The adoption of digital innovation in the South African oil and gas industry

Oupa Tshepo Mokgoto

Student number: 1668404

Supervisor: Prof. Eric Schaling

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DECLARATION

I Oupa Tshepo Mokgoto, declare that this research article is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the Graduate School of Business Administration, University of Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Oupa Tshepo Mokgoto

Signed at ____Centurion_____on the __29__day of _FEBRUARY_2024__

DEDICATION

I dedicate this research to my son Tshepiso Mokgoto for giving me motivation to pursue my purpose and do everything with passion.

AKNOWLEDGEMENTS

I appreciate these people who had an impact in my life during this journey:

- My supervisor, Prof. Eric Schaling for the direction, supervision, and support,
- My family and friends for the support and care,
- My sponsor and employer, Sasol
- Almighty God for enabling me to do everything that I do.

ABSTRACT

The ability to effectively adopt digital technology innovations such as Artificial Intelligence, Machine Learning, Digital Twin, and cloud computing is crucial for any's organization's continued growth and success. As much as innovation promises substantial value for organizations, not much is known about the attributes or factors that facilitate or impede innovation adoption. In addition, less is also known about how these attributes and factors influence adoption. There isn't much empirical data to support the growing significance of innovation through digital technologies in enabling the transformation of oil and gas organizations in South Africa, even though innovation globally is a growing phenomenon.

The purpose of this study was to investigate the factors that influence the adoption of digital technology innovation in the oil and gas industry in South Africa. The literature showed that there are number of factors that influence the rate of digital technology adoption and out of these the most prevalent ones were investigated for applicability in the oil and gas in South Africa. This study explored factors that were more prevalent in the oil and gas and grouped them into two categories, namely, knowledge and persuasion factors. The DOI theory was used as lens to explore the factors that influence the adoption of digital technology innovation. The theory has helped in categorizing and grouping the factors.

Data for this study was collected through survey questionnaires sent digital innovation subject matter experts from multiple companies in the oil and gas in South Africa. Trends in the data was observed through descriptive analysis and regression analysis was conducted to assess the relationship between the rate of adoption and the influential factors. The relationships were observed and the related extent of the relationships, if existed. A statistically significant positive relationship was found to exist between the rate of innovation adoption and two main factors, Know-How knowledge and motivation.

In order to accelerate the rate of digital technology adoption in the oil and gas industry it is recommended that organizations should invest and prioritize building

hands-on digital technology and leadership skills. Organizations should also focus on change management activities aimed at motivating current employees showing them benefits and opportunities brough about by digital technology adoption. This will serve as an incentive to ensure that they support and champion the initiatives. Digital technology initiatives should be made visible for awareness purposes and showing the transformation achieved and value unlocked.

Keywords: Diffusion of innovation, Digital technology Innovation, Oil and Gas, Adoption.

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DEFINITION OF TERMS

- DOI – Diffusion of Innovation
- IT – Information Technology
- ICT – Information Communication Technology
- IoT – Internet of Things
- COVID-19 – Corona Virus disease 2019
- OECD – Organisation for Economic Co-operation and Development
- WEF – World Economic Forum
- NLP – Natural Language Processing
- ML - Machine Learning

1 INTRODUCTION

1.1 Purpose of the study

The purpose of this study was to explore and describe the factors that influence innovation adoption in order to accelerate the adoption of digital technology innovation within the context of Oil and Gas industry in South Africa. Contrary to its flagship leading role in innovation diffusion; based on experience, the modern-day aspect of innovation adoption isn't as pronounced in the oil and gas industry as opposed to other high capital industries viz., automotive, aviation, manufacturing, financial etc. As a result, the South African oil and gas industry has become increasingly accustomed to a widening of a digital divide amongst and between itself and its competing industries.

In the South African research context, either there is limited know-how on how to innovate in the oil and gas digital industry and a lagging use of digital business strategies and technology adoption throughout the industry, or those with the know-how and information lack the incentive and/or ignore their imperatives to adopt digital innovation in the decision-making context for the advancement of digital transformation and change. This is indicative of a lack-lustre attitude with respect to innovation processes which is a far cry from the business transformation agenda and its equitable effects.

1.2 Context of the study

Digital technologies have disrupted all industries, however, organizations which are open to change, and innovation have seized opportunities and realized benefits. On the contrary, organizations that were slow to adopt innovation were disrupted to an extent of closure. During the recent During the recent corona virus disease 2019 (COVID-19) global outbreak of the coronavirus, digital technology adoption accelerated as organisations had to implement technologies to enable them to continue with their business under the difficult constraints implemented by governments to manage the spread of the disease. Organisation and individuals are on a quest to innovate in order to remain relevant. With innovation, organizations have an opportunity to apply new ideas that will improve existing products or services (Fagerberg, 2004).

It is through innovation that product and services are designed and updated to create value. While pursuing innovation, organisations are challenged with creating social and environmental value as well as economic returns, also known as the triple bottom line: people, process, and prosperity. The OCDE (2005) states that organizations objectives for innovation vary, some involve products, markets, efficiency, quality, or the ability to learn and to implement changes. They further state that it is important to identify the motive and examine the forces that drive these innovation activities, be it competition or ambition to enter new markets.

Paletta (2020) argues that through technological innovation organizations can increase their productivity and competitiveness. This is achieved by organizations identifying ways in which technology innovation can be used to influence products, services, processes, and marketing. However, innovation can be very expensive and time consuming (Paletta, 2020). He further adds that digital technologies enable an organization to conduct continuous testing, experimentation and prototyping quicker and cheaper. This is a game changer and organizations that innovate leverage all the digital technologies at their disposal to transform themselves and be more competitive.

As much as innovation promises substantial value for organizations, not much is known about the attributes or factors that facilitate or impede innovation adoption. In addition, less is also known about how these attributes and factors influence adoption. The literature suggests that there are multiple factors that influence innovation. These factors can include economic factors, internal factors, and legislative factors (OECD, 2005). According to Neely and Hii (1998, p.5), internal factors that impede innovation include rigid organisational arrangements and procedures, hierarchical and formal communication structures, conservatism, conformity and lack of vision, resistance to change, and lack of motivation and risk-avoiding attitudes. They further elaborate that external factors that impedes innovation would include lack of infrastructure, deficiencies in education and training systems, inappropriate legislation, and overall neglect and misuse of talents in society (Neely and Hii, 1998, p. 5).

The WEF (2017) in their white paper about digital transformation in the oil and gas industry, states that the oil and gas industry has not taken advantage of the opportunities that leverage digital technology to drive delivery benefits to all key stakeholders. Most

evidently, large databanks are generated on a daily basis, and yet only a small fraction of the data is used in decision-making. The report further states that other industries such as in the aviation, and automotive industries, have taken advantage of digital technology opportunities in their fields to revolutionize their businesses and operations models (WEF, 2017). Nevertheless, today is still an opportune point in time for the oil and gas industry to use the advantages that come with the adopting of digital technologies to transform their businesses.

Companies in all industries are challenged by disruption and digital technology is at the centre of this. The culture of innovation helps organization to accelerate the adoption. Even though digital technology makes innovation easier and promises business value, adoption of innovation is still slow and there seem to be multiple factors that influence this.

Digital Innovation

Digital technologies are defined as software, hardware and network solutions that enable, extend and support business activities. These technologies include the Internet of Things (IoT), big data analytics, artificial intelligence, and cloud computing (WEF, 2017). Zhu et. al. (2006, p. 612), also add that digital technologies are mainly based on ICT connectivity, accessibility, and usage. **Innovation** is described as “an idea, practice, or project that is perceived as new by an individual or other unit of adoption” (Rogers, 2003, p.33).

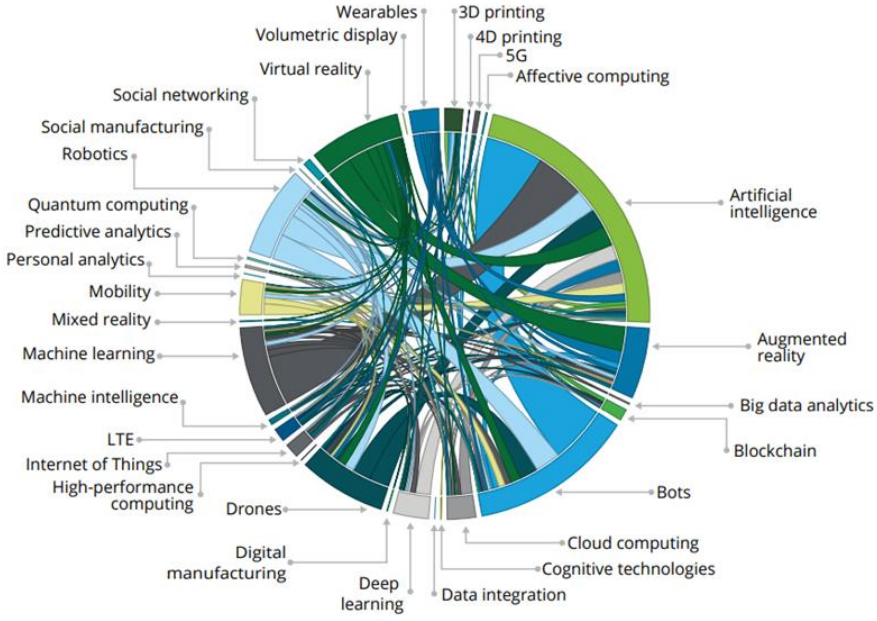


Figure 1: Digital deluge (Mittal et. al., 2017)

There are lots of digital technologies that contribute to digital innovation, the diagram above shows some of these technologies extracted from research between 2016 and 2017 by Mittal et. al. (2017). It also shows that there are a lot of digital technologies available to enable organizations to use digital innovation, this should ideally make it more attractive to invest in digital technologies.

1.3 Research Problem

Despite the growing importance of innovation through digital technologies to enable transformation of businesses across industries worldwide, there is limited empirical evidence of this in the South African oil and gas context. Furthermore, the aspect of innovation adoption is less pronounced in the oil and gas industry as opposed to other high capital industries i.e., the automotive, aviation, etc. South African oil and gas participants are becoming increasingly accustomed to a further widening of a steep digital divide. This is indicative of a lack-lustre attitude to innovation processes and is a far cry from the business transformation agenda and its equitable effects intended for previously disadvantaged and disproportionately represented peoples.

