experience and knowledge of the areas of the investigation.

The study's significant contribution is to create theoretical knowledge base regarding the adoption of blockchain technology in supply chain in the oil and gas by applying the Unified Theory of Acceptance and Use of Technology (UTAUT) to explore the stakeholder perception and the contextual factors that influences the adoption. It is believed that the findings will be useful for understanding blockchain adoption phenomena better, and to help oil and gas supply chain firms make superior decisions based on them.

There is no compensation or risk connected with the interview. For confidentiality, your name or that of your organisation will not be use in the main thesis. Data will only be stored on the University's cloud system for a period based on the University's policy for PhD. If you are happy to participate in the interview, please sign the consent form attached.

Please note that participation is voluntary, and you may wish to refuse at any time. If you will like a copy of the study, please complete the request of information attached.

Should you require more information or question please feel free to ask me, I can be reach on email: salisu.uba@strath.ac.uk and mobile: +441415745291 or my Principal Supervisor Dr Ian Whitfield on e-mail: ian.whitfield@strath.ac.uk and telephone: +44145484548.

While anticipating for your participation, please accept my best wishes.

Salisu A. Uba

PhD Researcher.

23 August 2020

Appendix 2: Consent Form

Name:

Company Name:

Name of department: Design, Manufacture and Engineering Management
Title of the study: "Investigating Stakeholders perception on adoption of Blockchain technology in the oil and gas supply chain in Nigeria: A Unified Theory of Acceptance and Use of Technology approach".

- I confirm that I have read and understood the Participant Information Sheet for the above project and the researcher has answered any queries to my satisfaction.
- I confirm that I have read and understood the Privacy Notice for Participants in Research Projects and understand how my personal information will be used and what will happen to it (i.e., how it will be stored and for how long).
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences.
- I understand that I can request the withdrawal from the study of some personal information and that whenever possible researchers will comply with my request. This includes the following personal data:
    - Name
    - Company Details
    - Audio recordings of interviews that identify me.
    - My personal information from transcripts.

- I understand that anonymised data cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the research will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project.
- I consent to being audio recorded as part of the project.

(PRINT NAME)	
Signature of Participant:	Date:

Appendix 3: Request for participant's information

Name:

Company name;

Email address;

I request that a copy of the final report of the study should be made available to me after completion.

Best regards,

Signature of Participant:	
Date:	

This research was granted ethical approval by the University of Strathclyde Ethics Committee.

If you have any questions/concerns, during or after the research, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Secretary to the University Ethics Committee
Research and Knowledge Exchange Services
University of Strathclyde
Graham Hills Building
50 George Street
Glasgow
G1 1QE

Telephone: 0141 548 3707
Email: ethics@strath.ac.uk

Appendix 4: Interview protocol

Interview Information

Date:

Venue:

Time:

Designing and Contextualising

The purpose of this interview is to obtain information from stakeholder in the oil and gas industry on the adoption of blockchain technology on supply chain.

This is in line with the aim of the study. It is believing that useful information will be obtain from supply chain departments and relevant supply chain stakeholder from the industry. The interview question is divided into four sections. This was done in order to guide the purpose of the study and help in answering the main research question and achieve the aim of the study. After the questions were prepared, they passed through a pilot test with supply chain professionals and academics. The administration of the interview will follow the following steps:

Before interview commences:

• Informal conversation to familiarise with each other.
• Restating the purpose of the interview.
• Seeking for consent to record, use of data and sign the appropriate form.
• Assurance of confidentiality

During interview:

- Introduction by the interviewer
- Brief description of the area of research

About the participant

1. What is your job role?
2. Years of experience in the industry?
3. Nature of company?

Main Questions

1. How familiar are you with blockchain technology?
2. What is your level of knowledge of blockchain technology and supply chain?
3. Do you think using blockchain technology will enhance oil and gas supply chain (operations and performance) in Nigeria?
4. What is your view on the adoption of blockchain technology in the industry in Nigeria?
5. What do you think is the potential advantage or disadvantage of adopting blockchain in the oil and gas supply chain in Nigeria?
6. What is your view on the potential ease or difficulty to use blockchain for supply chains within companies in Nigeria?
7. How compatible do you think will the blockchain be with your existing systems?
8. What categories of stakeholders that can influence the adoption of blockchain in the oil and gas industry in Nigeria?
9. What could be the contributions of stakeholders for effective decision making that may enhance adoption of blockchain?
10. What role will the Industrial Regulatory Agencies play which could influence or impede the adoption of Blockchain in Nigeria?
11. What is the facilitating infrastructure that is available to support the adoption of blockchain in the industry?
12. Do you think the knowledge of the blockchain among the stakeholders is sufficient to influence or impede the adoption?
13. When do you predict the fully adoption of blockchain for your supply chains?
14. What is the level of your readiness to completely adopt blockchain technology?
15. Would you consider influencing your supply chain partners to adopt blockchain technology and why?
16. What do you think would be the enabling factor for the adoption of blockchain among stakeholders in the oil and gas supply chain in Nigeria?
17. What will motivate oil and gas supply chain actors to consider adopting blockchain for their supply chain?
18. What other things do you think will accelerate the adoption of Blockchain within the supply chain in the Nigerian oil and gas industry?
19. What factors do you consider as a measure of success if an oil and gas company adopt blockchain technology?
20. What do you consider as a successful adoption?
21. What is your perception of the success of the adoption of blockchain in the oil and gas supply chain in Nigeria?

22. Is there any suggestion on the adoption of blockchain in the oil and gas supply chain in Nigeria?
23. Any other comment

There are follow ups question, depending on the answers provided by the participants.

Appendix 5 Letter of Introduction to the Industry

PETROLEUM TECHNOLOGY DEVELOPMENT FUND

PTDF House, Plot 1058 Memorial Drive, Central Business District, Cadastral Zone AOO, Abuja.
P. O. Box 9899, Garki Abuja. Post Code: 900211. Tel: +234 - 9 - 291595

2nd November 2020 PTDF/ED/PHD/SAU/084/18

Head of Engineering and Standards,
Department of Petroleum Resources
No 7, Sylvester U. Ugoh Crescent, Utako

Abuja.

Dear Sir,

LETTER OF INTRODUCTION – SALISU ALHAJI UBA

Salisu Alhaji Uba is a PhD student at the University of Stratclyde, United Kingdom under the sponsorship of Petroleum Technology Development Fund (PTDF) which commenced in 2019. PTDF is the Federal parastatal charged with the mandate of building indigenous capacity in the Nigerian Oil & Gas Industry through the development, promotion, implementation of programmes and activities aimed at enhancing competences in the Oil & Gas sector.

2. The scholar is undertaking a research on **"Blockchain based Supply Chain Transparency and Efficiency in the downstream oil and gas sector"** and is currently at the level of data gathering and has identified your organization as one of the key players in the Oil and Gas industry. Consequently, he wishes to visit your organization to gather necessary data that will assist his research.

3. Kindly render all necessary assistance to him in this regard.

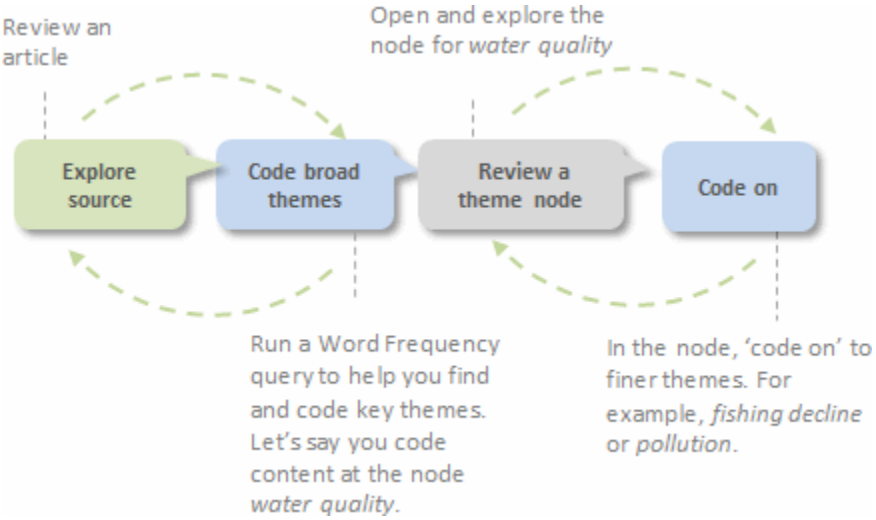
4. Please accept the assurances of the Fund's highest regards.