This tends to represent massive disparities in ownership proportions of natural resources due the South African historical context, given the country's status as the most inequitable society in the world, and growing, as opposed to other global regions. Managements' attempts to drive the adoption and transformation agenda fails to persuade the followership in the employees on an individual and in a collective basis. The individual may not see personal growth potential and benefits, and the collective may perceive calls for digital adoption and transformation as threatening of obsolescence over their desperate calls for much-needed skills transfers.

Consequently, this lack of persuasion leads to a reluctance of the individuals in question to see the benefits for leverage and their enterprise to flourish. Rather there are those who lack the knowledge and use of digital innovation and adoption effects, and/or those who are ignorant and/or dis-incentivised (in the decision-making context), with respect to the adoption of digital innovation in enterprises for strategic objectives and successes, consequently leaving a skill sets and skills-transfer vacuum in its wake.

1.3.1 *Sub-problems:*

1) There is a limited know-how on how to innovate in the oil and gas digital industry and lagging use of digital business strategies and technology adoption throughout the industry.
2) Those with the know-how and information lack the incentive or ignore their imperatives to adopt digital innovation in the decision-making context for the advancement of digital transformation and change in the oil and gas industry.

1.3.2 Research Questions

Adoption of digital innovation can be influenced by many factors which might either erode or accelerate the manifestation of its benefits. This study seeks to answer the following questions:

1) Does the awareness and know-how of digital technology positively influence the rate of innovation adoption?
2) Do persuasive effects of motivation positively influence the rate of adoption of digital technology innovation?

1.4 Research Objectives

The research objectives are to:

- Determine the factors that influence innovation adoption in order to accelerate the adoption of digital technology innovation within the context of Oil and Gas industry in South Africa
- Identify the factors that have significant impact on digital technology innovation adoption in the oil and gas industry of South Africa.

1.5 Contribution of the study

Through the articulation of the challenges and issues that impact the adoption of innovation, the significance of this research is in conceptualising a framework for accelerating the adoption of innovation through digital technologies. This study provides an informed understanding of what factors influence digital technology innovation adoption, in a South African context. It is envisaged that the study will add to the existing literature on innovation through the adoption of digital technologies.

Digital technology innovation is applicable to all business in all industries, irrespective of size location or type, however the interest of this study will be on businesses in the oil and gas industry of South Africa. The study identified factors that influence the adoption of innovation through digital technologies in the oil and gas industry of South Africa. These factors can now be leveraged or be further expanded in other industries.

2 LITERATURE REVIEW

2.1 Introduction

This section will describe the theoretical grounding of the rate of digital technology innovation adoption, understand how other innovations are adopted in the oil and gas industry globally, review literature on digital innovation and its impact to drive business value. This section also provides a summary of the key variables that impact the rate of innovation adoption.

2.2 Discussion of Topic

Through digital innovation businesses have the potential to create tremendous value for both the industry and society as a whole (WEF, 2017). The UNDP (2022) also adds that it is an important force for change to reshape businesses, government, and society. Technological innovation focuses on using new or improved technology to formulate product, processes, or service delivery methods (Kylliäinen, 2019).

Digital technology Innovation is defined as “innovative IT solutions that integrate emerging digital technologies to support the digitalization of non-tech businesses such as banking, health care, manufacturing, retail” (Khin and Ho, 2020, p.178). According to the WEF (2017), the growing sophistication of digital technologies enhances business agility and enable instantaneous decision making and execution. Nambisan et al. (2017) also adds that digital innovation is defined by the use of digital technology to create market offerings, business processes or models. Hund et al. (2021, p.2), refers to digital innovations as the creation or adoption, and exploitation of an inherently unbounded, value-adding novelty (e.g., product, service, process, or business model) by incorporating digital technology.

According to Rucket et al (2020) there is a perception that the adoption of digital technology adoption can lead to a digital divide whereby well-established organizations will be the ones benefiting while the rest will not benefit. The organizations that continue to benefit more from digital innovation adoption are mainly big technology companies such as Alibaba, Alphabet, Apple, Amazon, Facebook, Huawei, and Microsoft. Most of these

companies are from in US ad China. African companies do not feature in the big technology companies or any of the leading digital innovation research and development investors (EIB, 2018). The most established and high performing companies at the global frontier are typically larger, more innovative and have higher rates of digital technology adoption.

Bughin et al (2019, p. 4) states that European companies have fallen behind in the digital technologies and services race but might be able to take up leading positions in new industrial races. They further elaborate that it will depend on the capabilities such as integration of digital technologies, including IoT and AI, into the core business process. EIB (2018) also adds that there is growing concern that European companies in non-digital sectors lag in the adoption of digital technologies, especially in the services sector. Growing digital polarisation in the global corporate landscape between the technology haves and have-nots also has implications for the rising polarisation of productivity (EIB, 2018). If companies in emerging markets are unable to integrate new digital technologies into their business models, they will lose out, even in those sectors where they are currently still leading, such as the automotive sector.

According to Kitsara (2022), increasing digitalization has created the concept of the digital divide concerns about how no or inadequate internet access and use of related information could exacerbate existing socioeconomic gaps between industrialized and developing countries, metropolitan and rural areas, and more and less privileged individuals and groups. OECD (2005) also highlights that organization should ensure that there are proper adaptive structures and processes of the labour market. Furthermore, they also elaborate that organizations have challenges with the ability to appropriate benefits from innovation initiatives leads to lesser incentives to innovate (OECD, 2005).

2.2.1 Digital Technology Innovations in the Oil and Gas Industry

Digital technologies such as the internet of things, big data, and remote sensing (a technology used to detect, monitor, and acquire information about objects without physical contact), has led to major transformation and innovation in the oil and gas industry globally, leading to optimized recovery from oil and gas fields and also contributed to the

understanding of subsurface formation (Alshehri and Katterbauer, 2020, p.1). According to the WEF (2017) in their white paper report about digital transformation in oil and gas, this industry has been involved with digital technologies in order to address key business challenges such as resource and production optimization, improvements in health and safety and reducing operational inefficiencies.

Alshehri and Katterbauer (2020, p.1) also add that digital innovation in the oil and gas industry helps deal with significant issues related to harsh environmental conditions experienced mainly in the subsurface. Some of the technologies employed to deal with some of the challenges includes Internet of Thing (IoT) sensors in the reservoir, intelligent sensors for subsurface selection and monitoring, Natural Language Processing (NLP) solutions for formation evaluation interpretation, machine learning technology for incidents early detection in the drilling space (Alshehri and Katterbauer, 2020). In the past, the oil and gas industry took the lead as innovators, recently however they have been laggards. There are multiple research projects conducted about innovation through digital technology globally, this study seeks to explore this in the context of the South African in oil and gas industry.

Digital innovations help solve real problems in the oil and gas industry throughout the value chain. Mittal et. al. (2017, p.2) highlight some of these technologies and the associated digital transition:

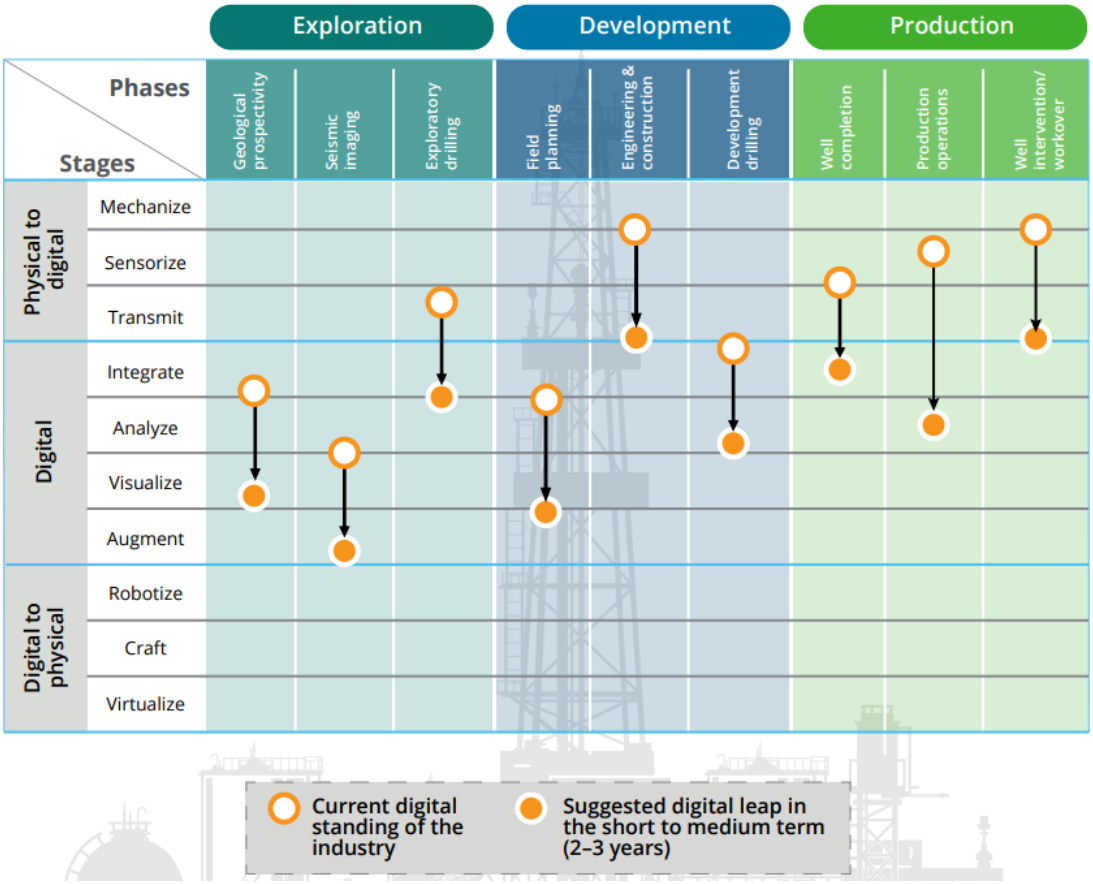


Figure 2: Digital maturity in oil and gas upstream value chain (Mittal et. al. 2017)

From the above figure stages of required digital interventions are, physical to digital, digital, and digital to physical. The figure shows us what is the current status and the intervention required across the value chain from, exploration to development and then to production.