Yours Sincerely

Bello Mustapha
Head (Overseas Scholarship Scheme Division)
For: Executive Secretary

Website: www.ptdf.gov.ng

Appendix 6 NVivo Coding book



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Influence and control	3	3	14/02/2021 04:23	ALSAUBA	23/02/2021 04:59	ALSAUBA
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Supply chain transformation	3	3	13/02/2021 06:26	ALSAUBA	23/05/2021 19:30	ALSAUBA
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Consortium	3	4	19/02/2021 06:15	ALSAUBA	28/03/2021 21:54	ALSAUBA
Experimental point	4	5	13/02/2021 03:27	ALSAUBA	11/04/2021 20:18	ALSAUBA
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Practical application	8	11	16/02/2021 03:01	ALSAUBA	01/06/2021 00:09	ALSAUBA
Procurement	7	11	13/02/2021 05:11	ALSAUBA	24/05/2021 03:26	ALSAUBA
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Internet and connectivity	14	18	13/02/2021 03:26	ALSAUBA	11/04/2021 20:18	ALSAUBA
IT Community Supports	5	8	16/02/2021 15:21	ALSAUBA	31/03/2021 01:35	ALSAUBA
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Value Proposition	8	13	16/02/2021 03:05	ALSAUBA	31/03/2021 01:14	ALSAUBA
Leadership and senior management	11	19	13/02/2021 04:58	ALSAUBA	17/03/2021 00:26	ALSAUBA
Effective communication	3	3	13/02/2021 06:24	ALSAUBA	31/03/2021 01:32	ALSAUBA
Major player	8	12	16/02/2021 15:19	ALSAUBA	11/04/2021 20:18	ALSAUBA
Supply Chain Partners	4	9	16/02/2021 15:21	ALSAUBA	31/03/2021 01:29	ALSAUBA
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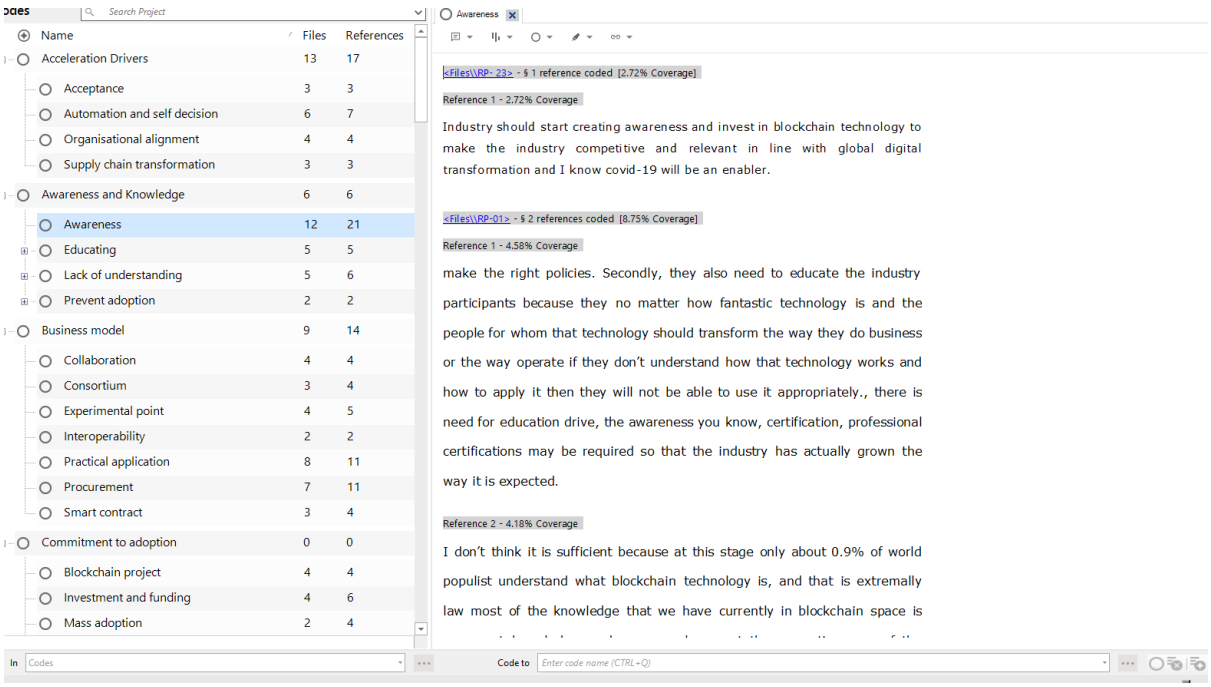
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Supply chain transformation 3 3
Awareness and Knowledge 6 6
Awareness 12 21
Educating 5 5
Lack of understanding 5 6
Prevent adoption 2 2
Business model 9 14