2.2.2 Digital Innovation Adoption Challenges

According to the WEF (2017) the oil and gas industry is challenged with digital innovation in the following areas: new business models based on data driven insights and digital technology leading to operations transformation, agility and improved strategic decision making, enhanced collaboration, costs reduction, transparency in the operations and improved innovation adoption, personalised experience, and improved and flexible customer engagement models.

While pursuing innovation, organisations are challenged with creating social and

environmental value as well as economic returns, also known as triple bottom line: people, process, and prosperity. Digital technologies have disrupted all industries and organizations which are open to change, and innovation seized the opportunity and realized benefits. On the contrary organizations that were slow to adopt innovation were disrupted and as such either lost business or some even went out of business. During the recent COVID-19 outbreak digital technology adoption was accelerated as organisations were forced to implement digital technologies to enable them to do work under the constraints of lockdowns and service disruptions, an undertaking that normally took a long time to implement.

Butler and Sellbom (2002) in their study to investigate the barriers to technology adoption highlighted these three as the main factors, namely, lack of institutional support, lack of financial support, and lack of time to learn recent technologies. The table below shows a summary of factors that affect the adoption of technology:

Factors Affecting Adoption of Technology*

Factor	Mean	Standard Deviation
Reliability of the technology	3.64	0.61
Knowledge of how to use the technology	3.57	0.64
Believe the technology improves or enhances learning	3.36	0.80
Difficulty in using the technology	3.15	0.87
Institutional support for using the technology now	3.06	0.89
Institutional support for using the technology in the future	3.04	0.91
Difficulty in learning to use the technology	2.98	0.96
I have used the technology often in the past	2.69	1.00
The technology helps me with thinking and planning	2.59	1.08
I expect the technology to save me time in the long run	2.55	1.14
Unique or innovative technology	2.35	0.98
Others in my department are using the technology	2.00	0.93

* Range is 1–4, where 1 = not important and 4 = very important.

Figure 3 : Factors affecting adoption of technology (Butler and Sellbom, 2002).

Of twelve (12) factors that affect adoption of technology, according to Butler and Sellbom (2002) six (6) scored an average of above three (3) indicating factors that resonated with more participant of the research. The findings of the research shows that support for current and future use of technology, reliability of technology, knowledge to use

technology, difficulty in using technology and the conviction to believe that technology enhances and improves learning, as key factors that resonated with most participants.

2.3 Theoretical foundation and framework

The Diffusion of innovation (DOI) was identified to as the theory to underpin this study in order to address the research problems aforementioned, listed in section 1.3 above.

2.3.1 Diffusion of innovation (DOI) theory

Rogers (2003) diffusion of innovation (DOI) theory was designed to understand how innovations are diffused and adopted by organizations and individuals. The theory identifies several key factors that influence the rate of diffusion, which are, the relative advantage of the innovation, the compatibility of the innovation with existing values and practices, the complexity of the innovation, and the trialability of the innovation (Rogers, 2003). DOI theory is a valuable tool for understanding the diffusion of digital technology innovations in the oil and gas industry (Rogers, 2003). The relative speed at which an innovation is embraced by members of a social system is known as the rate of adoption, according to the DOI Theory (Rogers, 2003).

There are other theories that could have been considered as the lens to underpin the study, such as bass diffusion model and social network theory but these could not cover all aspects of the research report. The DOI theory has been selected as the theory to underpin this study because it has all the key components that are aligned to the problem statement and thus will be used as the theory to underpin the report. By analysing the factors that influence the diffusion process, the theory will be used to predict the rate of adoption of a recent technology. The theory provides valuable insights for companies and industry stakeholders looking to promote the adoption of new digital technologies in the oil and gas industry.

Bass Diffusion Model focuses on the adoption process similar to DOI, however it only offers insight into interaction of existing adopter and prospective adopters, without delving more into the factors that influence innovation (Bass, 2004). On the contrary the DOI provides the perceived attributes that contribute to innovation adoption and also the innovation-decision process.

Social Network theory also concerned with how information or innovation is spread within a population, however it focuses mainly on the importance of social relationships and structures in a diffusion process (Wasserman and Faust, 1994). This theory is mainly about how people are connected within a network and how is information flowing amongst the people. This theory already limits the factors to be explored to more social factors, whereas DOI provides a more comprehensive factors to consider and explore both social and technological.

2.3.2 *Factors influencing the rate of adoption.*

Adopting Innovation does not seem to be an easy task and the main problem while attempting this ambitious journey seems to be the value of this innovation to the business and the realisation thereof. Understanding the value of innovation on its own does mean adoption will be efficient. There is therefore a need to understand factors that influence the innovation adoption process. WEF (2017) highlighted that similar industries like oil and gas have taken advantage of the digital technologies to innovate their business and operating model, however the oil and gas industry has done so extensively.

Rogers (2003) DOI theory highlights five key variables that contribute to the rate of innovation adoption, namely, perceived attributes of innovation, the type of innovation-decision, the nature of communication channels diffusing the innovation at various states in the innovation-decision process, the nature of the social system in which the innovation is diffusing, and the extent of change agents' promotion efforts in diffusing the innovation. The figure below depicts these variables in a diagrammatic format.

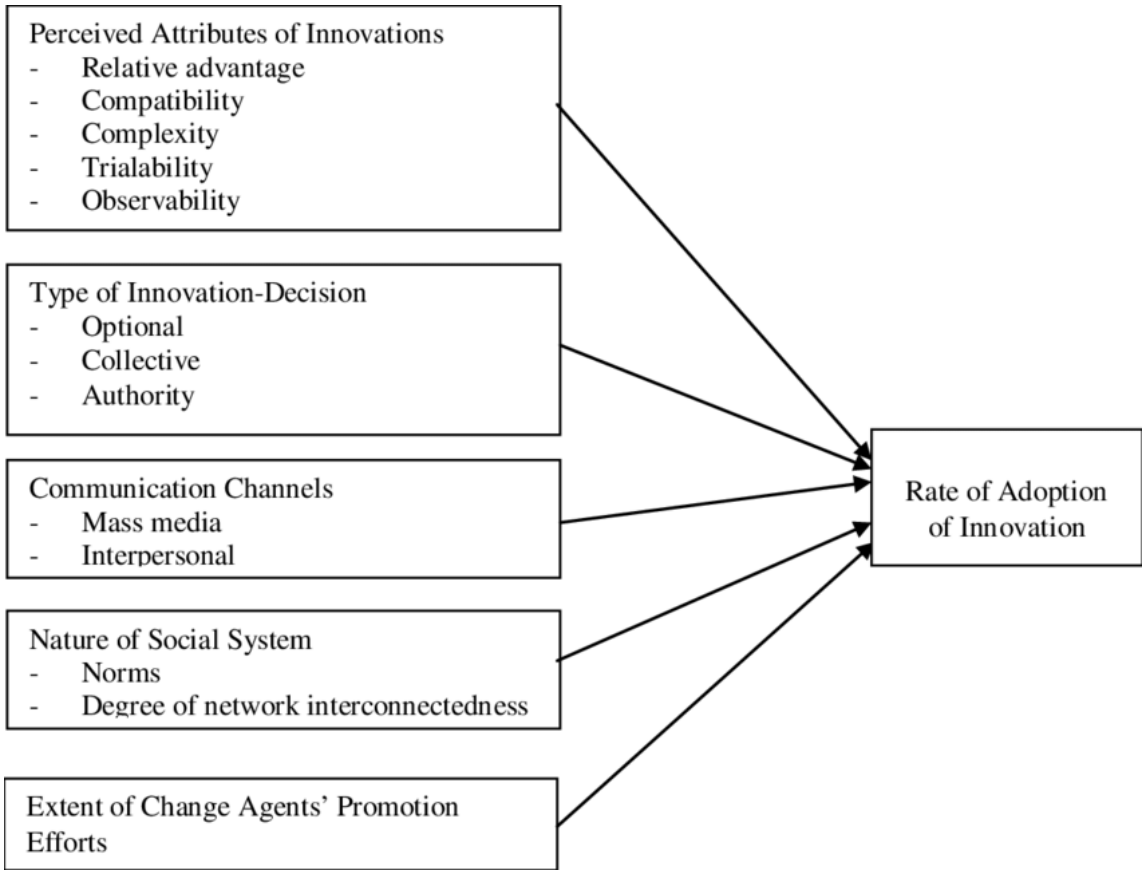


Figure 4: Variables determining the rate of adoption of innovation (Rogers, 2003)

Because the perceived attributes of an innovation are significant predictors of the rate of adoption, and as such about 49-87% of the variance in the rate of adoption of innovations is explained by these attributes (Rogers, 2003, p. 262). For the purpose of this study which aims to explore factors that influence the rate of adoption, focus will be more on the perceived attributes of innovations and the extent of change agents' promotions efforts. From multiple factors that influence the adoption of innovation and predict the rate of innovation adoption, relative advantage and compatibility are amongst the critical ones (Roger and Shoemaker, 1971). These factors including complexity, trialability and observability are said to be accountable for 49 to 87 percent of adoption of new products (Rogers, 2003).

Awareness Knowledge

Roger and Shoemaker (1971) proposed aware stage as the initial stage through which innovation has to go through before it is used. During this stage, the users get to know about the innovation, its use and possibly its benefits. Before one can develop an interest

in innovation, they need to be aware first. Innovation Observability, which is concerned about how innovation is visible and communicated as such leading to increase rate of adoption (Moore and Benbasat, 1991). Observability create awareness to innovation and also gives a sense of assurance to potential users leading to adoption. If digital technology initiatives can be widely shared by organization, it created demonstrability whereby users can touch and feel the features. The adoption of internet services was accelerated by high visibility and demonstrability of how it works and what benefits people get from it (O' Connor, 2007)

The diagram below shows the five stages of innovation decision process, with knowledge being the initial stage.

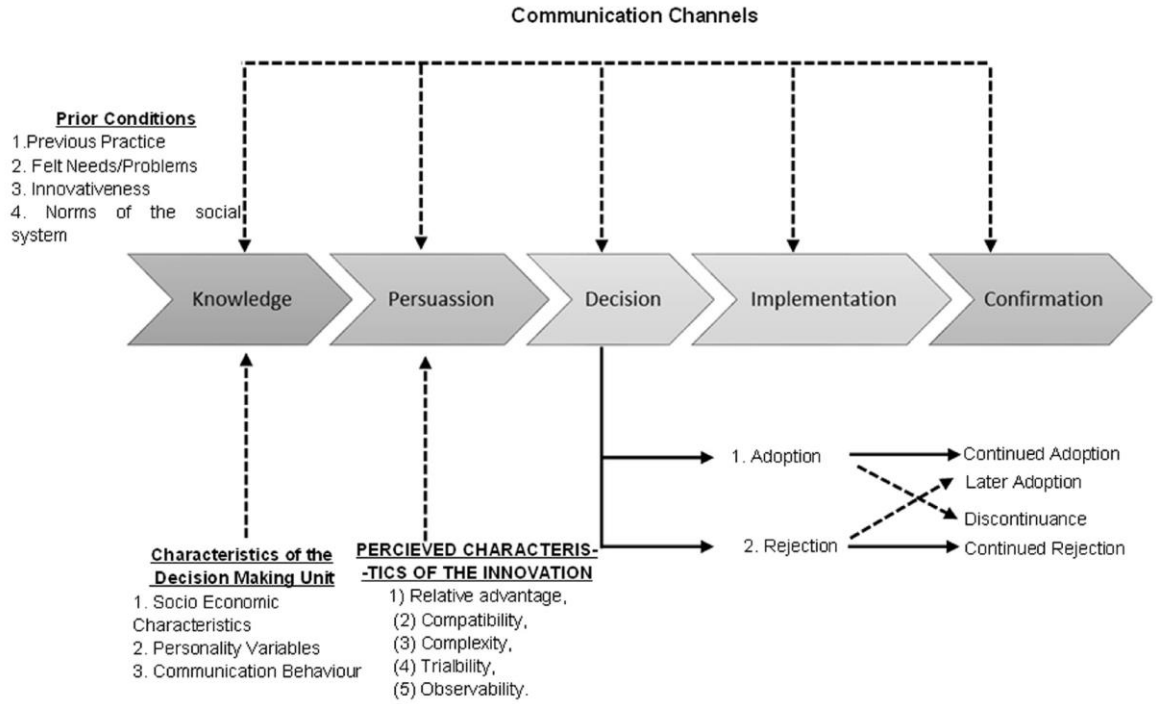


Figure 5. A model of five stages in the innovation-decision process (Rogers, 1983)

The organisation's efforts of promotion by the change agents can also affect the rate of innovation adoption (Rogers, 20023). It is therefore important to identify what efforts make sense for the organization and also to ensure that the timing of the efforts will yield results. If promotional efforts are not timed the organization could waste resources with less returns. If timed correctly and targeted at the right audience, it will be applied at the right time with less resources. It is believed that the greatest response to promotional efforts

occurs when first directed to opinion leaders, once adopted by these leaders the rest follow with little effort.

Know-How Knowledge

According to the OECD (2005) people and their skills are crucial in any organization's ambition for innovation. The quality of education will lead to the innovation knowledge people will have. Innovation knowledge is important to ensure that the organisation has the right people with appropriate skills that are needed to drive innovation adoption. WEF (2020) reported that digital skills among active population in South Africa is at 29% compared to an average of above 60% in most countries in Europe and ASIA. The OECD (2005) further mentions that there should be efforts to invest in good education, acquiring qualified people and creating opportunities to experiment on the job. Sag, Sezen and Guzel (2016) further adds that limited and under-skilled human resources are some of the barriers to innovation adoption because they fail to detect, assimilate and mange know-how knowledge.

Rogers (1995) also adds that through experimenting the participants in the value chain will gain some knowledge and hand on experience to be used in real business scenarios. It is also important to share outcomes of innovation initiatives whether favourable or not. Being transparent and increasing the visibility of initiatives of innovation will increase the likelihood of people to be more interested. Any organization should try to attempt digital innovation initiatives in alignment with their capability to execute them. Efforts must also be made to ensure that the complexity of initiatives is understood and how it will be used.

Without the necessary skills innovation can be perceived to be complex and as such difficult to understand and use (Rogers, 2003). This can lead to negative impact on the rate of adoption. If users perceived innovation to be simple to understand the greater will be the rate of adoption. WEF (2020) reported that skills gaps are one of the top barriers to adoption of recent technologies in the oil and gas, as shown in the diagram below.

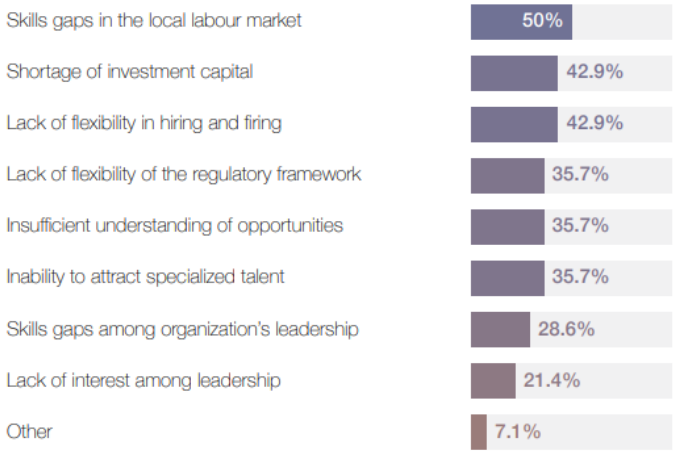


Figure 6: Oil and Gas barriers to adoption of new technologies (WEF, 2020)

Relative Advantage

The concept of relative advantage is premised on the notion that a person will adopt a new product or idea if it is perceived to be better than the existing one (Rogers, 2003). The new idea or product should have more advantages than the current one, for it to be adopted (Francesco, 2012). Organizations adopts technology when there is relative advantage of that technology aligned with the business goals (Rogers, 2003). Sonnenwald et. al (2001) further adds that relative advantage can be measured, in terms of attributes such as usefulness in accomplishing work goals, quality of work outcomes, added convenience and social prestige provided by the innovation.

Digital technologies frequently have qualities such as size and synergies, which provide huge enterprises an advantage and promote market concentration (Haskel and Westlake, 2017). According to Fitzgerald et. al. (2014, p. 7), businesses that need to be ahead of competition need to embrace transformation in order to improve their businesses through enhanced customer engagement and experience, creating new business models and streamlining operations. Business should take advantage of the opportunities that are brought by the emerging digital technologies by embracing and committing to digital technologies and capabilities in order to innovate their business and improve their performances (Khin and Ho, 2020).

Perceived Compatibility

According to Kaasinen (2005), perceived compatibility is the degree of consistency

between new ideas or products and existing one. In simple terms it is mainly concerned with ensuring that new digital technology adoption should be compatible with what people do. It regards new idea as more familiar by give it meaning based on current ways of doing things (Francesco, 2012). If the innovation is more compatible the better the chances of adoption, for example, compatibility of digital technology to existing systems and processes will increase the rate of digital technology innovation. If new technology is perceived to disrupt current processes and systems, it may lead to incurring additional cost and as such be terminated (Wani and Ali, 2015).

Perceived Motivation

Manso (2011) stated that motivation for innovation is achieved through incentivising the workforce. About 50% of workers in the United Kingdom are worried that their roles may be replaced by digital technology such as automation, artificial intelligence (AI) or robots. The World economic forum reported that by 2025 about eighty-five million jobs will be redundant and about 97 new roles will be identified (WEF, 2020). The workforce has the ability to derail or sabotage the vision and ambition of innovation if they do not see value for themselves. When technology is perceived to be impacting the workforce ambitions or interests such as job security or roles seen as redundant, they are likely to not support the initiative. The world economic forum reported that any current roles will be redundant in the future and in the Oil and Gas roles such as administrative secretaries, data entry clerks, assembly, and factory work (WEF, 2020). The diagram below shows some of the roles that will be redundant:

1.	Administrative and Executive Secretaries
2.	Assembly and Factory Workers
3.	Data Entry Clerks
4.	Accounting, Bookkeeping and Payroll Clerks
5.	Mechanics and Machinery Repairers
6.	Material-Recording and Stock-Keeping Clerks
7.	Accountants and Auditors
8.	Mining and Petroleum Extraction Workers
9.	Client Information and Customer Service Workers
10.	Legal Secretaries

Figure 7: Oil and Gas redundant roles (WEF, 2020)

2.4 Conceptual Framework

The oil and gas sector is characterized by its dynamic nature, continuously evolving with the integration of recent technologies and innovative practices. These advancements are essential for enhancing operational efficiency, safety, and environmental sustainability. The industry's capacity to effectively adopt and disseminate these innovations is pivotal for maintaining its competitive edge and ensuring long-term success. Innovation adoption in the oil and gas sector involves multiple factors, but this study specifically focuses on two critical determinants: innovation knowledge and motivation for innovation. The diagram below, depicts the summary of the conceptual model developed for this research:

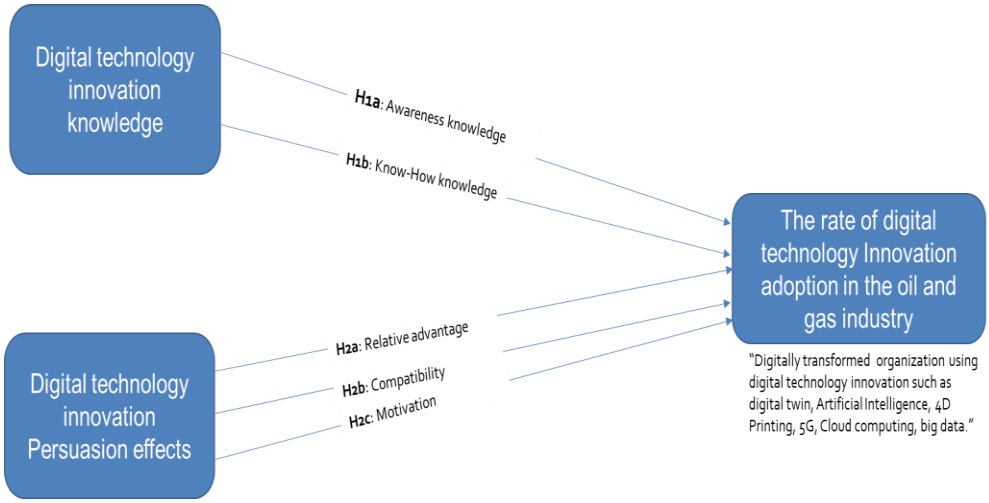


Figure 8 : Research Conceptual Model (Mokgoto, 2023)

The Innovation Knowledge refers to the awareness and understanding of digital technologies within the industry. It encompasses the technical know-how, familiarity with potential applications, and the benefits that these technologies can bring. Effective dissemination of innovation knowledge ensures that stakeholders at various levels of the organization are well-informed about the latest technological advancements and their potential impacts. Motivation for Innovation: This involves the factors that drive individuals and organizations to embrace recent technologies. Motivation can be influenced by perceived relative advantages (such as cost savings and efficiency gains), compatibility with existing systems and processes, and individual or collective incentives (such as performance bonuses or recognition).