Collaboration 4 4
Consortium 3 4
Experimental point 4 5
Interoperability 2 2
Practical application 8 11
Procurement 7 11
Smart contract 3 4
Commitment to adoption 0 0
Blockchain project 4 4
Investment and funding 4 6
Mass adoption 2 4
Awareness
<Files\\RP- 23> - § 1 reference coded [2.72% Coverage]
Reference 1 - 2.72% Coverage
Industry should start creating awareness and invest in blockchain technology to make the industry competitive and relevant in line with global digital transformation and I know covid-19 will be an enabler.
<Files\\RP-01> - § 2 references coded [8.75% Coverage]
Reference 1 - 4.58% Coverage
make the right policies. Secondly, they also need to educate the industry participants because they no matter how fantastic technology is and the people for whom that technology should transform the way they do business or the way operate if they don't understand how that technology works and how to apply it then they will not be able to use it appropriately., there is need for education drive, the awareness you know, certification, professional certifications may be required so that the industry has actually grown the way it is expected.
Reference 2 - 4.18% Coverage
I don't think it is sufficient because at this stage only about 0.9% of world populist understand what blockchain technology is, and that is extremally law most of the knowledge that we have currently in blockchain space is
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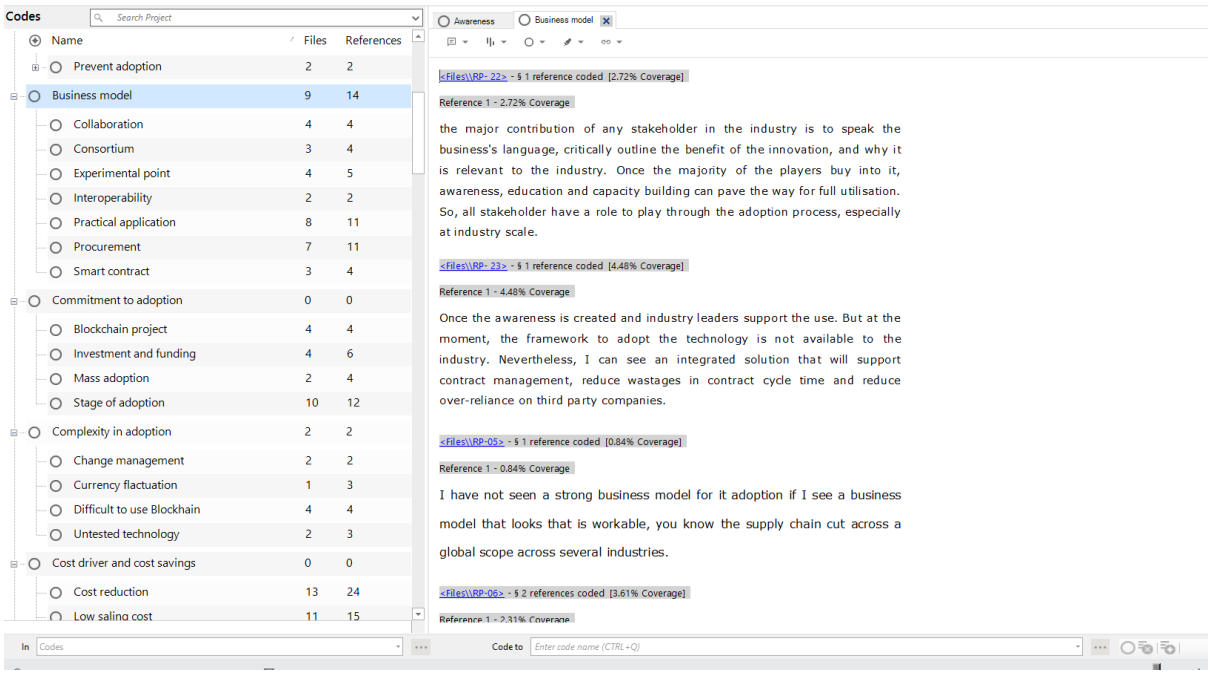
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Search Project
Name
Files
References
Prevent adoption 2 2
Business model 9 14
Collaboration 4 4
Consortium 3 4
Experimental point 4 5
Interoperability 2 2
Practical application 8 11
Procurement 7 11
Smart contract 3 4
Commitment to adoption 0 0
Blockchain project 4 4
Investment and funding 4 6
Mass adoption 2 4
Stage of adoption 10 12
Complexity in adoption 2 2
Change management 2 2
Currency flactuation 1 3
Difficult to use Blockhain 4 4
Untested technology 2 3
Cost driver and cost savings 0 0
Cost reduction 13 24
Low saling cost 11 15
Awareness
Business model
<Files\\RP- 22> - § 1 reference coded [2.72% Coverage]
Reference 1 - 2.72% Coverage
the major contribution of any stakeholder in the industry is to speak the business's language, critically outline the benefit of the innovation, and why it is relevant to the industry. Once the majority of the players buy into it, awareness, education and capacity building can pave the way for full utilisation. So, all stakeholder have a role to play through the adoption process, especially at industry scale.
<Files\\RP- 23> - § 1 reference coded [4.48% Coverage]
Reference 1 - 4.48% Coverage
Once the awareness is created and industry leaders support the use. But at the moment, the framework to adopt the technology is not available to the industry. Nevertheless, I can see an integrated solution that will support contract management, reduce wastages in contract cycle time and reduce over-reliance on third party companies.
<Files\\RP-05> - § 1 reference coded [0.84% Coverage]
Reference 1 - 0.84% Coverage
I have not seen a strong business model for it adoption if I see a business model that looks that is workable, you know the supply chain cut across a global scope across several industries.
<Files\\RP-06> - § 2 references coded [3.61% Coverage]
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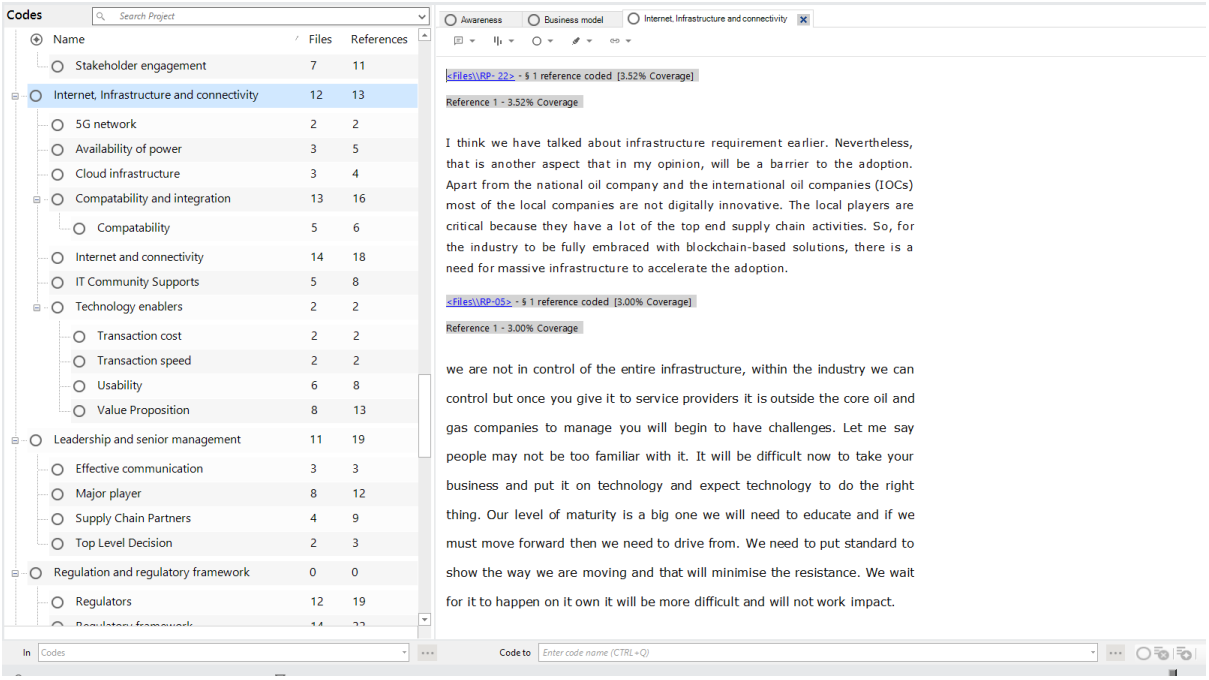
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5G network 2 2
Availability of power 3 5
Cloud infrastructure 3 4
Compatability and integration 13 16
Compatability 5 6
Internet and connectivity 14 18
IT Community Supports 5 8
Technology enablers 2 2
Transaction cost 2 2
Transaction speed 2 2
Usability 6 8
Value Proposition 8 13
Leadership and senior management 11 19
Effective communication 3 3
Major player 8 12
Supply Chain Partners 4 9
Top Level Decision 2 3
Regulation and regulatory framework 0 0
Regulators 12 19
Awareness
Business model
Internet, Infrastructure and connectivity
<Files\\RP- 22> - § 1 reference coded [3.52% Coverage]
Reference 1 - 3.52% Coverage
I think we have talked about infrastructure requirement earlier. Nevertheless, that is another aspect that in my opinion, will be a barrier to the adoption. Apart from the national oil company and the international oil companies (IOCs) most of the local companies are not digitally innovative. The local players are critical because they have a lot of the top end supply chain activities. So, for the industry to be fully embraced with blockchain-based solutions, there is a need for massive infrastructure to accelerate the adoption.
<Files\\RP-05> - § 1 reference coded [3.00% Coverage]
Reference 1 - 3.00% Coverage
we are not in control of the entire infrastructure, within the industry we can control but once you give it to service providers it is outside the core oil and gas companies to manage you will begin to have challenges. Let me say people may not be too familiar with it. It will be difficult now to take your business and put it on technology and expect technology to do the right thing. Our level of maturity is a big one we will need to educate and if we must move forward then we need to drive from. We need to put standard to show the way we are moving and that will minimise the resistance. We wait for it to happen on it own it will be more difficult and will not work impact.
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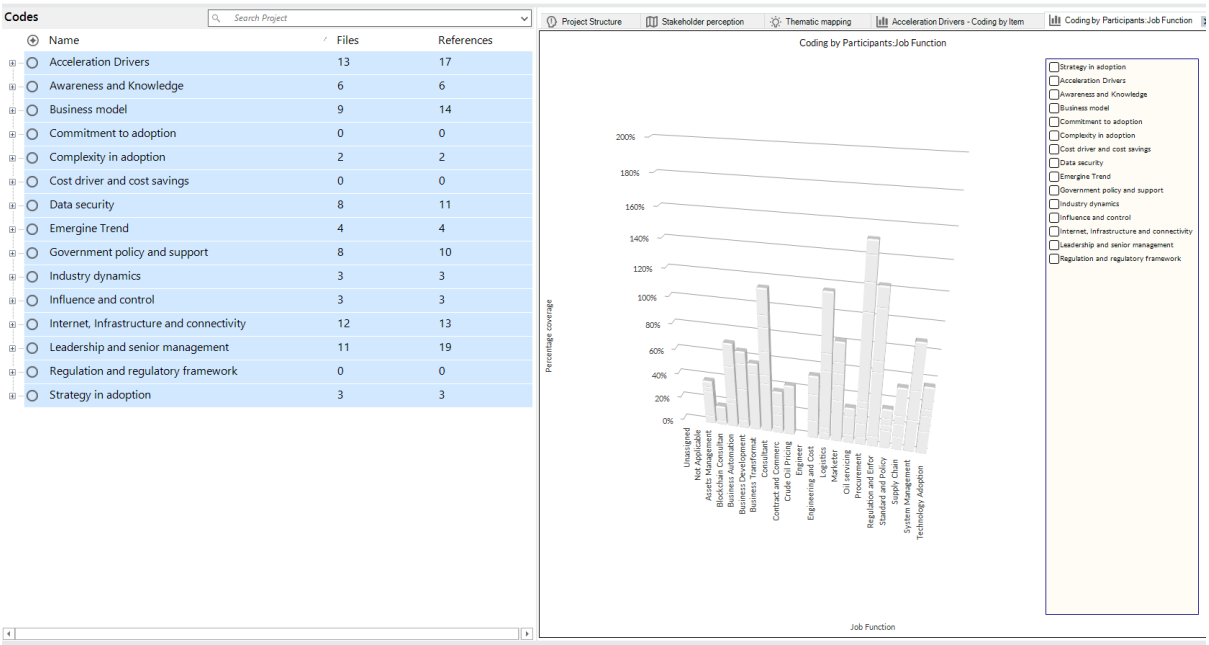
Codes
Code to
Enter code name (CTRL+Q)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Acceleration Drivers 13 17
Awareness and Knowledge 6 6
Business model 9 14
Commitment to adoption 0 0
Complexity in adoption 2 2
Cost driver and cost savings 0 0
Data security 8 11
Emergine Trend 4 4
Government policy and support 8 10
Industry dynamics 3 3
Influence and control 3 3
Internet, Infrastructure and connectivity 12 13
Leadership and senior management 11 19
Regulation and regulatory framework 0 0
Strategy in adoption 3 3
Project Structure
Stakeholder perception
Thematic mapping
Acceleration Drivers - Coding by Item
Coding by Participants:Job Function
Coding by Participants:Job Function
Percentage coverage
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
Unassigned
Not Applicable
Assets Management
Blockchain Developer
Business Automation
Business Development
Business Transformat
Consultant
Contract and Commerc
Crude Oil Pricing
Engineer
Engineering and Cost
Logistics
Marketer
Oil Servicing
Procurement
Regulation and Enfor
Standard and Policy
Supply Chain
System Management
Technology Adoption
Job Function
Strategy in adoption
Acceleration Drivers
Awareness and Knowledge
Business model
Commitment to adoption
Complexity in adoption
Cost driver and cost savings
Data security
Emergine Trend
Government policy and support
Industry dynamics
Influence and control
Internet, Infrastructure and connectivity
Leadership and senior management
Regulation and regulatory framework