The conceptual model posits that both innovation knowledge and motivation for innovation are crucial for the successful adoption of digital technologies in the oil and gas industry in South Africa. This leads to the formulation of the following hypotheses:

Hypothesis 1:

H_{o1}: The awareness and know-how of digital technology knowledge uses positively influences of the rate digital technology adoption.

This hypothesis suggests that when individuals and organizations within the oil and gas sector are well-informed about digital technologies and understand how to utilize them effectively, the rate of adoption of these technologies will increase. The underlying assumption is that knowledge empowers stakeholders to make informed decisions, thereby facilitating smoother and more widespread implementation of innovations.

H_{11}: The awareness and know-how of digital technology knowledge uses have no significant influence or negatively influences the rate of digital technology adoption.

The alternative hypothesis challenges the assumption that knowledge alone is sufficient to drive adoption. It suggests that even with awareness and understanding, other factors (such as resistance to change, high implementation costs, or lack of infrastructure) might hinder the adoption process, leading to either no significant impact or a negative influence on the rate of adoption.

Hypothesis 2:

H_{02}: Persuasive motivation effects (relative advantage, compatibility, and motivation) leading to individual agent and collective incentive, or motivation positively influence the rate of adoption of digital technology innovation.

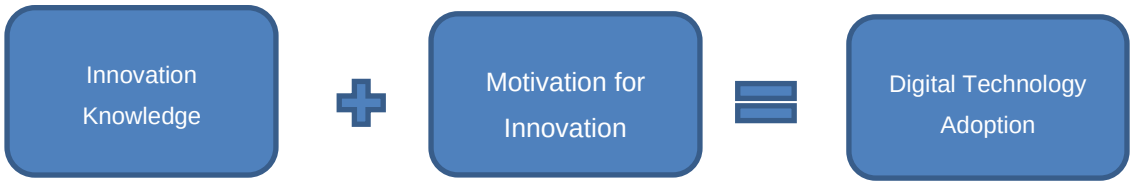
This hypothesis asserts that when the motivations for adopting digital technologies are strong, whether it is due to perceived advantages, alignment with existing processes, or incentives for stakeholders, the adoption rate will be positively impacted. It emphasizes the role of motivation in overcoming barriers to innovation, suggesting that motivated individuals and organizations are more likely to embrace recent technologies.

H_{12}: The persuasive motivation effects leading to individual agent and collective incentive, or motivation have no significant influence or negatively influence the rate of adoption of digital technology innovation.

The alternative hypothesis posits that motivational factors might not always lead to higher adoption rates. It acknowledges the possibility that even with strong motivational drivers, other obstacles (such as organizational inertia, cultural resistance, or inadequate support systems) could negate the positive effects of motivation, resulting in no significant impact or even a negative influence on technology adoption.

2.5 Summarised version of Model

The diagram below depicts the summarised version of the model, indicating that innovation knowledge and incentive for innovation will yield adoption of digital technology adoption.



The proposed hypotheses are grounded in the understanding that both knowledge and motivation are essential for the successful adoption of innovations. For hypothesis 1, the relationship between knowledge and adoption is supported by the theory of diffusion of innovations, which states that knowledge is the first stage in the adoption process. Without awareness and understanding, stakeholders are unlikely to recognize the value of recent technologies, leading to lower adoption rates. For hypothesis 2, the role of motivation is highlighted and premised around these perceptions; attitudes, perceived ease of use, and perceived usefulness are critical determinants of behavioural intention to adopt new technologies. Motivation acts as a catalyst, enhancing these perceptions and driving adoption.

In the context of the South African oil and gas industry, both hypotheses reflect the unique challenges and opportunities within this sector. By examining the influence of innovation knowledge and motivation, this study aims to provide insights into how these factors can

be leveraged to enhance the adoption of digital technologies, ultimately contributing to the industry's growth and sustainability.

2.6 Conclusion

To summarize, the empirical evidence shows that there are multiple factors that influence the adoption of digital innovation in the oil and gas industry. It also highlighted that not all key variables that are indicated in the DOI theory are all applicable. By further empirically evaluating the factors that influence the rate of digital innovation adoption in the oil and gas industry in South Africa, the current study adds to the literature on the influence digital innovation adoption.

3 RESEARCH METHODOLOGY

The previous chapter discussed the theoretical framework and conceptualized a research framework to drive the objective of the study. This chapter discusses the research methodology and approaches that will be employed for this study. It discusses the research paradigm, approach, strategy, design, and the data collection techniques.

3.1 Research Method:

The use of primary data collection through surveys is well-suited for this study because it allows for direct interaction with the target population. Surveys are efficient for gathering substantial amounts of data from respondents who are geographically dispersed, as is the case with experts in the oil and gas industry. Questionnaire Distribution via Email, SMS, and WhatsApp. These distribution methods are appropriate given the professional nature of the respondents. Email, SMS, and WhatsApp are widely used communication tools among professionals, ensuring that the survey reaches the participants promptly and allows for convenient responses.

The questionnaire design ensures that all aspects of the research questions are addressed. This comprehensive approach maximizes the relevance of the data collected, ensuring that it directly informs the study's objectives. An ordinal scale is appropriate for measuring degrees of agreement or disagreement, as it captures the intensity of respondents' feelings or opinions on the issues at hand. This is particularly useful in understanding the nuances in experts' perspectives on ICT and digital innovation.

By focusing on a well-defined group of experts, leaders, consultants, and users, the study ensures that the data collected is highly relevant and actionable. These individuals are best positioned to provide insights into the current state and future potential of ICT and digital innovation in the oil and gas industry. In conclusion, the chosen sample size and methodology are well-justified for this study. They ensure that the data collected is both high-quality and relevant, providing a solid foundation for analyzing the state of ICT and digital innovation in the South African oil and gas industry.

3.2 Data collection

This research used primary data source whereby data was collected by the researcher through surveys from selected experts, leaders, consultants and users from oil and gas industry companies. Data was collected through questionnaire surveys that was distributed through email, or SMS or WhatsApp. The survey helped reach people in the country irrespective of where they are based. All key questions were included in the questionnaire covering all the research questions. This study used an ordinal scale whereby responses related to the variables were collected through rating or ranking the degree to which they agree or disagree with a statement.

The sample for this research included sixty (60) individual experts, leaders, consultants and users within the Oil and Gas involved in ICT or digital innovation in South Africa. The individual experts and leaders included service providers, consultants, and subjects matter experts within organizations. The table below summarises the type of respondents based on their role in digital technology innovations:

Table 1: Profile of respondents

Description of respondent type
• IT Leadership (Senior Manager, Vice President (General Manager), Senior Vice President (CIO), CDO)
• Business Leadership (Senior Managers, VP, SVP, EVP)
• Digital Leadership (Senior Manager, Vice President (General Manager), Senior Vice President (CIO), CDO)
• Service Providers
• Digital technology Users

Purposive Sampling method was used for this study in alignment to the objectives of this study. Palinkas et al. (2015), stated that purposive sampling is particularly useful when the researcher needs to obtain insights from specific individuals who have particular expertise or experience related to the research topic. The selection of sixty (60) individual experts,

leaders, consultants, and users within the oil and gas industry in South Africa for this study is both strategic and justifiable for this study.

Firstly, from an expertise and relevance perspective the chosen participants are highly knowledgeable and experienced in their respective fields. They include service providers, consultants, and subject matter experts who are directly involved in ICT or digital innovation within the oil and gas industry. This ensures that the data collected is both relevant and insightful, as these individuals are likely to provide informed and accurate responses to the survey questions. From a focused scope perspective, given the specific focus on ICT and digital innovation within the oil and gas sector, the selected sample size is appropriate. A larger sample might dilute the quality of responses with input from less relevant participants, while a smaller sample could miss out on diverse perspectives. Sixty participants strike a balance, providing a comprehensive view without overwhelming the study with too much data.

From a feasibility and practicality perspective, logistically, reaching out to a large number of highly specialized individuals can be challenging. The chosen sample size is manageable within the constraints of time and resources, ensuring that the researcher can effectively distribute, collect, and analyze the questionnaires. Representation of Industry Insights: In a specialized field like ICT in the oil and gas industry, the pool of true experts is limited. Therefore, sixty participants are likely to represent a significant portion of the key stakeholders in this niche sector, capturing a wide array of insights and experiences without redundancy. Lastly from a statistical considerations' perspective, while the study uses ordinal scales for responses, the sample size is large enough to conduct meaningful statistical analyses. It allows for the identification of trends and patterns and ensures the reliability and validity of the findings.

3.3 Research Model and Variables

Multiple linear regression modelling was used for this study. The model represented by the equation below defines the influence of awareness, know-how knowledge, persuasive motivation effects leading to individual agent and collective incentive, or motivation to digital technology innovation adoption rate. The variables considered were widely used in

previous empirical studies such as factors investigated by Butler and Sellbom (2002) and WEF (2017).

Variables are mainly classified as dependent or independent, whereby dependent variables are considered to have an influence on the independent variable (Zikmund, Babin, Carr, & Griffin, 2013). Multilinear Regression analysis was used to analyse the associations between multiple variables where one of the variables (the dependent variable DV) is explained or predicted by the others (the independent variables IVs). The mathematical equation for multilinear regression is $Y=a+b_1X_1+b_2X_2+ \ldots+b_kX_k$ (Ferson, Siegel and Wang, 2024). Y represent the dependent variable and X the independent variables.

Hypotheses:

- H1: The awareness and know-how of digital technology knowledge uses positively influences of the rate digital technology adoption.
- H2: Persuasive motivation effects (relative advantage, compatibility, and motivation) leading to individual agent and collective incentive, or motivation positively influence the rate of adoption of digital technology innovation.

Given the hypotheses above and the multilinear regression mathematical equation, the regression model for this study is:

$$\mathbf{RDTA}=\alpha_o + \beta_1 \mathbf{AK}+ \beta_2 \mathbf{KH}+\beta_3 \mathbf{PRA}+ \beta_4 \mathbf{PC}+ \beta_5 \mathbf{PM}+\varepsilon i$$

The independent variable rate of digital technology (RDTA) is influenced by multiple variables which includes awareness knowledge (AK), know-how knowledge (KH), perceived relative advantage (PRA), perceived complexity (PC) and perceived motivation (PM).

Dependent variable:

Rate of Digital Technology Adoption (RDTA) represents the extent of digital technology adoption which is a dependent variable. It will be measured by assessing how digitally technology were adopted from the 45 respondents from the oil and gas companies in South Africa which represents about 6 companies in this industry. The dimension for this

variable is a 4 Likert scale with the following options: 4 - Highly adopted, 3 - Fairly Adopted, 2 - Poorly Adopted and 1 - No Adoption. This variable is supported by additional information variable which confirms the type of digital technology adopted from the following options: digital twin, Artificial Intelligence, 4D Printing, 5G, Cloud computing and big data. For this variable, respondents were also asked to specify any other technologies adopted using free text.

Independent Variables:

Awareness Knowledge (AK) represents the awareness knowledge of digital technology with focus on understanding of what is digital technology innovation, how digital technology works, the purpose of digital technology and the availability of information about digital technologies. The measured of this variable was done asking the respondents to answer five (5) questions using 5 scale Likert dimension, with the following options 5 – strongly agree, 4 – Somewhat agree, 3 – neither agree or disagree, 2 - somewhat disagree, and 1 – strongly disagree. The following were the questions for this variable: (1) There is clear understanding of what digital technology innovation is, (2) There is clear understanding of how digital technology innovation works, (3) There is clear understanding of why digital technology innovation is implemented, (4) Information about Digital innovation technologies is easily accessible for exploration, and (5) Those with know-how freely share information to other colleagues.

Know-How Knowledge (KH) represents the know-how of digital technology with focus on practical expertise to implement, use about digital innovation technology and relevance of digital technology to oil and gas industry value chain technology and use cases. The measured of this variable was done asking the respondents to answer five (5) questions using 5 scale Likert dimension, with the following options 5 – strongly agree, 4 – Somewhat agree, 3 – neither agree or disagree, 2 - somewhat disagree, and 1 – strongly disagree. The following were the questions for this variable: (1) There are lots of opportunities made available to explore digital innovation technologies in our organization, (2) Employees have principle knowledge about key digital innovation technologies for the industry, (3) Before implementing digital innovation technologies there is an opportunity to properly try it out, (4) Employees have the right technical skill sets to implement digital innovation technologies and (5) Employees have the right skills to use digital innovation technologies.

Perceived Relative Advantage (PRA) represents the perceived relative advantage of digital technology adoption by organisations. The relative advantage includes, delivery of business results efficiency, improve quality of service and experience, improved productivity and decision making. The measured of this variable was done asking the respondents to answer four (4) questions using 5 scale Likert dimension, with the following options 5 – strongly agree, 4 – Somewhat agree, 3 – neither agree or disagree, 2 - somewhat disagree, and 1 – strongly disagree. The following were the four (4) questions for this variable:

(1) Digital innovation technology improves management and/or delivery of business results efficiently, (2) Digital innovation technology improves the quality of Services and experience, (3) Using digital technology innovation enables quicker execution of business tasks or decision making and (4) Digital technology innovation improves business Productivity.

Perceived Compatibility (PC) represents the perceived compatibility factors of the digital technology adoption. These factors include, ways of work and business operations, organization's value and culture system, existing technology solutions and systems.

The measured of this variable was done asking the respondents to answer four (4) questions using 5 scale Likert dimension, with the following options 5 – strongly agree, 4 – Somewhat agree, 3 – neither agree or disagree, 2 - somewhat disagree, and 1 – strongly disagree. The following were the four (4) questions for this variable: (1) Digital innovation technology fits the ways of work for your organization, (2) Digital innovation technology is fully compatible with current business operations, (3) Using Digital innovation technology is compatible with your company's corporate culture and value system and (4) Using digital technology innovation will be compatible with existing technology solutions and systems in the company.

Perceived Motivation (PM) represents the perceived factors that influence individual and collective group motivation towards the adoption of digital technology. These factors include the incentive to adopt digital technology, information on the impact of digital technology on current roles, growth opportunities and alternative jobs presented by digital technology. The measured of this variable was done asking the respondents to answer

three (3) questions using 5 scale Likert dimension, with the following options 5 – strongly agree, 4 – Somewhat agree, 3 – neither agree or disagree, 2 - somewhat disagree, and 1 – strongly disagree. The following were the three (3) questions for this variable:
(1) There is an incentive to encourage individuals to adopt digital innovation technology, (2) There is information and/or alternative opportunities for people whose work might be impacted due to digital innovation technology implementation, and (3) There is enough information about the growth opportunities presented by Digital innovation technology.

3.4 Analysis Method

The collected data will be exported from Qualtrics Survey tool into IBM SPSS Statistics for analysis. Using SPSS, the data was analysed for missing data and if the missing data is less than 5% then the data will be deemed acceptable (Alice, 2015).

Descriptive Analysis

The data was analysed for descriptive statistics to assess the dispersion and central tendency. This was done by analysing the mean, median, standard deviation, minimum and maximum values for all the individual variables, both independent and dependent variables.

Correlation Analysis:

Correlation analysis was used to understand the relationship between the independent variables. The Pearson correlation matrix was used to analyse the relationship between the independent variables to establish if there was a statistically significant association between the variables, and ascertain the strength of association (Mukaka, 2012).

4 RESULTS

The purpose of this study was to understand, explore and describe the factors that influence innovation adoption in order to accelerate the adoption of digital technology innovation within the context of Oil and Gas industry in South Africa. This section presents the results of the study from the collected data. The total size of the sample consisted of 60 individuals from companies in the Oil and Gas in South Africa, these includes, employees, service providers and leaders. The data collected will be analysed to answer the research questions of this study as identified in the first chapter. The results are represented by first discussing the validity and reliability of the variables elements.

Thereafter two (2) research questions are evaluated: Both addressing the factors influencing the rate of digital technology innovation adoption. The factors that influence digital technology innovation in this study are grouped in to five categories, namely, Awareness Knowledge (AK), Know-How Knowledge (KH), Perceived Relative Advantage (PRA), Perceived Compatibility (PC), and Perceived Motivation (PM). Lastly, the findings are then summarised.

4.1 Reliability and Validity Statistics

Table 2: Reliability Statistics

Scale	Cronbach's Alpha	No. of Items
Rate of Digital Technology Adoption (RDTA)	.527	2
Awareness Knowledge (AK)	.784	4
Know-How Knowledge (KH)	.661	3
Perceived Relative Advantage (PRA)	.927	3
Perceived Compatibility (PC)	.804	3
Perceived Motivation (PM)	.786	3

Table 3 above summarizes the reliability statistics for the 6 scales representing the variables that were analysed. For a scale to be deemed statistically reliable, the Cronbach's alpha of at least greater than .700 is required. The results above shows that Awareness knowledge (AK), Perceived Relative Advantage (PRA), and Perceived

Compatibility (PC) satisfied this requirement. Rate of Digital Technology Adoption and Know-How Knowledge do not satisfy this requirement and will be noted as limitation to the study. The way the questions were phrased could have led to the reasons why these scales where statistically unreliable which could be understood differently by the study participants.

Even though not all scales met the reliability compliance Pearson's correlation analysis was run on all 5 scales to further assess construct validity. The results are summarised in Table 4 below as follows:

Table 3: Constructs validity Statistics

Correlations

		RDTA	AK	KH	PRA	PC	PM
RDTA	Pearson Correlation	1	.420**	.332*	.255	.063	.516**
	Sig. (2-tailed)		.004	.024	.091	.681	<.001
	N	50	46	46	45	45	45
AK	Pearson Correlation	.420**	1	.736**	.303*	.403**	.654**
	Sig. (2-tailed)	.004		<.001	.043	.006	<.001
	N	46	46	46	45	45	45
KH	Pearson Correlation	.332*	.736**	1	.202	.442**	.575**
	Sig. (2-tailed)	.024	<.001		.183	.002	<.001
	N	46	46	46	45	45	45
PRA	Pearson Correlation	.255	.303*	.202	1	.415**	.200
	Sig. (2-tailed)	.091	.043	.183		.005	.187
	N	45	45	45	45	45	45
PC	Pearson Correlation	.063	.403**	.442**	.415**	1	.399**
	Sig. (2-tailed)	.681	.006	.002	.005		.007
	N	45	45	45	45	45	45
PM	Pearson Correlation	.516**	.654**	.575**	.200	.399**	1
	Sig. (2-tailed)	<.001	<.001	<.001	.187	.007	
	N	45	45	45	45	45	45

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

The construct validity can be summarized in the following manner:

- AK (Cronbach's Alpha = 0.784, r = 0.420, p = 0.004): The high internal consistency (α = 0.784) and significant correlation with RDTA support the construct validity of RDTA in relation to Awareness Knowledge.
- KH (Cronbach's Alpha = 0.661, r = 0.332, p = 0.024): A moderate internal consistency (α = 0.661) and significant correlation indicate that RDTA is related to Know-How Knowledge, further supporting construct validity.
- PRA (Cronbach's Alpha = 0.927, r = 0.255, p = 0.091): Despite a very high internal consistency (α = 0.927), the non-significant correlation suggests RDTA may not strongly relate to Perceived Relative Advantage, indicating limited construct validity in this aspect.
- PC (Cronbach's Alpha = 0.804, r = 0.063, p = 0.681): High internal consistency (α = 0.804) but negligible and non-significant correlation with RDTA indicates that RDTA is unrelated to Perceived Compatibility.
- PM (Cronbach's Alpha = 0.786, r = 0.516, p < 0.001): High internal consistency (α = 0.786) and a strong, significant correlation with RDTA support both the construct and criterion validity of RDTA concerning Perceived Motivation.

The scales for the variables comply with construct validity because the correlations are statistically significant and almost all variables have a scale of greater than .300 in magnitude or correlation strength. However, some of the variables in the scale have satisfied this requirement except for only 4 items, namely, RDTA, AK, KH, PM. We then used the scale by computing the items according to their means (averages). For the other scales we did the same, but we have noted as a limitation concerning this study.

The rate of digital technology adoption (RDTA) demonstrates robust construct validity as evidenced by significant correlations with related constructs such as Awareness Knowledge (AK, r = 0.420, p = 0.004, α = 0.784), Know-How Knowledge (KH, r = 0.332, p = 0.024, α = 0.661), and Perceived Motivation (PM, r = 0.516, p < 0.001, α = 0.786). The high internal consistency of AK, KH, PRA, PC, and PM (α ranging from 0.661 to 0.927) indicates that these scales are robust measures of their respective constructs. These relationships suggest that RDTA effectively measures aspects of the theoretical domain it aims to capture. The validity and reliability statistics provide a compelling argument for the validity of RDTA in assessing its intended constructs.

4.2 Findings on the knowledge and awareness on digital technology innovation adoption

This section investigates whether awareness and know-how knowledge influence the rate of digital technology innovation adoption. The following results are to test the following hypothesis: The Null hypothesis **H_{01}** is:

H_{01} – The awareness and know-how of digital technology innovation uses positively influences of the rate digital technology adoption.

And the alternative Hypothesis **H_{11}** is:

H_{11} - The knowledge (awareness and know-how) of digital technology uses have no significant influence or negatively influence the rate of digital technology adoption.

ANOVA Analysis was run to test the hypothesis based on the independent variable. The following are the results of this analysis:

4.2.1 *Descriptive Statistics*

Table 5 below summarises the descriptive statistics for all the variables that were included in this study.

Sample Size: The analysis included a sample of 45 observations or participants.

Table 4: Descriptive Statistics

Variables	N	Mean	Std. Deviation	Minimum	Maximum
AK	45	2.6522	.84423	1.00	5.00
KH	45	3.0000	.95874	1.00	5.00

Based on Table 5 above, we observe that Know-How Knowledge (KH) showed the highest mean (*M* = 3.0000, *SD* = .84423). This indicates that most of the responses were more in agreement towards the positive side of these scales. Awareness Knowledge (AK) has the

lowest Mean which seems to suggest that most participants are not in agreement wit**h** the positive side of the scale.

4.2.2 *Hypothesis Testing*

Table 5 : Regression Model Summary

Model Summary[b]

Model	R what is R?	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.458[a]	.210	.192	.07839	.210	11.704	1	44	.001	1.753

a. Predictors: (Constant), Knowledge

b. Dependent Variable: RDTA

Table 6 above summarises the model summary with the following results:

- A moderate positive relationship between the independent and dependent variables represented by **correlation coefficient (R)** of **0.458**
- 21% of the variance in the rate of digital technology adoption is explained by the knowledge of digital technology knowledge uses, this is represented by the coefficient of determination (R Square) of 0.210
- **Model Fit,** for these statistics shows no significant autocorrelation in the residual, represented by the Durbin-Watson statistic of 1.753, since a value between 1.5 and 2.5 suggests no significant autocorrelation.

4.2.3 *Significance*

Table 7 below shows that the results are statistically significant with an F value of 11.704, and the associated significance level (sig.) is .001. This leads us to reject the alternative hypotheses and accept the Null hypothesis concluding that knowledge (awareness and know-how) of digital technology uses have significant influence on the rate of digital technology adoption.

Table 6 : ANOVA Statistics

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	.072	1	.072	11.704	.001[b]
	Residual	.270	44	.006		
	Total	.342	45			

a. Dependent Variable: RDTA

b. Predictors: (Constant), Knowledge

4.3 Findings on how Persuasive effects influence digital technology innovation adoption.

The following results are to test the following hypothesis:

The Null Hypothesis: **H_{02} -** Persuasive effects leading to individual agent and collective incentive, or motivation positively influence the rate of adoption of digital technology innovation.

The Alternative Hypothesis: **H_{12} -** Persuasive effects leading to individual agent and collective incentive or motivation have no significant influence or negatively impact the rate of adoption of digital technology innovation.

4.3.1 *Descriptive Statistics*

Table 8 below summarises the descriptive statistics for all the variables that were included in this study.

Sample Size: The analysis included a sample of 45 observations or participants.

Table 7 : Descriptive Statistics

Variables	N	Mean	Std. Deviation	Minimum	Maximum

PRA	45	1.5852	.78224	1.00	5.00
PC	45	2.3037	.91790	1.00	5.00
PM	45	2.8667	1.05744	1.00	5.00

Based on Table 8 above, we observe that Perceived Motivation (PM) showed the highest mean (*M* = 2.8667, *SD* = 1.05744). This indicates that most of the responses were more in agreement towards the positive side of these scales. Perceived Relative Advantage (PRA) has the lowest Mean which seems to suggest that most participants are not in agreement wit**h** the positive side of the scale.

4.3.2 *Statistical Hypothesis Testing*

Table 8: Regression Model Summary

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.311[a]	.097	.076	.08442	.097	4.604	1	43	.038	1.890

a. Predictors: (Constant), Motivation

b. Dependent Variable: RDTA

Table 9 above summarises the model summary with the following results:

- A moderate positive relationship between the independent and dependent variables represented by **correlation coefficient (R)** of **0.311**
- 9.7% of the variance in the rate of digital technology adoption is explained by the knowledge of digital technology knowledge uses, this is represented by the coefficient of determination (R Square) of 0.097
- **Model Fit,** for these statistics shows no significant autocorrelation in the residual, represented by the Durbin-Watson statistic of 1.890, since a value between 1.5 and 2.5 suggests no significant autocorrelation.

4.3.3 *Significance*

Table 10 below shows that the results are statistically significant with an F value of 4.604, and the associated significance level (sig.) is .001. This leads us to reject the alternative hypotheses and accept the null hypothesis concluding that persuasive effects leading to individual agent and collective incentive, or motivation have significant influence on the rate of adoption of digital technology innovation adoption.

Table 9: ANOVA Statistics

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.033	1	.033	4.604	.038[b]
	Residual	.306	43	.007		
	Total	.339	44			

a. Dependent Variable: RDTA

b. Predictors: (Constant), Motivation

The provided sample size of 45 is marginally adequate for a regression model with one predictor. According to the rule of thumb, having at least 10-15 cases per predictor is generally acceptable, and this model meets that criterion. Also noting that increasing the sample size could enhance the robustness and reliability of the results.

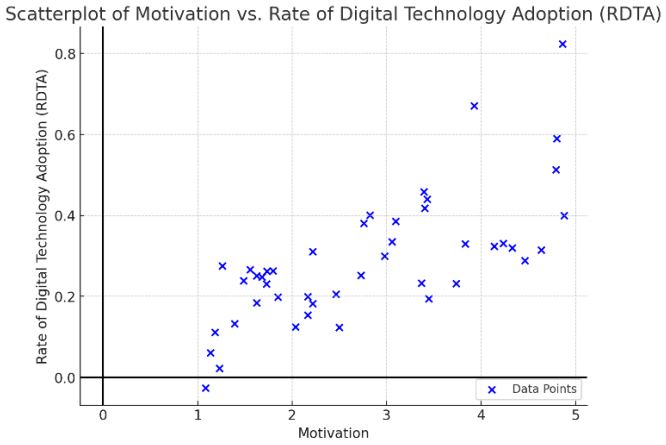


Figure 9 : Scatterplot Motivation vs. Rate of Digital Technology Adoption (RDTA)

The scatterplot above visualizes the relationship between Motivation (independent variable) and the Rate of Digital Technology Adoption (RDTA) (dependent variable).

Assumptions analysis:

The scatterplot shows a generally positive relationship between Motivation and RDTA, indicating that higher levels of motivation are associated with higher rates of digital technology adoption. The points suggest a linear trend, which is consistent with the assumption of linearity in regression analysis. There is no obvious pattern of increasing or decreasing variance as Motivation increases, suggesting homoscedasticity. The points are spread relatively evenly across the range of Motivation, which supports the assumption of a normal distribution of residuals. The scatterplot of Motivation versus the Rate of Digital Technology Adoption (RDTA) demonstrates a positive linear relationship, supporting the validity of the regression model. The scatterplot indicates linearity and suggests homoscedasticity, satisfying key assumptions for regression analysis. The significant F-statistic (4.604, $p = 0.038$) from the ANOVA table further supports the model's validity, indicating that Motivation is a significant predictor of RDTA.

4.4 Summary of Results

This chapter presented the results of the research and will be used to help in discussion the findings in the following chapter. Reliability tests were run and showed that awareness knowledge, know-how knowledge and perceived motivation scales conformed to the reliability test.

The other two scales perceived relative advantage and perceived complexity did not meet the requirement and therefore removed from the analysis and noted as possible limitations. We further tested the constructs for validity and all scales satisfied the requirements for construct validity.

The two hypotheses were tested using multiple regression analysis using SPSS software and the following was concluded: based on the analysis and findings, for hypothesis 1, the knowledge of digital technology knowledge uses has a statistically significant positive influence on the rate of digital technology adoption, thereby adopting the null hypothesis. Furthermore, approximately 21% of the variance in the rate of adoption can be explained by the knowledge of digital technology knowledge uses.

We can also conclude that based on the analysis that for hypothesis 2, the persuasive effects (relative advantage, compatibility, and motivation) leading to individual agent and collective incentive, here motivation in the absence of relative advantage and compatibility, has statistically significant positive influences on the rate of adoption of digital technology innovation. However, the overall variance explained by these variables is relatively low, with only 9.7% of the variance in the rate of adoption is accounted for.

5 DISCUSSION OF RESEARCH RESULTS

This chapter discuss the findings of the research regarding the interaction of variables and how the hypothesis framed in Chapter 2 is affected. This chapter also contrasts the findings with the literature as discussed in Chapter 2. Chapter 4 presented the results of the research focusing on descriptive statistics and the statistical model. The purpose of this study was to explore the factors that influence the rate of digital technology innovation adoption in the oil and gas with the context of South Africa.

5.1 The influence of knowledge on digital technology innovation adoption

Although there are multiple factors that influence digital technology innovation adoption, the result of this study shows that both awareness knowledge and know-how knowledge have a significant influence on the rate of digital technology adoption. Knowledge overall accounts for 21% of the influence on this rate of adoption. It is made up of the following sub-factors:

- **Awareness Knowledge (AK)** which represents the understanding of what is digital technology innovation, how digital technology works, the purpose of digital technology and availability of information about digital technologies.
- **Know-How Knowledge (KH)** which represents the practical expertise to implement and use the digital innovation technology. This includes relevant oil and gas industry value chain technology and use cases.

This finding makes sense because for any organisation to aspiring to adopt digital technology, there is a need to invest in efforts to grow the knowledge in the organization. These findings support the literature which show that there is a limited know-how on how to innovate in the oil and gas digital industry and a lagging use of digital business strategies and technology adoption throughout the industry.

The literature further showed that for some of the organisation with some efforts to adopt digital technology they face further challenges because those with the know-how and information are not incentivised to share the knowledge (OECD (2005), Butler and Sellbom (2002), Neely and Hii (1998)). Due to lack of knowledge, we will further see the slowness

to adoption efforts and as such lose out in the business value promised by such technological efforts. The study was conducted to multiple energy companies in this industry and if the results is a fair representation of the industry, it means something must be done in the industry and individual companies to increase the level of knowledge in this sector.

5.2 Persuasive effects influence on digital technology innovation adoption

The second objective of the study was to explore persuasive factors that influence digital technology adoption in the oil and gas industry in South Africa. As shown in the findings, not all factors in this theme have the same effect.

Perceived Relative Advantage had a lower score in the findings than other factors in this category. Perceived relative advantage represents the perceived business value brought about by digital technology innovation which includes, delivery of business results efficiency, improve quality of service and experience, improved productivity and decision making. From the literature the relative advantage of digital technology innovation plays a crucial role towards adoption, in simple terms this means the perceived business value of digital technology innovation to an organization (Sonnenwald et. al, 2001, Francesco, 2012, Fitzgerald et. al, 2014, Khin and Ho, 2020). Generally, in the literature, digital technology innovation promises great value to business, however, for business to buy-in to the promises of digital technology innovation, the value needs to surpass the current value and practices (Khin and Ho, 2020). Literature also illustrates that if business do not adopt digital technology innovation and runs a risk of being irrelevant and subsequently extinct (Fitzgerald et. al, 2014).

Another important factor in the persuasion theme is perceived compatibility which represents the perceived compatibility factors of the digital technology adoption to what the organization already knows (Kaasinen, 2005). These factors include, ways of work and business operations, company's corporate culture and value system, existing technology solutions and systems. This factor resonated with most participants although it was not the most prominent one. The results shows that compatibility of digital technology innovation to the organisation and its current capability is crucial and cannot be ignored. As much as

digital technology innovation can promise great value, it is also crucial that it addresses real issues and challenges of the business. These technologies need to be aligned with the values of the organization as well as their needs. Literature by OCDE (2005), Paletta (2020) and Fagerberg (2004) asserts that businesses are challenged with achieving business results in a sustainable manner, as such three key elements of the business outcomes needs to be met, namely, people, profits, and planet.

The most prevalent factor in the theme of persuasion is the **perceived motivation** factor which represents the perceived factors that influence individual and collective group motivation towards the adoption of digital technology. This is not entirely aligned with the literature which suggest that skills are at the top of the charts when it comes to factors that influence digital technology adoption (WEF, 2020). The attributes that make up the perceived motivation variable includes incentive to adopt digital technology, information on the impact of digital technology on current roles, growth opportunities and alternative jobs presented by digital technology. This shows that for most participants as much as they care about the promise of digital technology innovation, this must be done in such a way that it meets the individual needs for it to be adopted.

6 CONCLUSION, LIMITATIONS AND RECOMMENTATIONS

6.1 Conclusion

The purpose of this study was to investigate the factors that influence the adoption of digital technology innovation in the oil and gas industry in South Africa. The literature showed that there are number of factors that influence the rate of digital technology adoption and out of these the most prevalent ones were investigated for applicability in the oil and gas in South Africa. This study explored factors that were more prevalent in the oil and gas and grouped them into two categories, namely, knowledge and persuasion factors. These factors are crucial and cannot be ignored if an organisation would like to transform and benefit from the promises of digital technology innovation. The DOI theory was used as lens to explore the factors that influence the adoption of digital technology innovation. The theory has helped in categorizing and grouping the factors.

As much as all factors are important, the results showed that both Know-How knowledge and motivation play the most important roles in the adoption of digital technology in the oil and gas industry in South Africa. This indicates that companies need to put more effort in the motivation while upskilling the individuals.

The study therefore recommends that organizations should invest in upskilling their employees on digital technology innovation skills. Awareness knowledge might be important but for an accelerated adoption there is more need for hand-on and practical skills. Individuals should be incentivised to adopt digital technology. This means there is a need for further exploration about the options to incentivise individuals. These incentives could differ from one organization to another. More information about the impact of digital technology innovation on the current roles and capabilities should be shared.

These findings make more sense, because for one to support an initiative they need to know the impact on them and the promised value thereof. Information about growth opportunities and alternative jobs presented by digital technology should also be shared and discussed.

The other factors, namely, awareness knowledge, perceived compatibility, and perceived relative advantage, as much as they did not resonate more with all participants they cannot be ignored. The extent of influence by these factors should be used as a mechanism to prioritize the importance and impact on the innovation adoption efforts. If some of these factors are excluded, they might still impact the adoption ambitions.

6.2 Recommendations

The objective of this study was to determine the factors that influence innovation adoption in order to accelerate the adoption of digital technology innovation within the context of Oil and Gas industry in South Africa. Innovation through digital technology plays a crucial role in all industries, for the Oil and Gas to leverage digital technology there is a need to understand what are the factors that influence adoption, thereafter, learn from other industries how they have dealt with these factors.

From the findings of this study through the empirical evidence, the literature, and the theory the following it is recommended the to accelerate the rate of digital technology adoption in the oil and gas organizations should invest and prioritize building digital technology and leadership skills. This can be done through upskilling current employees and deliberately hiring employees who already have these skills. Efforts to ensure that individuals have hands-on experience and know-how should be prioritize at all levels in the organization.

Oil and gas organizations in South Africa should also focus on change management activities aimed at motivating current employees showing them benefits and opportunities brough about by digital technology adoption. This will serve as an incentive to ensure that they support and champion the initiatives. Digital technology initiatives should be made visible for awareness purposes and showing the transformation achieved and value unlocked.

Before attempting to embark on an innovation through digital technology, organizations should ensure that they have all the basics in place to carry out such an initiative, this include understanding of the digital innovation, required competence work force and change management efforts to ensure that the teams are motivated.

6.3 Limitations

The main limitation of this study is that it may not give a true reflection of the experiences of the factors influencing adoption of digital technology in the oil and gas industry of South Africa. The results of this study cannot be generalised for the oil and gas industry in South Africa as the number of participants were very limited. The limitations were due to the challenge that although there many organizations that are represented in the industry only few could be reached due to logistical constraints and time constraints of this study period, only a limited number of participants in the organizations approached could be reached.

6.4 Suggested future research studies.

The study was based on a fraction of companies and a few participants per company in the oil and gas industry in South Africa. Further research that includes more companies and participants could be more beneficial and lead to a possible generalisation of such findings. The current study only focused on top factors that were prevalent in other industries and countries, there is therefore an opportunity to expand on the factors that influence digital technology in various industries in South Africa to show their applicability.

The benefits of digital technology adoption are evident in many industries and continents, further studies in this field will help organization and industries with empirical evidence and recommendations that will help them unlock more value. Furthermore, factors such as digital divide can be explored to ascertain whether this as any cause to the adoption of digital technology innovation.

Lastly it could also be beneficial to extend the study to other countries in the region to further confirm whether the factors are due to macroeconomics rather than microeconomics and internal capabilities at company level. This will also confirm the generalizations of these findings in an adequate manner.

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APPENDIX A: RESEARCH QUESTIONNAIRE QUESTIONS

Q1. What Industry is organisation?

- Oil and Gas
- Other

Q2. What Division are you working in?

- Operations
- Upstream (Exploration or Mining)
- Downstream (Marketing and Sales)
- Mid-Stream (Logistics and Warehousing)
- Information Technology or Digital Office
- Functions (HR, Finance, Supply Chain, Legal, etc)

Q3. How long have been working in the industry?

- Up to 1 year
- 1 - 3 Years
- 3 - 5 Years
- More Than 5 Years

Q4. To what extent is digital technology innovation being adopted in your organization?

- Highly Adopted
- Fairly Adopted
- Poorly Adopted
- No Adoption

Q5. How many digital innovation technologies projects/initiatives have you been involved in since joining the company.

- None
- 1 Project
- 2 - 5 Projects
- more than 5 Projects

Q6. What type of digital technologies are implemented in your organization?

▢ None

▢ Digital Twin

▢ Cloud Computing

▢ Artificial Intelligence

▢ Machine Learning

▢ Drones

▢ 5G

▢ Other (specify) _____

Q7. Digital innovation technologies **awareness knowledge** in your organization

a. There is clear understanding of what digital technology innovation is.	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
b. There is clear understanding of how digital technology innovation works (2)	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
c. There is clear understanding of why digital technology innovation is implemented (3)	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
d. Information about Digital innovation technologies is easily accessible for exploration (4)	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
e. Those with know-how freely share information to other colleagues (5)	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

Q8. Digital innovation technologies Know-How knowledge in your organization

a. There are lots of opportunities made available to explore digital innovation technologies in our organization	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
b. Employees have principal knowledge about key digital innovation technologies for the industry	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
c. Before implementing digital innovation, technologies there is an opportunity to properly try it out	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
d. Employees have the right technical skill sets to implement digital innovation technologies	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
e. Employees have the right skills to use digital innovation technologies	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

Q9. Relative Advantage of Digital Innovation Technology to your organization

a. Digital innovation technology improves management and/or delivery of business results efficiently.	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

b. Digital innovation technology improves the quality of Services and experience.	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
c. Using digital technology innovation enables quicker execution of business tasks or decision making.	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
d. Digital technology innovation improves business Productivity.	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

Q10. Adaptability of Digital Innovation Technology to your organization

a. Digital innovation technology fits the ways of work for your organization	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
b. Digital innovation technology is fully compatible with current business operations	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
c. Using Digital innovation technology is compatible with your company's corporate culture and value system.	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

d. Using digital technology innovation will be compatible with existing technology solutions and systems in the company	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree

Q11. Motivation for Digital Innovation Technology adoption

a. There is an incentive to encourage individuals to adopt digital innovation technology	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
b. There is information and/or alternative opportunities for people whose work might be impacted due to digital innovation technology implementation	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
c. There is enough information about the growth opportunities presented by Digital innovation technology	Strongly Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree