Gordon Institute of Business Science
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FACTORS NECESSARY FOR EFFECTIVE ADOPTION OF MODERNISATION IN THE SOUTH AFRICAN MINING INDUSTRY

by

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ABSTRACT

The sustainability of the mining industry in South Africa is under threat due to global and local pressures including high production cost, low profit margins, labour unrest and rising demands by government. These additional local pressures have limited economic recovery for the industry, resulting in job losses including multinational mining companies exiting the country. However, the mining industry remains one of the highest employers in South Africa, hence the need to transform to become productive through modernisation. The adoption of technology innovation has been experienced as a credible solution in other industries, where integration of technology has been employed to solve problems and improve efficiencies.

The objective of the study was to explore the organisational factors that support or inhibit the acceptance of technology solutions for adoption of modernisation in the mining industry of South Africa. A qualitative, exploratory research method was selected to understand relevant adoption factors for the mining industry. Thirteen interviews were conducted with management from mining organisations across four commodity clusters. Thematic analysis was employed to uncover deeper meaning around the factors that influence acceptance of technology solutions.

The key factors identified were found to be: 1. Value drivers associated with perceived benefits; 2. Execution processes to ensure integration of technology into current business processes; 3. Change management and communication driving acceptance of technology solutions; and 4. Stakeholder engagement. Key enablers were found to be innovative culture, research and development and business ethics. An adoption model was proposed as a guide to mining organisations in South Africa on factors that need to be addressed in driving acceptance of technology for modernisation of the industry.

KEYWORDS

Mining modernisation, Technology adoption in mining, Acceptance of technology, Influencing factors for mining modernisation

DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

	11 November 2019
Signed: Name	Date

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1.1 Introduction

This chapter introduces the state of the mining industry in recent years and outlines the global challenges faced by the industry. The chapter provides a summary of the complexities faced by South African mining companies in managing their operations locally, with unique challenges including labour unrest and rising demands by the government as they continue efforts to remain in business to deliver value for their shareholders. This chapter outlines the problem statement for the research study and draws from literature to provide evidence on the existing gap in the field of technology management in order to explore and understand the factors that influence the adoption of modernisation for the mining industry. The chapter concludes with a purpose statement and outlines the scope of the research study including highlighting the limitations of the study.

1.2 Challenges Facing the Mining Industry

1.2.1 State of the Global Mining Industry

The global mining industry has been under pressure following the weak economic conditions, volatile commodity prices and decline in the demand for resources due to the slow-down in China's growth (Lane, Guzek and Van Antwerpen, 2015). The industry has experienced a decline in the demand for resources following China's growth decline, which has resulted in commodity prices remaining relatively under pressure (Mavroudis and Pierburg, 2017). The industry is facing several challenges including low economic conditions, compliance to legislation and environmental conditions, operational changes caused by maturity of existing operations, and stakeholder management (Lane et al., 2015).

The industry is faced with a declining grade of resources, the need to mine deeper resources and the necessity to improve safety and health conditions (Stanway, Graeme, Mahoney, Paul and Griebel, 2017). This has resulted in higher production costs, lower revenues generated at low profit margins and little return on investment for shareholders. These challenges place an increasing pressure on mining organisations globally to increase their efforts in improving safety, efficiencies and profitability for shareholders.

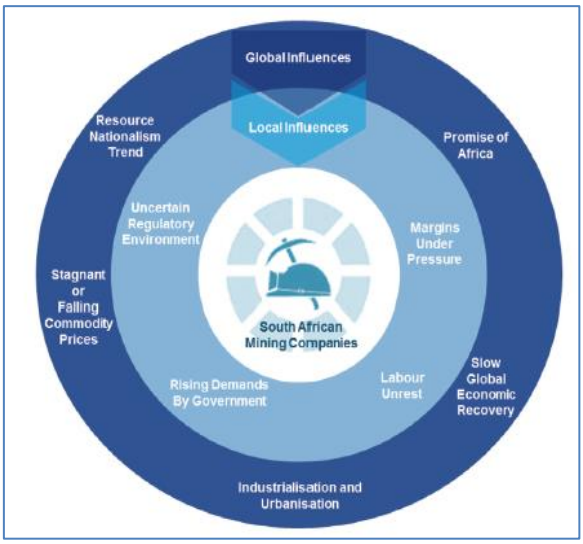
The mining industry has faced unpredictable and volatile commodity prices, which has caused investors to place a higher risk premium on mining stocks (Lane et al., 2015). Despite the current state of weak global economic performance and what is arguably the industry's lowest performance in the past century, stakeholders continue to demand greater value to be delivered by mining organisations across all commodities (Bryant, 2015).

1.2.2 South African Mining Industry

In addition to global pressures, the South African mining operations have faced various local challenges, which have exacerbated the situation when compared to their global mining counterparts (Lane, Guzek and Van Antwerpen, 2015). Figure 1-1 below details the uniqueness of the complex challenges faced by South African mining companies including labour unrest, uncertain regulatory environment, rising demands by the government, low margins and energy reliability issues (Lane et al., 2015).

The South African labour market is characterised by a highly unionised workforce, with labour unions having a large bargaining power as a result of the number of members (Minerals Council South Africa, 2019). The mining sector has an annualised wage negotiation season, which is accustomed with strikes that paralyse the industry through production loses. Accordingly, mining companies tend to settle on above inflation increases in an effort to curb these strikes (Lane et al., 2015). The low margins accrued are the result of high input costs resulting from the high exchange rate along with increases in labour and energy costs, which have risen above the inflation rate and falling global commodity prices.

Figure 1-1: Global and local influences facing the South African Mining Industry (Lane et al., 2015, p. 472)



South African mining companies have experienced ongoing pressure from the government to increase their social commitment for resources to provide for services that are generally part of government's responsibilities, including access to basic services, education and health care for the local mining communities (Lane et al., 2015).

This pressure is further exacerbated by the expectations from local communities to gain access to modern healthcare, and skills development and employment opportunities. These factors have led to higher production costs and job losses, as they negatively impact the business viability of mining operators.

The South African mining industry has been on the decline following the impact of additional pressures faced. These factors have caused increasing pressure for South African mining companies in comparison to their global counterparts (Lane et al., 2015). Evidence of this decline is the shedding of 70 000 jobs between 2012 and 2016 as mining organisations struggled to remain profitable, with major global mining organisations leaving the country as a consequence (Jansen van Vuuren, 2017).

1.3 Problem Background

The global mining industry has been under pressure following weaker economic conditions, volatile commodity prices and a decline in the demand for resources due to China's growth decline (Lane et al., 2015). The industry is expected to increase its profitability despite a weakened global economic environment and what is arguably the industry's lowest performance in the past century (Bryant, 2015). In addition to these global pressures, the South African mining operations are faced with complex local challenges,

which have resulted in greater pressure when compared to global mining counterparts (Lane et al., 2015).

The South African mining industry was said to be a *"sunset industry"* during the annual mining indaba conference that was held in Cape Town in February 2019 (Petersen, 2019). According to Statistics South Africa (2017), the mining industry was reported as being the second largest economic contributor in South Africa in 1980, with a contribution of 21% of Gross Domestic Product (GDP). However, according to the 2018 fact sheet report published by the Minerals Council South Africa, formerly known as the Chamber of Mines, the industry has since slipped to seventh place by contributing only 6.8% in 2017 (Minerals Council South Africa, 2018). The performance decline for the South African mining industry has been due to several factors, including the weak global economic conditions and high production costs resulting from additional local pressures faced by mining operations in the country (Minerals Council South Africa, 2018).

In this regard, the group director for technical and sustainability for Anglo American, a major global mining company, said:

> *"The mining industry urgently needs to get a grip on its challenges and innovation is the key" (Bryant, 2015, p.10).*

This statement infers that global mining organisations are implementing technology solutions and thereby modernising their business to deliver sustainable value for all their stakeholders.

A consensus has been reached which stipulates that South African mining operations require a step-up in implementing technology-driven solutions in order to remain competitive globally. According to the Minerals Council South Africa (2016), the industry has collaborated with the South African government in driving the technology innovation programme titled *"Modernisation: Towards the Mine of Tomorrow".* This programme aims to accelerate the adoption of modernisation in the mining industry to ensure that mining remains a significant contributor to the South African economy.

1.4 Problem Definition

The adoption of technological solutions since the first industrial revolution has brought about economic and social growth. To align with the fourth industrial revolution or Industry 4.0, mining companies have been accelerating the rate of adopting automation across their

value chain. In the near future, the industry will digitise the mining value chain completely to transform mining.

Significant investment is required to achieve modernisation goals set by the mining industry and to deliver on the sustainable return on investment for all stakeholders (Bryant, 2015). This requires that technology solutions be imbedded as part of business operations across the mining value chain. Investors and business in the mining industry argue that the failure to introduce modernisation such as automation will result in sterilisation of resources (Jacobs and Webber-Youngman, 2017).

According to the Minerals Council South Africa (2016), mining companies have spent in excess of R500 million annually over several years on innovation technology. Despite the investment made towards modernisation the industry has seen a decline in margins (Minerals Council South Africa, 2018). This is evidence that investment into modernisation cannot be the only solution and that a gap exists to understand the influencing factors that are necessary for effective adoption of modernisation for mining.

There is therefore a need for this study to identify other key factors that support or inhibit effective adoption of technology in modernising the mining industry in South Africa. These factors can be used by the industry as a guide for effective adoption of technological solutions aimed at modernising mining operations in South Africa and delivering value for all stakeholders.

1.5 Motivation for the Research Study

1.5.1 Theoretical need

Great emphasis has been placed on developing theory for adoption of technology in the field of information systems (Oliveira & Martins, 2010). This is due to the field being the fundamental base for information communication systems, which enabled application of other technologies for all industries. According to Oliveira and Martins (2010), very little literature exists that covers the comparison and application of information technology (IT) adoption models at a firm or organisational level, which supports the need for this research study. The study therefore aims to explore the influencing factors that enable and inhibit effective adoption of technology in the mining industry.

It is important to understand theoretical models that have been proven in order to define the adoption of technology for organisations, specifically those that could be applied to the mining industry. Three dominating theories describe the adoption of technology innovation

for Information Systems (IS) at an organisation level, which are as follows: (1) Diffusion of Innovation (DOI) by Rogers, (1983); (2) the technology-organization-environment (TOE) framework by Tornatzky and Fleischer, 1990; and (3) the Iacovou, Benbasat and Dexter (1995) model. The mining industry has seen some application of these models; for example, the research by Fujiono (2011) provides a framework of an agent-based, diffusion model to determine methods of how innovations can be adopted in the mining industry. None of the academic or business literature found, have described a model identifying the factors influencing the adoption of technology for the mining industry.

This research study aims to address the gap that exists in the field of technology management by adding to the current body of knowledge. The aim is to identify the supporting and inhibiting factors necessary to achieve acceptance of technology solutions for effective adoption of modernisation in the mining industry of South Africa.

1.5.2 Business need

According to a policy paper released by the South African Institute of Race Relations (IRR), the country has unique and large resources including:

> *"having the third largest gold reserves in the world, 80% of the known platinum resources, over 50% of platinum group mineral resources, an unusually high concentration of diamond-iferous kimberlites, and very large reserves of chromium, iron ore, manganese and other industrial metals" (Jeffery, 2018, p. 4).*

According to the Minerals Council South Africa (2016), modernisation of the South African mining industry is expected to save 200 000 jobs, which would impact two million household dependants by the year 2030. This would account for almost three percent of the South African population given the expected population estimate of 65 million by 2030.

The South African mining industry is faced with unique and complex challenges that are different to their global counterparts (Lane, Guzek and Van Antwerpen, 2015). Thus, the industry has formulated mitigation actions which involve modernising operations through the adoption of technology solutions to address the unique challenges faced by the local operators.

According to Bryant (2015), certain mining companies have failed to adopt technology solutions aimed at enabling companies to curb some of the challenges faced by the industry. The consequences for these companies have been severe in that they are either out of business or are struggling with low or negative profit margins, posing enormous investment risk for stakeholders.

Bryant (2015) has argued in support of Stanway et al. (2017) and with the Minerals Council South Africa that global mining companies such as Anglo American, BHB Billiton, Rio Tinto Vale and AngloGold Ashanti have accelerated the adoption of automation technology and modernisation to improve safety and drive down the cost of production. Modernisation of the mining industry has been highlighted as making a significant contribution to solving the challenges faced by the industry and ensuring sustainability (Bryant, 2015). Modernisation has emerged as a critical subject in the mining industry, necessitating stakeholders and especially decision-makers to be committed and have confidence in driving the urgent transformation of the industry to address current challenges faced.

1.6 Research Purpose Statement

This research study aims to address the gap identified in the field of technology management based on the research problem statement. The purpose of the research is to identify the organisational factors that support or inhibit the acceptance of technology solutions for effective adoption of modernisation in the mining industry of South Africa. This will be investigated in line with the following objectives:

- To determine the factors and characteristics that influence the acceptance of technology solutions in the mining industry of South Africa;
- To determine the factors that support the acceptance of technology solutions in the mining industry of South Africa; and
- To determine the factors that inhibit the acceptance of technology solutions in the mining industry of South Africa.

1.7 Scope and delimitation of the research study

A wide scope for research exists within the field of information technology. This study however focuses only on the mining industry due to the existing challenges in the sector and the role that modernisation is believed to play in redressing the downward economic trend and its effects upon the industry. Furthermore, the research is restricted to a selected mining population following the need and drive from the Minerals Council South Africa to promote modernisation for the mining industry (Minerals Council South Africa, 2016).

The scope of the research is adequate for the purpose, and is expected to offer the necessary transferability that is required to guide the mining industry (Shenton, 2004). The study collected data from only four of the eleven commodities produced in South Africa.

Thus, the research study will not attempt to generalise the factors to assume that they cover all the aspects of the industry (Shenton, 2004). The student has chosen to restrict the study to a selected mining population by interviewing fewer than fifteen participants, as recommended for saturation of the results.

The study aims to support the need from the Minerals Council South Africa to promote modernisation in the mining industry (Van Der Woude and MacFarlane, 2016). The student has acquired an endorsement letter from the Minerals Council, which motivates the need for the research in business (see Appendix A). The business need is to understand the factors that influence technology acceptance, and to develop a guide to be used by mining organisations for modernisation of their mining processes.

1.8 Summary of Chapter 1

This chapter provided an overview of the current state of the mining industries and identified the problem that the study is focused on. The overall objective of the study was to explore the organisational factors that support or inhibit the acceptance of technology solutions for effective adoption of modernisation in the mining industry of South Africa. The academic need was identified as the need for a mining-specific adoption model that would serve as a necessary guideline for effective modernisation of one of the fundamental economic-contributing industries in the world.

The following chapter provides the literature review, which focuses on the anchoring academic theories and business practices in IS technology that form a baseline for the research study. Following Chapter 2 is the outline of the research questions in Chapter 3, followed by the design, sampling and methods of the study which is presented in Chapter 4. Thereafter, the findings are presented in Chapter 5 and discussed in Chapter 6. The final chapter of the research study, Chapter 7 presents the conclusions, summaries of the theoretical and business application findings, the study limitations, and recommendations for future research.

Chapter 2: LITERATURE REVIEW

2.1 Introduction

The chapter introduces the relevance of the Fourth Industrial Revolution in addressing the operational challenges faced by mining companies in order to reverse the economic decline in the industry. This chapter also provides an understanding of what modernisation in mining entails and recent global trends in this regard. In addition, the chapter provides an academic context for the technology adoption models developed primarily for the information systems industry and draws conclusions on the relevance of these models for the research study. The chapter also details consolidated relevant theories from different sources on the influencing factors that support and inhibit effective adoption of innovation and technology. The chapter concludes by providing a consolidated review of the literature on the salient influencing factors relevant for the research study.

2.2 Theory related to adoption of modernisation in the mining industry

The mining industry continues to struggle despite a slight recovery of commodity prices and higher production numbers (Bryant, 2015). The evidence of these weak trends is seen in financial indicators; however, despite these trends' investors are still seeking higher profit margins and return on capital. Bryant (2015), Lane et al. (2015), Jacobs and Webber-Youngman (2017), Stanway, Graeme, Mahoney, Paul and Griebel (2017) and a number of other academic scholars are in agreement that the mining industry has seen a consistent increase in operational expenses, decreased productivity and diminishing grades, which have resulted in an increase in stranded assets. Rapid transformation is therefore required to reverse these deteriorating and unsustainable trends for the industry and for the economies that are thereby affected. These factors should not be viewed in isolation, because in order to remain viable mining companies must also maintain safer working environments as part of regulatory requirements.

Modernisation of mining has emerged as an enabler in redressing the decline of this critical industry, as it said to have transformative effects in achieving safer work environments and improved efficiencies and productivity (Mavroudis, 2017). In the same vein, opposing views have been raised by other stakeholders such as organised labour, which articulate concern at the possible loss of employment and replacement of jobs that modernisation will bring (Whiton and Muro, 2019).

2.2.1 Defining and understanding effective adoption

In order to understand effective adoption of technology in the mining industry, it was important to firstly understand the academic definitions on adoption, effectiveness and acceptance. According to Ghazizadeh, Lee and Boyle, (2011) adoption can be defined as an act of taking up ownership of an object or entity. Rogers (1983), on the other hand, provides a definition of adoption of technology as the decision to maximise the use of a technology innovation as the best course of action available. Thus, this study explored and attempted to understand those factors that influence decision-makers to choose, implement and maximise the use of a technology solution as the best course of action.

Enabling factors can be defined as those factors that make it possible for people to accept the technology solutions on offer, thereby supporting the adoption of modernisation. Inhibiting factors are those that constrain the possible acceptance of a technology solution, hence resulting in their rejection. This research study explored the factors that support or inhibit the acceptance of technology solutions and how mining companies are influenced to introduce a new technology solution across their existing value chain process.

Mining companies have key performance indicators (KPI), and one such key KPI's is efficiency. Efficiency improvements can be described as achieving more output with minimum input. This definition of efficiency was used throughout the document and should be noted. Effective use can be defined as the use of an objects or solution to produce the intended application or the transformative practice without any constrained factors (Ng'Ambi, 2013). According to Chaulya, Bandyopadhyay and Mishra (2008), the objective of an effective information systems technology in the mining environment is to improve safety for the mining employee and deliver increased productivity and profitability. Thus, mining companies can expect to benefit from effective technology adoption. Thus, the study sought to explore the factors that influence mining companies to decide on implementing new technology solution and transforming their existing practises to maximise the use of the solution.

2.2.2 Modernisation trends in the mining industry

The fourth industrial revolution also known as Industry 4.0, is characterised by technological advancements in wireless technologies, robotics, quantum computing to analyse big data, 3D printing, artificial intelligence and nanotechnology (Ayentimi and Burgess, 2019). Digital transformation is said to be one of the top ten megatrends expected

to impact the business ecosystem, which comprises business, government, society and culture (Ernst & Young, 2015).

Digital transformation may be described as a component of the fourth industrial (4.0) revolution, this as these concepts are used interchangeably. Ayentimi and Burgess, (2019) agrees with Mavroudis and Pierburg, (2017) in stating that the digital changes brought about by Industry 4.0 result in improvements in collaboration, networking and ground-breaking sensor technology to ensure improved smart controls. The adoption of these technological solutions is said to bring about economic and social growth and is relevant to developing economies, including the majority of economies in the African continent (Ayentimi and Burgess, 2019).

The mining industry has also experienced a wave of digital transformation with the introduction of automation, cameras, and other emerging technologies (Chaulya, Bandyopadhyay and Mishra, 2008). Thus, modernisation of the mining industry is characterised by implementation of technologies that transforms the way of mining for example autonomous mining having driverless machinery (Bryant, 2015). The adoption of these technological solutions is said to bring about economic and social growth and is relevant to developing economies like most economies in the African continent (Ayentimi and Burgess, 2019).

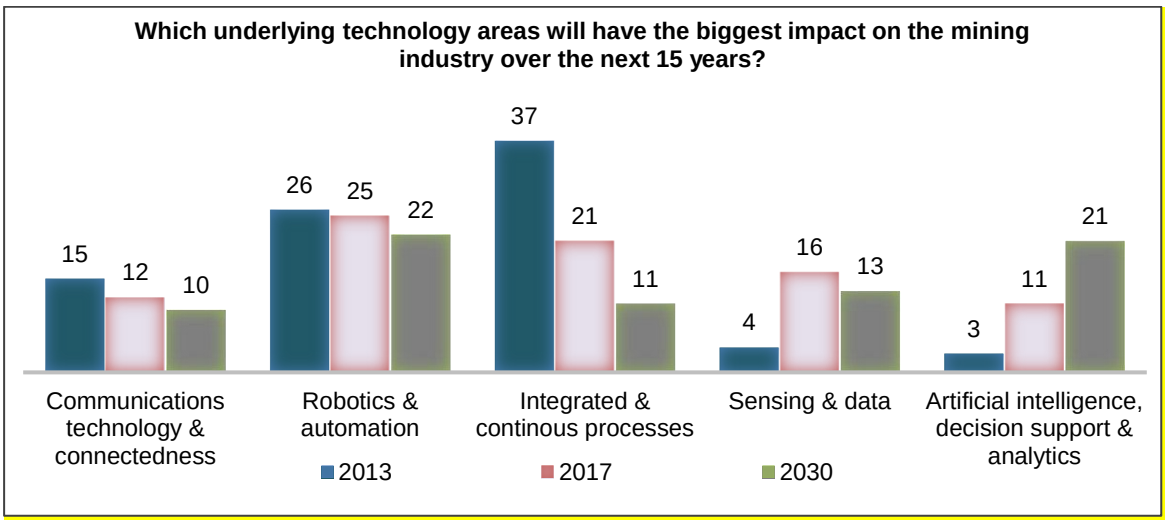
According to Mavroudis (2017), mining companies have been accelerating the rate of adopting automation across their value chain and, in the near future, the industry will digitise the mining value chain completely to transform current manual mining to mining 4.0. Alike to other industries, Mavroudis (2017) highlights the adoption of emerging technological solutions in the mining industry will rapidly increase to provide smart solutions to assist mining companies in addressing the complexity of managing multiple processes across the value chain.

Thus, according to the Minerals Council South Africa modernisation in the mining industry is defined as a process of transitioning and transforming the industry for the future (Minerals Council South Africa, 2016). According to Jacobs and Webber-Youngman (2017), mining modernisation can be defined as an innovative process of implementing and adopting advanced technologies to create value and allow the transition towards a more technologically advanced and modernised industry. Modernisation also incorporates automation of equipment and technology in mining, often referred to as automation of mobile machinery or the installation of sensors and instrumentation for control (Jacobs and Webber-Youngman, 2017).

According to Ghazizadeh, Lee and Boyle (2011), automation can be defined as technology that performs a function or role which was previously performed by a human being. Ghazizadeh et al. (2011), on the other hand, argue that automation technology does not substitute a human being, but rather alters the task performed by a human being, thereby creating more meaningful work. This definition is contrary to the widely-held belief that technology replaces human beings. Before the introduction of artificial intelligence, mechanisation this function was regarded as being repetitive and did not require cognitive abilities. Nevertheless, the adoption of automation technology for mechanisation of mines has been in place for over 150 years (Mavroudis, 2017).

According to the Minerals Council South Africa (2016), the effective adoption of technologies has resulted in safety improvements, increased efficiencies and lower production costs for mining operators. Figure 2-1 below indicates the recent digital trends being adopted by global mining companies, namely: the Internet of Things (IoT), big data, analytics and artificial learning (Stanway, Graeme; Mahoney, Paul; Griebel, 2017). According to Stanway et al. (2017), previous trends have indicated that mining companies have mostly implemented communications technology to enable the use of robotics and automation in support of integrated operations.

Figure 2-1: Global technology trends for the mining industry (Stanway et al., 2017, p. 10)



2.2.3 Case for modernisation in the South African mining industry

Bryant (2015) has argued in support of Stanway et al. (2017) and the Minerals Council South Africa that global mining companies such as Anglo American, BHB Billiton, Rio Tinto Vale and AngloGold Ashanti have accelerated the adoption of automation technology and

modernisation to improve safety and drive down the cost of production. The adoption of technology to modernise mining operations has been highlighted as making a significant contribution to solving the challenges faced by the mining industry and ensuring sustainability (Bryant, 2015).

Jacobs and Webber-Youngman (2017) argue that mining companies that have embraced technology innovation have proved to be successful in reducing their cost of production through improved efficiencies, safer working conditions, and reduced capital and labour requirements. Further, there is consensus between Lane et al. (2015), Bryant (2015) and Jacobs and Webber-Youngman (2017) that most global mining companies have endeavoured since the early 2000s to optimise their operations in order to decrease production costs and increase their profit margins, and that such a change is required by South African mining operations to remain competitive globally.

The South African mining companies are faced with unique complexities that need to be managed in order to continue producing quality raw materials and remain profitable, in addition to global pressures being faced by the mining industry. According to Lane et al. (2015), these unique complex challenges are: 1) high levels of labour unrest, 2) uncertain regulatory environment, 3) rising demands by the government and 4) low profit margins. These factors have led to higher production costs, job losses and premature mine closures, as they negatively impact the business viability of mining operations in South Africa. Thus, it is necessary that a tailored solution be investigated to support the mining companies in ensuring that they remain competitive and a significant contributor for the economy of South Africa.

According to the Minerals Council South Africa (2016), significant efforts have been committed into adopting a modernisation strategy that is based on global research which indicates that adoption of technology has lessened the decline of the industry in other parts of the world. Mining companies need to change from using historical mining methods, as failure to adopt new technological methods will result in failure to extract deep-level complex ore bodies economically in South African mines (Minerals Council South Africa, 2016). According to research studies conducted in this regard, this failure to extract deep-level minerals will lead to 200,000 job losses by 2030, indirectly impacting two million individuals as a result (Minerals Council South Africa, 2016). Given the expected population estimate of 65 million in South Africa by 2030, this would account for almost three percent of the population who would be negatively impacted by the lack of economic growth (Statistics South Africa, 2018).

Thus, the strategy for South African mining companies to adopt modernisation as an enabler to addressing challenges faced is aligned with the recommendations for competing strategies by Strickland III, Thompson and Gamble (2008), who argue that there are three main growth strategies for mature and declining industries such as South Africa mining to enable them to compete with their peers. These are outlined as follows: 1) Implementing a strategy for rapid growth in order to outgrow competitors, with the objective to become dominant; 2) Differentiation through innovation; and 3) Striving to lower costs to become the lowest cost producer (Strickland III, Thompson and Gamble, 2008). Accordingly, the adoption of innovative technology solutions was identified as a common strategy for most of the mining companies in South Africa to enable them to be competitive.

According to Lane et al. (2015), mining companies globally are under pressure through facing difficult economic conditions, suppressed commodity prices and higher input costs, including additional factors faced by South African mining companies. This has led to reduced capital expenditure for these organisations, which has resulted in the mining companies being cautious regarding any investment funding (Ernst & Young, 2015).

The Minerals Council South Africa (2016) has reported that mining companies have spent in excess of R500 million annually over several years on innovation technology. Despite the investment made towards modernisation, the industry still saw a decline in margins over this period. This is evidence that investment into modernisation cannot be the only solution and that a gap exists in understanding the influencing factors that are necessary for effective adoption of modernisation for mining, hence the need for this study to identify other key factors that support or inhibit effective adoption of technology in modernising the mining industry in South Africa.

The Minerals Council South Africa (2016) in collaboration with the South African government has initiated a study programme titled “Modernisation: Towards the Mine of Tomorrow”. This programme is aimed at modernising the South African mining industry to achieve the following strategic objectives: 1) achieve zero harm for people and the environment, 2) sustainable investment in longer-term resources and 3) create jobs for the South African economy (Minerals Council South Africa, 2016). Specific focus on technology has been applied for the fast-tracking of exploration and for maximising resource utilisation (Minerals Council South Africa, 2016).

According to the modernisation fact sheet by the Minerals Council South Africa (2016), modernisation of the industry includes the following four areas:

a) Capitalise South Africa's minerals resources and maintain the extraction of the deep complex resources in a safe, efficient, economically viable and sustainable manner.
b) Mining in a sustainable way to ensure conservation of natural resources, maintain the environment and acknowledge the valuable resources and their application in the economy.
c) People-centred technology with key focus on skills development, improved health, quality of life and accomplishment of employees.
d) Development of local communities, the growth of the mining industry and the transformation agenda for mining and for South Africa.

2.3 Previous cases of modernisation in mining

It is important to detail the extend of modernisation for the global mining industry and to include the modernisation landscape for mining, South Africa. This following contradictory statements between some authors on the extent of technology adoption in the industry. Bryant (2015), Chaulya, Bandyopadhyay and Mishra (2008), Jacobs and Webber-Youngman (2017), argues that the mining industry has lagged behind other industries and that they are now accepting technologies with the aim of improving safety, productivity and cost-effectiveness. While authors like Mavroudis and Pierburg, (2017), mentioned that the industry is tracking along with other industries and is on a journey to achieving mining 4.0. The following cases have been identified where mining companies have implemented technology as part of their value chain processes as part of their modernisation drive.

i. Rio Tinto, which in an Australian based global company with a footprint in six continents (Rio Tinto, 2019). The company has been reported to be the most noticeable example of mining modernisation particularly at their mining operations in Australia (Bryant, 2015). The company mentions having pioneered automation for the mining industry and regard themselves as being early adopters, with having 130 Autonomous driverless Haul Trucks, Trains including state of art control centre (Rio Tinto, 2019). This definition of being early adopters aligns with Rogers, (1983) diffusion theory where the decision makers are classified.

ii. Bryant (2015) also refers to BHP Billion, Vale, Anglo American, and Anglo Gold Ashanti as being early and late majority adopted of technology into the mining industry.

iii. According to Mavroudis (2017), there has been successful cases of automation in the underground coal mining industry with the article titled “Highly automated systems for underground mining”. In this article Mavroudis (2017),mentions that the automation of an underground equipment has been effective.

iv. South African mining companies like Exxaro, Anglo American Business unit operations like Kumba Iron Ore, Anglo Platinum have also reported having adopting technology motivated by the same benefits as the rest of the industry (Stanway, Graeme; Mahoney, Paul; Griebel, 2017) .

2.4 Technology Adoption-Based Theories

Adoption theories for information technology have been widely developed for information systems (IS) technology since the 1980s, following the association of information technology development with the use of computers and the economic development of a society (Oliveira and Martins, 2010). It is important to understand and discuss the fundamental elements underpinning these adoption models, following the argument by Mavroudis and Pierburg (2017) that IS infrastructure is a requirement to enable automation and other technology innovations in mining. Thus, this research aimed to understand the existing parallels of companies which needed to adopt the use of a computer system to enhance productivity and to incorporate it as part of everyday business with modernisation in the mining industry.

According to Oliveira and Martins (2010), there are several widely-accepted fundamental research theories that underpin the adoption of technology predominately in the IS field, as detailed in Table 2-1.

Table 2-1: Extensively-used Technology adoption-based theories

Technology Adoption Model	**Author, date**	**Overview on the theory and application of IT**	**Recent applications**
Technology acceptance model (TAM)	Davis (1985)	• TAM theory was developed to understand the systems characteristics for how individuals accept and use computer-based information systems technology. • The theory suggests that individuals are motivated by perceived	TAM was used to understand the adoption of driverless car technology (Koul & Eydgahi, 2018).

		usefulness (PU), perceived ease of use (PEOU), and anticipated future usage of the technology (Davis, 1985).	
Unified theory of acceptance and use of technology (UTAUT)	Venkatesh (2003)	• The theory aims to describe how an individual is influenced by their intention and behaviour to adopt information system technology (Venkatesh, Thong & Xu, 2016). • The theory attributes the reasons for the behaviour to four key concepts: 1) performance expectancy, 2) effort expectancy, 3) social influence, and 4) facilitating conditions (Venkatesh, Thong & Xu, 2016).	Applied in the medical field to analyse factors influencing healthcare professionals in a tertiary hospital environment (Kim et al., 2016).
Diffusion of innovation (DOI)	Rogers (1983)	• The theory describes the varying degree of inclination that influence the willingness to adopt new technological innovations by individuals in an organisation (Rogers, 1983).	The Diffusion of Innovation in the Mining Industry: Agent-Based Modelling and Simulation (Fujiono, 2011)
TOE framework	Tornatzky and Fleischer, (1990)	• The technology-organisation-environment (TOE) framework describes the process followed by organisations in adopting technology innovations and uses the context from three elements, namely technology, organisation and the environment.	Applying theory of diffusion of innovations to evaluate technology acceptance and sustainability (Aizstrauta, Ginters and Eroles, 2015)
Iacovou et al. (1995) model	Iacovou, Benbasat and Dexter (1995)	• Iacovou et al, model describes the characteristics that influence firms to adopt information technology innovations	Electronic Data Interchange and Small Businesses: Adoption and Impact of Technology (Iacovou, Benbasat and Dexter, 1995)

Following the literature review, which involved understanding the appropriateness of the list of adoption models in the table above, this study will focus on three core theories prominently used to describe the adoption of technologies and innovation in organisations. The following adoption theories were used in the research study to understand the fundamentals on adoption of technology in an organisation; 1. Diffusion of Innovation

(DIO), 2. Technology-organisation- environment framework (TOE) and 3. Iacovou et al. (1995) model.

2.4.1 Diffusion based theories

According to Rogers (1983), diffusion is a process of introducing a new innovation or technological solution through communication with participants within a defined social system using various channels of communication. Diffusion theory aim to define why, how and at what rate innovation or a technology-based solution is adopted by individuals in an organisational (Fujiono, 2011). This theory is relevant for this research study to understand the key diffusion elements for technology innovation and explore if these factors can be transferred to the mining industry.

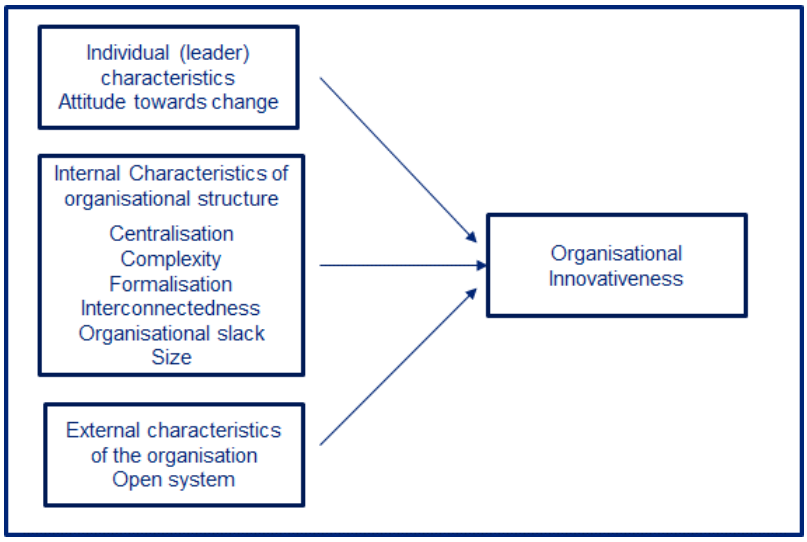
Diffusion of innovation theory describes the varying degrees of inclination that influence the willingness to adopt new technological innovations by individuals who are leaders in an organisation (Rogers, 1983). An inherent individual characteristic exists that influences leaders and individuals' responses to their receptiveness towards accepting an innovation (Rogers, 1983). According to Rogers, (1983) opinion leadership is one of the key elements required for diffusion of innovation. Opinion leadership can be described as the extent to which an individual can influence other's attitudes or behaviour informally, as anticipated regularly. Thus, it was important to understand the role of individual leaders in diffusion of technology in mining and what mechanism was being applied.

The role of leadership was also confirmed as one of the eight critical components necessary for strategy execution (Thompson et al., 2008). In their article, Thompson et al. (2008) assert the need for organisations to fill executive and senior management positions with smart individuals who have appropriate skills and attitudes and are "adaptable thinkers, able to solve complex problems". According to Rogers (1983), the individual innovation leaders can be classified into five categories, namely: innovators, early adopters, early majority, late majority and laggards. This classification can be used to identify the receptiveness of different mining organisations to adopting technology innovation.

Modernisation of the mining value chain is a strategy that needs to comprise an appropriate roadmap that can be executed successfully (Jacobs & Webber-Youngman, 2017). Thus, it was important understand how these lessons can be incorporated from strategy execution literature and business application into mining modernisation, mainly around the role played by executive leadership in ensuring effective execution of strategy.

According to Rodgers (1983), organisational characteristics are informed by a group of individuals. Oliveira and Martins (2010) provide a summary diagram of the critical elements necessary for the diffusion theory. Figure 2-2 shows the association between individuals, how the individuals are influenced by the internal characteristics of the organisation and how the organisation is influenced by the external characteristics in an open system.

Figure 2-2: Characteristics of Diffusion of Innovations ((Oliveira and Martins, 2010, p. 111)



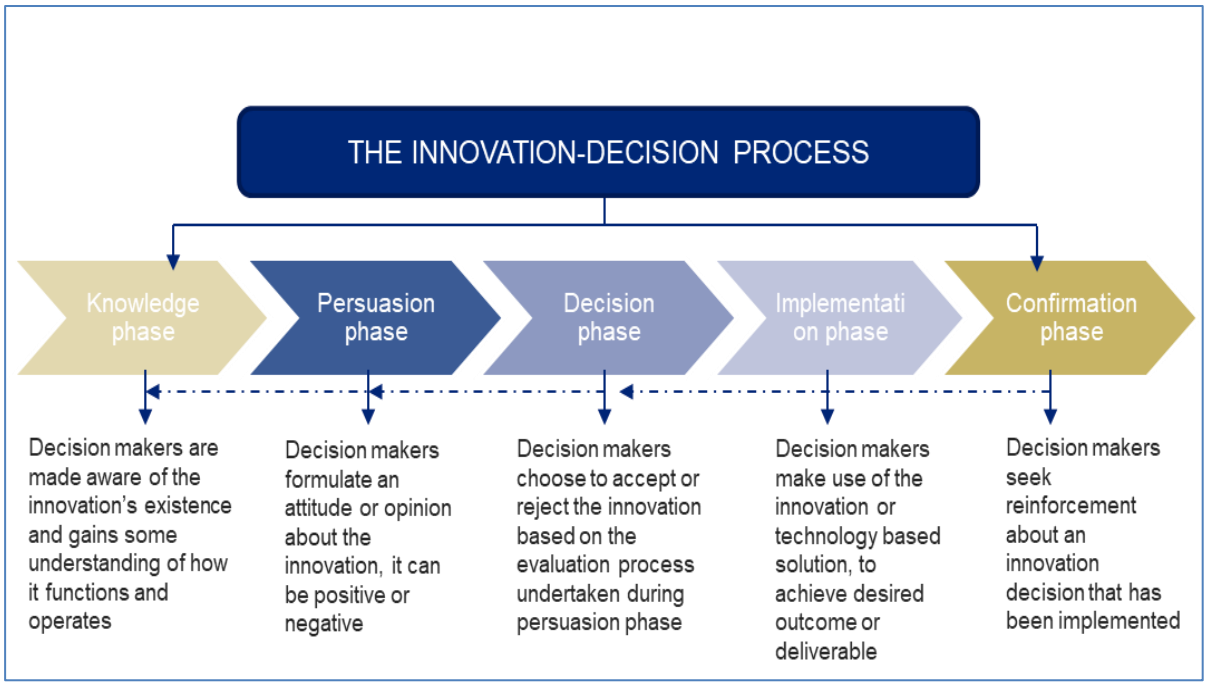
One of the critical process elements for DOI is in decision-making and that it requires communication. Rogers (1983) defines communication as a process that involves participants creating and sharing information with each other to reach a mutual understanding. According to Rogers (1983), the innovation-decision process may lead decision-makers to adopt the technology innovation, which is also defined as making complete use of the technology innovation.

The innovation decision has been defined as a five-step process which involves decision-makers firstly obtaining the knowledge about the innovation technology and establishing attitudes toward deciding to adopt or rejecting the innovation, followed by implementation and, lastly, confirmation of the decision. The innovation decision process stages are shown in Figure 2-3.

The knowledge stage is an awareness process where the decision-makers are made aware or seek information regarding the technological innovation, to reduce uncertainty about the cause-effect of the about how it functions and the appropriateness to solve the existing challenge (Rogers, 1983, p. 21). During persuasion the decision-makers are

seeking to understand the advantages and disadvantages to understand the risk and associated consequences of adopting the innovation using a process of evaluation.

Figure 2-3: Innovation-Decision process (Rogers, 1983, p. 21)



The decision process involves making a choice to adopt, reject, or return to the persuasion or knowledge stage to re-evaluate the innovation for further course of action. The decision to further evaluate the technology can be as a result of a lack of information required to understand the risk associated with the innovation.

The decision-making process is a critical stage and requires time. Accordingly, it is defined by Rogers (1983, p.21) as *"the length of time required to pass through the innovation-decision process".* It is recommended that sufficient time be allocated to stakeholders to consume information regarding the innovation technology in order to enable them to make an opinion prior to the decision-making phase. Implementation is a process that involves the actual application of the innovation to achieve the desired goal or objective. Confirmation is the final stage of the innovation-decision process, which involves reinforcement of an innovation decision that has been implemented. The decision-makers may reverse the decision made if there are contradictory messages that the desired deliverable has not been achieved. This research sought to explore how decisions regarding innovation takes place in mining and if elements of the innovation- decision process can be applied in the mining industry.

2.4.2 Technology-organisation-environment (TOE) framework

The technology-organisation-environment (TOE) framework was developed to identify three aspects of an enterprise's context that influence the process by which it adopts and implements a technological innovation, namely: technological context, organisational context and environmental context (Oliveira & Martins, 2010). It is important to understand the different contexts and how they influence technology adoption.

According to Oliveira and Martins (2010) technology context is described as technologies that are relevant to the organisation which can be found internally within the organisation and those that external to the organisation. Technology can be referred to as equipment ,processes and information systems (Aizstrauta, Ginters and Eroles, 2015) The technology context can be applied to the mining industry this as mining companies such as Rio Tinto mentioned being leaders in terms of technology in mining and having to develop technology internally but also adopting technologies from suppliers (Rio Tinto, 2019).

According to Oliveira and Martins (2010), the context of the organisation refers to measures that describe the organisation such as the formal and informal process, structures, communication processes , size etc. These elements may differ for mining organisations depending on the product produced, the history and background of the mining company, how long the company has been in existence; all of these descriptive factors will ultimately influence technology adoption.

Environmental context describes the context in which an organisation operates in, this includes for example market structure, technology support, infrastructure and government regulation. The environmental context for the mining industry was described in detail in chapter 1, with the objective to provide the current context in which the mining industry operates in. The theory of TOE is relevant to the mining industry as all the context elements could be described for mining, in order to understand the how these elements influence technology adoption.

2.4.3 Characteristics influencing organisations to adopt technology innovation

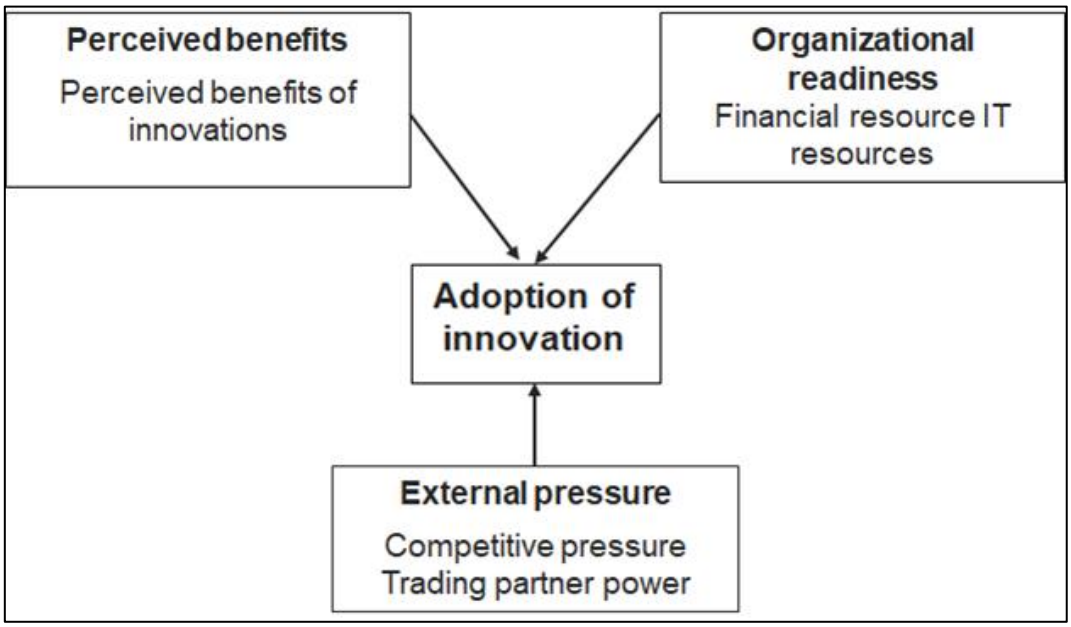
Iacovou, Benbasat and Dexter (1995) describe the characteristics that influence firms to adopt information technology innovations. According to Iacovou et al. (1995), there are three main circumstances that influence organisations in adopting information technology innovation, and these are as follows:

1) the derived or perceived benefits that the company wishes to achieve, 2) the organisational readiness and 3) pressures that are external to the organisation. These three elements influence the decisions made by organisations and Figure 2-4 shows the association of the three elements

With regard to the perceived benefits, these can be described as the value drivers that influence company decisions to invest resources in order to achieve the desired goals. The perceived benefit for South African mining companies is that they remain competitive globally when compared to their global mining counterparts, while the benefit for the Minerals Council South Africa is for mining to remain a significant contributor to the economy of South Africa. According to Ernst and Young (2015), the mining industry requires transformation and a set of value drivers needs to be defined as part of the transformation strategy.

The model refers to organisational readiness being one of the elements, it refers to the infrastructure and funding allocated specifically for technology adoption. Similarly, this factor can be related to capital funding and information's systems backbone required to enable technology adoption for the mining industry. The last elements relate to the external pressures that organisations are faced with, which refers to the competitive pressure. For South African mining companies relates to the global and local pressures that were outlined by Lane, et.al.(2015) in Chapter 1.

Figure 2-4: Iacovou, Benbasat and Dexter model (Oliveira et.al, 2011,p.117)



2.4.4 Relevance of the adoption theories for the research study

Mavroudis and Pierburg (2017) argue that information systems form the basis for implementation of any technology solution as communications is an enabler and a requirement for all the mining technology themes outlined in Figure 2-1 above. The adoption models discussed in sections 2.3.1 to 2.3.3 discussed specific elements or characteristics that are important for adoption of technology innovation, specifically for the Information Systems (IS) industry.

The following factors can be concluded to be the same from all three adoption models and these are;

- Organisational factors – Infrastructure, Financial resources,
- External factors

2.5 Relevant business literature detailing the factors that influence the adoption of technology

There is consensus among most authors, including Bryant (2015) and Mavroudis and Pierburg (2017) that the mining industry needs to transform into a new digital era to accelerate the adoption of digital technology in order to improve working conditions through unmanned operations, including the use of artificial intelligence for enhanced control measures and prediction. The digital era will assist with understanding and managing complex operations to improve productivity and efficiencies to produce sustainable mining for the benefit of all stakeholders.

Mavroudis and Pierburg (2017) argue that mining companies are focusing mainly on making operational investments to adhere to regulatory requirements by creating safer working environments, improving efficiencies and reducing costs, thereby resulting in improved profitability.

According to Ernst and Young (2015), mining executives and board members have come to realise that the erosion of resource utilisation together with lower efficiencies and productivity have resulted in higher production costs. This was brought about by the drive for higher production output during the commodity boom cycle. There is consensus among most authors, including Ernst and Young (2015) and Mavroudis and Pierburg (2017) that the majority of companies are focused on technology solutions that would assist them to redress the productivity and efficiency losses, which have eroded over recent years as a result of chasing tonnages due to the boom in the commodity market.

According to Bryant (2015), the adoption of technology innovation has historically been hampered by several factors, namely:

- ✓ Lack of investment due to mining companies driving cost savings;
- ✓ Lack of innovation by original equipment manufacturers (OEM), supported by corporate purchasing from the industry and low research and development spending; which can be related to technology readiness. Technology readiness level has been defined by Jacobs and Webber-Youngman (2017) as the maturity level of an innovation which is associated with the risk of adopting the technology component integration into a system application. Mining companies are said to avoid low readiness level technology as it
- ✓ Inability of mining organisation to set prices, conforming to being price takers;
- ✓ Incorporating the technology innovation as part of strategic business planning and execution; and
- ✓ Failure of managers and executives to understand the benefits of modern technology and innovation.

2.5.1 Leadership support necessary for adoption of modernisation

According to Rogers (1983) the role of leadership is important in raising awareness and in influencing others to accept technology innovation. Thus, it was important to explore the details around the role of leadership and gain an understanding of what type of leader attributes are required to drive acceptance of technology solutions.

The role of leadership is mentioned as one of the eight critical components necessary for strategy execution (Thompson et al., 2008). These researchers emphasise the need for organisations to fill executive and senior management positions with smart individuals with appropriate skills who are adaptable thinkers capable of solving complex problems (Thompson et al., 2008). Modernisation of the mining value chain is a strategy that needs to comprise of an appropriate roadmap that can be executed successfully (Jacobs & Webber-Youngman, 2017). Thus, the mining industry can take learnings from literature on strategy implementation and its business application, particularly around the role that executive leadership plays in ensuring effective execution of strategy.

According to Thompson et al. (2008), executive members play a critical role in influencing and shaping the organisational culture through communicating direction and promoting the way things are executed. The drive for modernisation across the mining industry should

commence with executives supporting innovation technology by promoting innovation projects and encouraging a culture of innovation across their business.

The mining industry has been adapting to the changing business environment with recent implementation of emerging technologies brought about by Industry 4.0 (Mavroudis & Pierburg, 2017). This can be said to be influenced by the decision taken by mining executives to be agile and react dynamically to the changes in business associated with Industry 4.0. According to Hinson and Osborne (2014), adaptive leaders are required to have a paradigm mind-shift which includes learning to deal with emergence in an unpredictable system, influencing instead of being directive, driving interconnection and having an integrative approach. It is therefore important for mining leaders to display these skills in order to lead mining into a new age.

The South African mining industry can be referred to as existing in a system that comprises several components including the mining processes, stakeholders (which includes employees), shareholders, communities, technology suppliers, government and the global mining industry. According to Senge, Hamilton and Kania (2015), system leaders need to possess core capabilities such as the ability to see the larger system, to connect and influence through building relationships, and the ability to embrace and manage diversity (Senge, Hamilton & Kania, 2015).

2.5.2 Digital skills necessary for modernisation in mining

There is a need for mining companies to establish digital capability to address the emerging changes in the market, as has been argued by Sirinanda (2019) in an article titled “Skills needed for digital mines”. This article recommends for mining companies to acquire professional capabilities in technology in order to understand the integration of technology innovations into the mining value chain. These include understanding digital strategy, analytics, software development, optimisation and innovation. This is widely observed by companies having to become agile and adapt to emerging changes in the business environment by acquiring dynamic capabilities.

According to Harreld, O’Reilly and Tushman (2007), recent findings have shown the need for organisations to transform from having core competencies to having dynamic capabilities instead in order to address the rapidly changing environments. This research study sought to understand what were the core competencies and skills required by mining organisations in adopting technology solutions into their existing operations, while

managing the external and internal pressures that they face operating in a volatile economic environment?

2.5.3 Change management process

According to Koul and Eydgahi (2018), technological change influences social and behavioural changes. Ghazizadeh et al. (2011) argue that effective automation technology cannot be effective unless the users have socially accepted and adopted the technology solution.

According to Ghazizadeh et al. (2011), there are behavioural factors that influence this acceptance, namely: trust in the reliance of the technology to perform according to the desired specifications, self-confidence, individual workload, and risk and consequences if the desired outcome is not achieved. This concept of changing behaviour based on perceived value related can be related to innovation- decision process by Rogers (1983) which refers to how the individual decision makers formulate a perception based on how the technology will benefit them. This concept of perceived value which was highlighted by Iacovou, et.al (1995), contributes to individuals decision making process of rejecting or accepting the technology solution

2.5.4 Enablers of modernisation in the mining industry?

Enablers were described as having to support technology acceptance.

The Minerals Council South Africa (2016) outlined key enabling factors for modernisation to be as follows: 1. Research and development, 2. Mining manufacture and 3. Sustainability issues. A collaborative effort needs to be established between key government departments, research institutions, universities and equipment manufacturers to facilitate research and development for the development of appropriate technology solutions. Massive investment is required for the development of specific technology solutions for application in deep, hard rock mining (Minerals Council South Africa, 2016). The Minerals Council South Africa is also facilitating the development of local mining manufacturing to aid the readiness and availability of technology solutions. The last enabler, being the sustainability impact of future mining activities, is to include skills development for local communities.

2.5.5 The influence of environmental changes and how they influence mining modernisation

Bryant (2015) highlights that the current environmental practises are a major concern given the growing hype around global climate change and the pressure on governments to change policies to curb these changes. The awareness of climate change has increased with communities in an around mining areas holding mining organisations to account on their mining methods that are impacting local water sources, their carbon footprint and environmental footprint, and observing that this is unacceptable.

2.6 Conclusions

This chapter can was concluded with understanding the adoption models, the similarities of the elements from the three organisational models. The next chapter details the research question and outlines the sub-questions that were formulated to explore the factors that influence technology acceptance in mining following the literature gathered.

Chapter 3: RESEARCH QUESTIONS

The research aims to explore the influencing factors that enable and inhibit acceptance of technology-based solutions in the modernisation of the mining value chain, specifically in South Africa. The research aims to contribute to the body of knowledge in the field of technology management by exploring and proposing an adoption theory applicable for modernisation in the mining industry, limited to South Africa. Great emphasis has been placed in developing theory specifically applicable to information systems (IS) for adoption of technology (Oliveira & Martins, 2010). The research aims to answer the principal question, which is detailed as follows:

Principal Research Question: What are the organisational factors that support or inhibit the acceptance of technology solutions for effective adoption of modernisation in the mining industry of South Africa?

To explore and understand these factors, the principal research question has been further divided into three sub-questions. These questions have been derived from the following reviewed literature:

- Diffusion based theories, (Rogers, 1983), (Fujiono, 2011)
- Characteristics that influence firms to adopt information technology innovations (Iacovou, et,al, 1995)
- The Case for Innovation in the Mining Industry (Bryant, 2015)

Sub-Question 01: Research Question 01: What are the factors and characteristics that influence the acceptance of technology solutions in the mining industry, limited to South Africa? This question aims to understand the factors and processes that influences mining companies to commit towards implementing and adopting technology solutions across the mining value chain?

Sub-Question 02: What are the factors that support the acceptance of technology solutions in the mining industry, limited to South Africa? The objective of this question is to explore the system in which South African mining companies operate in and to understand the factors that influences effective adoption of technology-based solutions across the mining operations.

Sub-Question 03: What are the factors that inhibit the acceptance of technology solutions in the mining industry, limited to South Africa?

Chapter 4: RESEARCH METHODOLOGY

4.1 Introduction

This chapter aims to detail the research methodology and design that was followed to investigate the research questions presented in chapter 3. These research questions were designed to explore factors that enable and inhibit technology adoption in the mining industry of South Africa. Creswell (2003) argues that when a research focuses on the 'what' question, alike to this current research, it is recommended that it be conducted as an exploratory research due to the flexibility this provides and its ability to acquire in-depth answers on the research question posed.

This research followed an exploratory study that focused on a discovery approach, which included determining the influencing factors found in literature pertaining to the research, collecting data from participants and inferring a model based on the research findings (Saunders and Lewis, 2018). According to Soiferman (2010), this approach supports the qualitative research method, which is considered to be a rigorous method for exploring the relevant research factors in depth. According to Saunders and Lewis (2018), the objective of an exploratory research is to pursue new insights and assess topics from a new perspective. An inductive exploratory approach was selected as no specific framework was evident in the literature to test against the acceptance of technology solutions in the mining industry.

4.2 Research Philosophy

According to Saunders and Lewis (2018), the interpretivism philosophy is concerned with in-depth understanding of organisational complexity, social behaviours and the role of human beings as social actors. The student has selected an interpretivist philosophy as the research aims to understand the complexity associated with adoption of appropriate technology solutions in an existing mining value chain process. This philosophy enabled the student to engage in-depth dialogue with the targeted population to understand their perceptions and behaviours given their experience in the subject (Creswell, Hanson, Clark Plano & Morales, 2007).

4.3 Research Approach

Creswell et al. (2007) explained the three common research approaches employed in business studies as qualitative, quantitative and mixed research approaches. A qualitative

research approach was selected as the preferred approach for this study as there is limited literature in the field of technology management for the adoption of technology, specifically in the mining industry of South Africa. According to Oliveira and Martins (2010), there are several renowned adoption models relating to Information Systems (IS), however, none of these have been adopted by the mining industry.

A qualitative study method was employed to expand the body of knowledge by understanding and uncovering deeper meaning from the data collated during the interviews, which was enhanced by the data analysis (Willig, 2017).

4.4 Research Design and Strategy

According to Saunders and Lewis (2018), there are three common research designs for a qualitative research study, namely: exploratory, descriptive and explanatory. The research design of this study aims to facilitate exploration of the factors that enable or inhibit the phenomenon of accepting technology innovation solutions for the mining environment, limited to the South African context.

The study took direction from Yin (2009) to employ the case study research strategy, which assisted in building in-depth and contextual understanding of the case in question using multiple sources of evidence. According to Baxter and Jack (2008), the collective case study strategy is intended for gaining insight and understanding of a situation or phenomenon, when more than one case is being examined (Baxter & Jack, 2008). The results from a collective case study are robust and reliable (Baxter & Jack, 2008). This research study used a collective case study strategy and aligned with the need of identifying key enablers and inhibitors of a mining environment that are necessary for effective technology adoption in the South African mining industry.

This strategy also involves a detailed description of the case or multiple cases within a specific contextual environment (Yin, 2009). Baxter and Jack (2008) agree with Yin (2009) in arguing that a qualitative case study strategy provides tools for researchers to study complex phenomena within their contextual environment. The South African mining industry produces several commodities, which presents multiple cases in the mining environment. This study described a case as a mining commodity having several organisations that have implemented technology solutions across their value chain process. A case represents a group of mining organisations operating in the same commodity field such as coal, platinum and diamonds. The assumption made is that

organisations within a single commodity cluster have a similar process value chain and will require similar technology innovations for addressing their challenges.

The study acquired access to four of the eleven commodity clusters from which data was gathered by conducting semi-structured interviews. The data gathered from four cases was used to provide context on the factors influencing adoption of modernisation for the different commodities. The collective case study enabled the researcher to analyse each case setting and understand the challenges given the operating environment and subsequently analyse the similarities and differences that exists across the four commodity clusters. The researcher also collected data from industry experts, which were used to validate the data from the different commodities.

4.5 Time horizon

A cross-sectional time horizon was selected for this research study to satisfy the prescribed timeframe given by the university research programme. The limitations of a cross section time horizon is that the data collected will provide a reflection of a specific setting, time and occurrence, which cannot be extrapolated over a longer period (Saunders and Lewis, 2018).

4.6 Population

The complete population for this study comprised all the mining organisations in South Africa that have implemented or are in the process of considering technology solutions for at least a single piece of equipment. It was not practically plausible however to sample the entire population, as this refers to the entire mining industry.

The study selected four of the eleven commodity clusters for the purposes of collecting data. The commodities selected were diamond, coal, iron ore and platinum. The criteria used in selecting the mining operations was that they needed to have implemented or be in the process of considering a technology or any modernisation concept for at least one piece of equipment in their value chain.

4.7 Unit of analysis

The unit of analysis answered the question of who or what was being analysed. According to Creswell et al. (2007), the unit of analysis in a qualitative study may range from being an individual, which is the smallest unit of analysis, to an entire community, which is the largest unit of analysis.

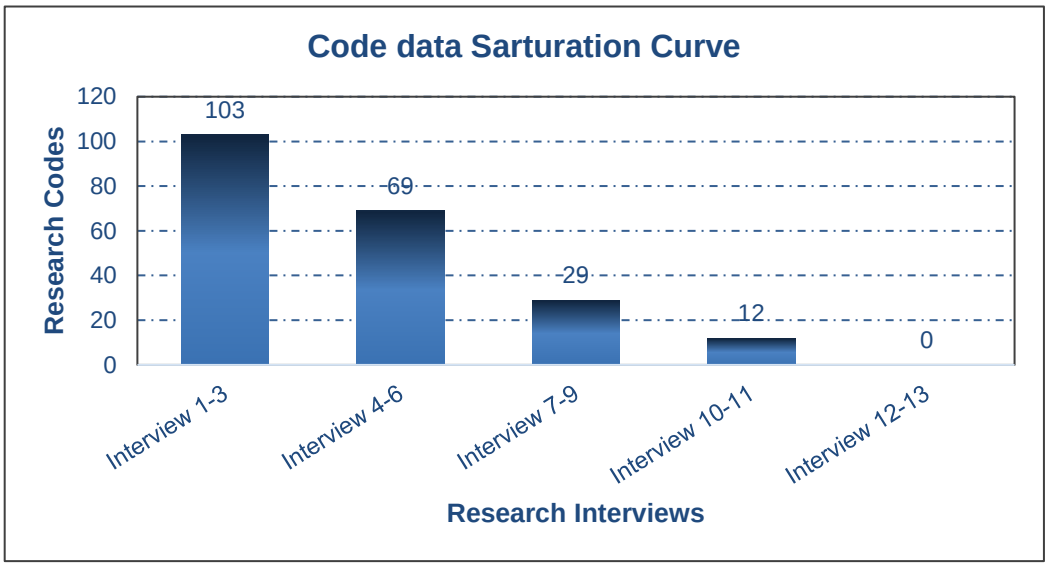
For the purpose of this research, the unit of analysis selected was the decision-makers in the mining industry in South Africa, who may be defined as the executives, senior managers and senior operational managers who are directly involved with introducing technology innovative solutions to their business. Their main responsibility includes incorporating the technological solutions as part of their value chain. The selected population was believed to be best suited to answer the questions tabled in the interview guide in Appendix B to enable the study to answer the research questions in Chapter 3.

4.8 Sample size and Data Saturation

Saunders, Lewis and Thornhill suggest that the sample design should comprise between five and 25 participants for semi-structured interviews. The sample size for this research study amounted to thirteen, following saturation. This number was within the range of the recommended sample size by Guest, Bunce and Johnson (2006) and other papers suggesting that twelve interviews should be adequate for a qualitative study to reach saturation.

According to Guest et al. (2006), saturation can be regarded as the critical guiding principle to determine sample sizes in qualitative research and is achieved when no new codes are identified during the coding process. The empirical data obtained from the 13 interviews resulted in 213 initial codes, 21 categories and six themes. Figure 4-1 below shows that the data saturation for the study was achieved from the empirical data after eleven interviews, as the codes and, by extension, the themes were beginning to diminish with no new themes created from interviews twelve and thirteen. This was indicative of code saturation, as proposed by Guest, Bunce and Johnson (2006), which meant that no further data was required as no new discoveries were expected.

Figure 4-1: Code Saturation curve



4.9 Data collection techniques and procedures

The study made use of a data collection instrument in the form of an interview guide with five main questions with two to three sub-questions, which were derived from the literature in Chapter 2. According to Sanders and Lewis (2018), the interview guide should be constructed to include questions that are aligned to and which answer the research questions, as outlined in Chapter 3. The instrument questions were guided by the literature review, which justified the development of these questions with an objective to answer the research questions outlined in Chapter 3. The interview guide focused on exploring and understanding how various factors, including the allocation of investment funding, readiness of technology-based solutions, executive support and behavioural change influence the acceptance of these innovative solutions across the mining value chain. To ensure reliability and consistency, the same interview guide and questions was applied during all interviews held.

The research used semi-structured interviews to collect the data from the selected population. Face-to-face and video call interviews were used to collect data in order to understand the social constructs, perceptions and behaviours of the population, given their experience in the subject (Creswell et al., 2007). This technique supports the qualitative method in gaining rich, quality data that would be used to answer the research questions outlined in Chapter 3.

The participants were sent an email using the Google student calendar account. The email contained a background paragraph about the research in order to provide context, along

with a consent letter for the participants to read through in their own time to understand the anonymity commitment and, if satisfied, to complete before the interview could be conducted. The interview questions were also sent beforehand to the respondents for their perusal and to clarify any questions before or during the interview. The interviews were conducted face to face and were recorded verbatim for transcription.

According to Saunders and Lewis (2018), the researcher is advised to appear presentable for the face-to-face interviews in order to display professionalism. The researcher therefore dressed in formal business wear for all the interviews to appear and act professional with all participants. The research study followed two of the four main guidelines in preparing for the interviews, which according to Saunders and Lewis (2018) are as follows: 1) printing or emailing the interview guide, and 2) making personal contact with the participants at differing times to remind them about the interview and to confirm their availability during the allotted timeslot.

The participants were contacted telephonically to formulate context with them and determine suitable times for the interviews. Once the contact was established with the participants and an agreement was reached on a specified date including preferred available timeslot, the researcher proceeded to schedule interviews with the respondents using the Google student calendar account.

The researcher also conducted a pilot test to evaluate the interview technique and made any necessary changes before commencing with the interviews (Saunders and Lewis, 2018). This was carried out to check the clarity of questions posed and ensure that the questions were not leading the participants, not to allude to a specific way of answering.

The researcher held 10 face-to-face interviews with most of the respondents as they were situated in and around Gauteng, where the researcher is based. The researcher held video conferences with the other three respondents individually, as they were based in other provinces. These included Diamond 2 from the diamond cluster, based in Cape Town, and Platinum 2 and Platinum 4 from the platinum cluster, both based in Limpopo. All thirteen interviews were recorded to collect data for further transcription and coding as part of analysing and understanding the data obtained.

During the interviews, the participants were asked to answer a list of definitive questions outlined in the interview guide (see Appendix B). The identity of all participants was kept anonymous in the report, and all data collected during the interviews was also reported anonymously to avoid breaching the consent agreement with the study participants.

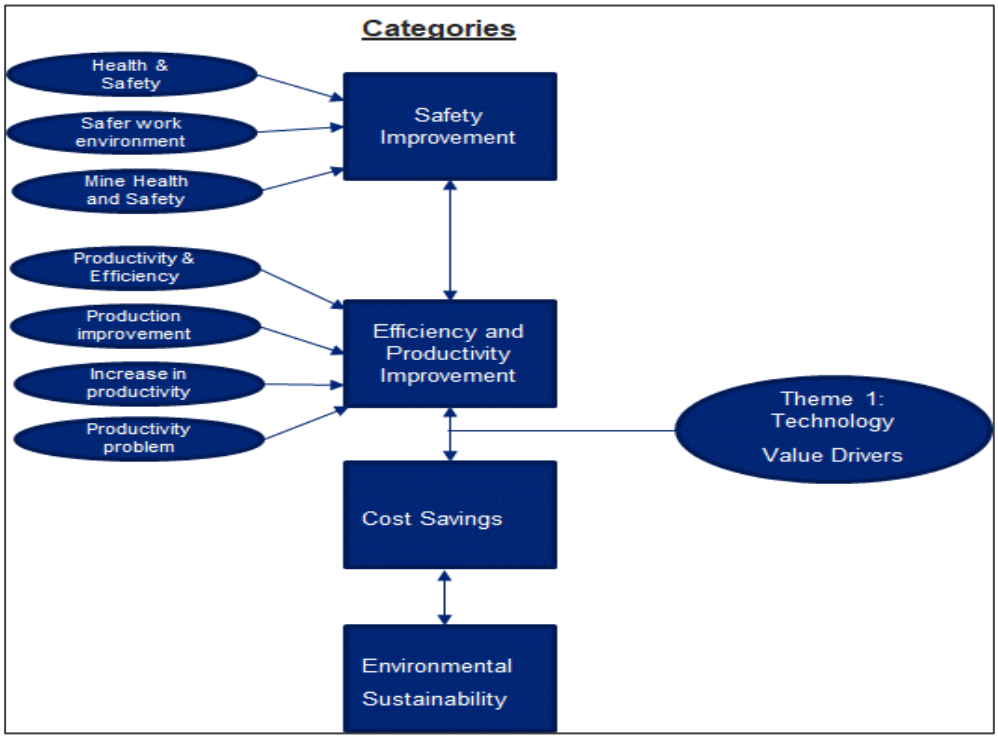
4.10 Data Analysis Method

Coding and thematic analysis were used in the analysis of the research data. According to Saldana (2009), a code describes a word or phrase that encapsulates the essence of the data in question. Saldana (2009) describes the coding process as a two-stage cycle process, where the first cycle process may include a range of codes, from using a single word to sentences and even a couple of paragraphs, while the second cycle includes the rephrasing of the codes using either the same codes, or else reconfiguring these codes into longer sentences to ensure that the information is well captured.

The researcher conducted thirteen interviews to collect the data from respondents in the form of interview recordings. The voice-recorded data were then transcribed and read through individually to verify that the recording was properly captured. These thirteen transcripts were used to understand the fundamental meaning from the data, which is referred to as decoding by Saldana (2009, pg. 4). The researcher proceeded to code each transcript to determine linkages and discover appropriate phrases from the respondents' data, which according to Saldana (2009, pg. 4) can be defined as the "encoding" process. The student continued to identify repetitive and consistent patterns of data in order to continue with the coding process.

Thereafter, the researcher proceeded to the second coding process, which included seeking understanding and summarising the 213 codes into 21 categories, also called groups of codes as shown in Figure 4-2 below and Figure 5-1 in Chapter 5. The 21 categories were further analysed and grouped into six themes, some of which were drawn from literature. The researcher then analysed the associations between the categories and presented them using network diagrams, as shown in Chapter 5.

Figure 4-2: Coding process showing codes, categories and themes (Saldana, 2009, p. 12)



Upon analysing the data, the study identified the research factors that influence technology adoption, which enabled the answering of research questions as outlined in chapter 3. These results are presented in Chapter 5 in detail.

4.11 Data Validity, Reliability and Transferability

Scandura and Williams (2000) argue that the appropriateness and quality of the rigour applied to a research study method have a significant impact on the outcome of a management research study. Thus, to ensure the appropriateness of the sample selected the researcher approached the Minerals Council South Africa, which is the mining industry employers' organisation representing mining organisations nationally, for reference to companies that have implemented or are in the process of implementing technology solutions across their operations and to assist in identifying the appropriate respondents to interview.

In addition, the researcher utilised several expert industry reports to validate the industry view and to triangulate and validate the data collected. Triangulation of data was conducted by comparing the data collected from the four commodity clusters. The results from each cluster were then evaluated to understand and identify factors that are similar versus those that are unique to the clusters.

According to Scandura and Williams (2000), the concept of triangulation can be defined as the process where a researcher evaluates different methods or traits to study the discriminant and convergent validity of the measures obtained. The data was validated by using the interviews from three industry experts, who also confirmed the data gathered from the commodity clusters including from the industry experts' representatives against the data collected from respondents and published industry report. These reports provided data from different sources and were used to validate a finding or result. Triangulation of data analysis is then used to validate the data integrity.

Baxter and Jack (2008) define data triangulation as a data gathering process to be viewed and explored from multiple perspectives of data sources. Triangulation of data was conducted by comparing the data collected from the four commodity clusters, including industry representatives and findings from experts' industry reports. The student was able to validate the data collected from the interviews using this process.

According to Daniel (2019), transferability for qualitative research means that the findings from one research study can be applied to other situations or industries. It is important not to generalise research but rather to understand how the findings from one study can be applied as lessons or learnings in a different context (Daniel, 2019). To ensure transferability, the researcher conducted face-to-face interviews in order to understand the environment that the respondents are exposed to by being physically present at the mine where the interviews were conducted. In addition, the researcher had the opportunity to be immersed in the mining environment and experience the technology solutions employed.

4.12 Credibility and consistency of the data

The credibility and consistency of the research findings were reviewed before discussing the actual findings. According to Shenton (2004), the credibility of research findings depends on the use of an appropriate design and the approach adopted for the data analysis. According to Shenton (2004), the credibility of the sample depends on both the extensiveness and relevance of the sample selected. Thus, the credibility of the sample was evaluated in terms of the appropriateness of the research design, data analysis approach and the relevance of the sample chosen.

As presented in Chapter 3, the research questions entailed 'the what?' of the phenomenon under investigation. Exploratory questions were posed and aligned with the qualitative research method grounded on exploratory study research design, as outlined by Creswell

(2003). According to Guest et.al (2006) data saturation for interviews should be achieved within the first twelve interviews. Thirteen interviews were conducted using semi-structured interviews to collect the empirical data. In line with the expectations of Guest et.al (2006) adequacy of the sample size was achieved.

The number of interviews held was within the range for the semi-structured interview qualitative method, which is five to 25 as proposed by Saunders and Lewis (2018). This is supported by Creswell (2003) who suggest that a minimum of six interviews is required for this type of study and Guest et al (2006) who stipulate up to 12 interviews will be sufficient for saturation. In addition to the proposed sample size, explained that the data must reach saturation. This is the state in which the final few interviews do not generate any new codes (Guest et al, 2006). In this study, saturation was achieved after 11 interviews with no new codes extracted in the last two interviews as illustrated by Figure 4-1.

As presented in Table 5-1 in Chapter 5, the sample data indicates the respondent's details which were relevant to the study. The wealth of collective experience held by the participants was equivalent to more than 100 years. This demonstrates the credibility of the data collected across the different commodity clusters, which included iron ore, diamond, platinum, coal, including data from three experts with vast knowledge across the different commodity sectors of mining globally. The respondents who were interviewed held very senior positions with immense responsibility in the mining industry, ranging from Chief Executive Officer, Head of Mining, Group Strategic Business and Innovation Manager, General Manager, Executive Head Technical and Head of New Mining Technology.

During the interviews, it was evident that these participants had a combination of both mining experience and technological background, which affirms the type of purposively selected participants to help generate the knowledge required for this study (Scotland, 2012). The participants had adequate experience to generate this knowledge, which is necessary to develop a conceptual model for the effective adoption of modernisation in the South African mining industry.

As explained in this chapter, in order to ensure credibility, the approach selected included triangulation of the data as highlighted in Chapter 5, member checking to ensure that the data was not interpreted out of context and using an evidence-based approach to ensure confirmability of the findings. The data was presented in an objective manner with contradictions also reported. This ensured that all possible threats to the validity of the

study were addressed. In summary, the credibility and consistency of the design, sample and data analysis of the study can be confirmed.

4.13 Ethical consideration

Gordon Institute of Business Science (GIBS), University of Pretoria requires that all students who are registered for Applied Business Analysis and Research course to submit for ethical clearance before collecting data. the following document for ethical clearance (GIBS, 2019); The ethical clearance application had to be submitted to the Research Ethics Committee of GIBS in order to fulfil the requirements stipulated by the university. According to GIBS (2019), the main objective for ethical clearance is to ensure that research is conducted in keeping to high moral standards and conducted in a responsible manner to preserve and respect the rights, freedom of all persons.

All the respondents a consent letter, a sample shown on Appendix B, which stated and made the respondents aware that their participation was voluntary, and they could withdraw at any time without any penalty. The respondents were confirmed that their identity would be kept anonymous, and all data collected during the interviews will be reported anonymously (GIBS, 2019). The student obtained ethical clearance letter as evidence that the study was conducted in an ethical manner.

4.14 Methodological limitations

Due to the limited timeline in which to conduct the research, the study selected a sample from four of the eleven commodity clusters that make up the mining industry of South Africa. Thus, the sample size was limited to these four commodity clusters and cannot be used to generalise the study for the industry as a whole. The study was limited to collecting data from the units of analysis selected, which included the decision-makers for technology adoption. Further research could expand upon this by including the general workers and employees responsible for the operation and maintenance of the technology solutions adopted.

Another possible limitation was the presence of the researcher during the data gathering process, which is often unavoidable in qualitative research and could have affected the answers provided by the respondents. In addition, the researcher had limited time to examine the data from different angles, thus limiting the interpretation time.

Chapter 5:RESULTS

5.1 Introduction

This chapter presents the findings of the research study, which aims to answer the research questions outlined in Chapter 3. The purpose of this study is to identify the critical factors that support or inhibit the acceptance of technological solutions for effective adoption of modernisation in the mining industry of South Africa. A qualitative research method was adopted for this study, where thirteen semi-structured interviews were conducted to collect the data recordings from the respondents.

5.2 Sample and Data analysis process

5.2.1 Sample of respondents

Table 5-1 below gives a detailed list of the thirteen respondents interviewed, which comprised of executives and senior managers from different mining houses. The respondents were at some point directly responsible for influencing the decision-making of implementing automation technology and modernisation in the mining industry. The respondents have all had a minimum work experience of seven years in the field of modernisation, which indicates the relevance of the data collected.

The respondents' work experience and their current positions are provided in Table 5-1, which indicates evidence of the relevance of the respondents selected. The respondents' details were classified in terms of the commodity clusters according to their current roles, namely: Iron Ore, Diamonds, Platinum and Coal. The other four participants were classified as being experts in the mining industry given their current roles and do not belong to a specific commodity cluster. The sample shows the collection of data across four commodity clusters, which displays the views from five organisations across the mining industry. This data enabled the study to evaluate both the differing and consensus views for the different clusters. The experts' data provides an industry view and was thus used to validate the data collected from the four commodity clusters.

Table 5-1: List of participants interviewed as part of the data collection process

Respondent Identification		Role	Mining Commodity Cluster	Respondents relevant information
1.	Iron Ore 1	Head of Mining	Iron Ore	Over 15 years of working experience in mining technology and modernisation in South Africa
2.	Iron Two	Snr Specialist Technology	Iron Ore	Over 10 years of working experience in mining technology and modernisation in South Africa
3.	Diamond 1	Head of De Beers Group of Technology South	Diamonds	Over 15 years of working experience in mining technology and modernisation in South Africa and across other countries
4.	Diamond 2	General Manager De Beers Marine	Diamonds	Over 12 years of working experience in mining technology and modernisation in South Africa
5.	Diamond 3	Group strategic business and innovation manager	Diamonds	Over 10 years of working experience in mining technology and modernisation in South Africa
6.	Platinum 1	Head of New Mining Technology, Platinum	Platinum	Over 15 years of working experience in mining technology and modernisation in South Africa and across other countries
7.	Platinum 2	General Manager Production	Platinum	Over 7 years of working experience in mining technology and modernisation in South Africa
8.	Platinum 3	Executive Head Technical	Platinum	Over 20 years of working experience in mining technology and modernisation in South Africa and across other countries
9.	Platinum 4	Executive Head Mining	Platinum	Over 15 years of working experience in mining technology and modernisation in South Africa and across other countries
10.	Coal 1	CEO, Exxaro resources	Coal	Over 6 years of working experience in mining technology and modernisation in South Africa and across other countries
11.	Expert 1	Principal Material Handling Open Pit, Mine Modernisation	Industry expert	Over 15 years of working experience in mining technology and modernisation in South Africa and across other countries
12.	Expert 2	Programme Manager: Mechanised Drill and Blast (MDB) and Non-Explosive Rock Breaking (NERB)	Industry expert	Over 20 years of working experience in mining technology and modernisation in South Africa and across other countries

13.	Expert 3 and Expert 4	Senior Executive: Modernisation & Safety and Head of the Mosh Learning Hub Minerals Council	Industry expert	Over 15 years of working experience in mining technology and modernisation in South Africa

5.2.2 Details of interview transcripts

The total number of respondents who were interviewed was thirteen with a total duration of nine hours of transcriptions. The shortest interview was 20 minutes' long with all the questions answered according to the interview guide. The researcher found that the interviews that took longer to complete was due to the detailed description that was provided by the respondents in question.

Table 5-2: List of participants interviewed as part of the data collection process

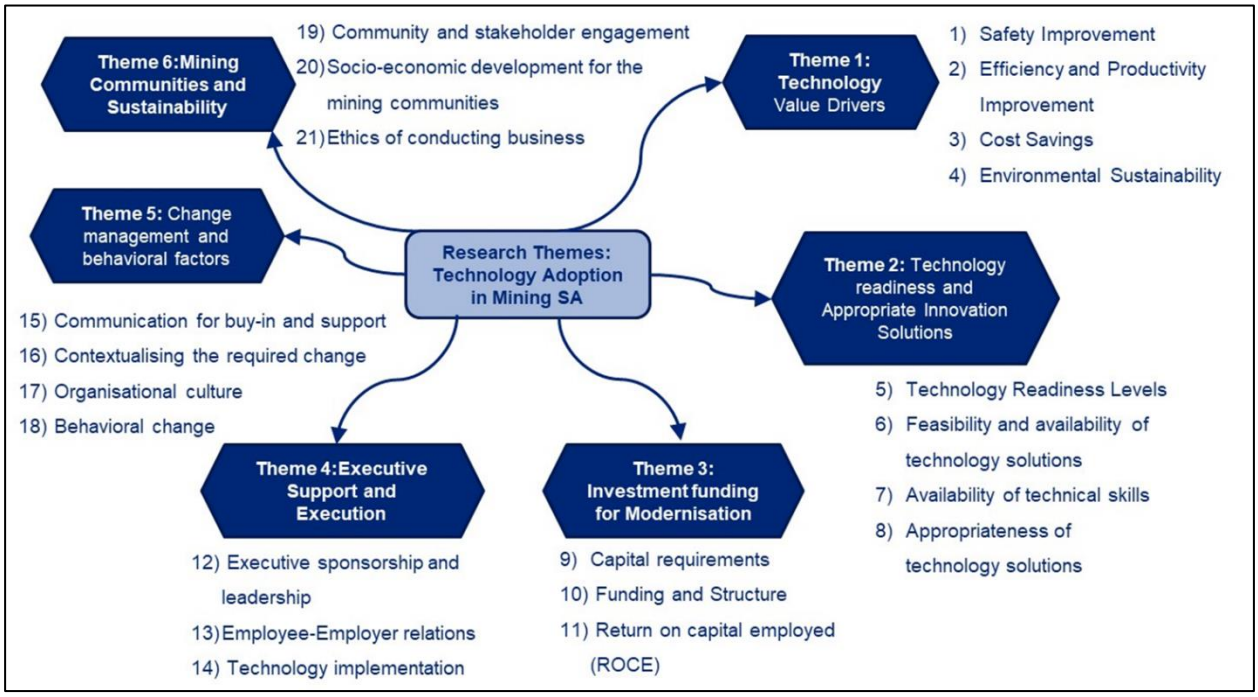
Description	**Quantity**
Number of interviews	13
Total duration of the interviews (Minutes)	545,5
Average duration (Minutes)	42,0
Shortest duration (Minutes)	20,12
Longest duration (Minutes)	69,2

5.3 Themes of the Research Study

Figure 5-1 details the overview of the thematic analysis where 21 categories were formulated from the 213 codes derived during coding of transcripts, as per the recommendations of Saldana (2009). The categories were then further classified into six key themes outlined in Figure 5-1. Further analysis was conducted on the various categories to examine associations between the categories and present the association using network diagrams, presented in each theme.

This section presents the findings in detail for each of the themes outlined in Figure 5-1.

Figure 5-1: Diagram showing research themes and groups of codes



5.3.1 Theme 1: Value Drivers for Technology adoption

The business value driver theme presents a summary of the results to explain the reason why mining companies would be motivated to adopt technology innovations, and what value or benefit they would derive from adopting such change. This theme elaborates on the burning platform and details the key influencing factors for mining companies to modernise their operations.

A quotation from the Diamond 3 commodity cluster made mention that everything begins with a business need, which explains the drive for companies to make and commit to certain decision in order to fulfil a business requirement. This respondent captured the views of most of the respondents in identifying strategic value drivers as being the main reasons why their organisations adopt automation and other innovation technologies across their value chain processes to support business goals. Many of the respondents highlighted the key value drivers as follows: Safety improvements, Efficiency and Productivity improvements, Reducing Operational Costs and driving Environmental Sustainability.

> *"So, everything in terms of technology starts with a business need. I need to improve production, [and] you need to provide information that is necessary to improve production." [Diamond 3]*

Iron Ore 1 from iron ore commodity cluster made mention of financial matrices that must often be achieved before a new solution can be introduced into the business value chain. Mining organisations make use of the value driver tree-process to link the operational key parameters to business financial outputs that are used to report company financials.

> *"There will obviously be financial metrics that have to be achieved like NPV and IRR and so on, but you would also consider the strategic value of the project and that strategic value could lie in the fact that it will unlock maybe future resources in the future." [Iron Ore 1]*

Iron Ore 1 from the iron ore cluster mentioned the unlocking of future resource value as a strategic value driver which can be included under the sustainability value driver. This motivation for securing the future of mining comes as a unique finding from the data gathered, as most respondents were looking at surviving today and not necessarily at securing future resources given the depressed state of the economy. The unlocking of future value from resources was identified as a motivational factor for some of the mining businesses to commit towards investigating technology solutions that will provide viable beneficiation treatment processes for producing product from low-grade resources, which will lead to maximising resource utilisation and secure the future of mining.

> *"[At the] most strategic level, we got our technology department where we would scan and look at what our peers are doing, what technologies are out in the market that can be adopted within the business in terms of enhancing how we do things, from a processing side, to an efficiency side and most importantly also we are looking at enhancing safety." [Iron Ore Two]*

Platinum 2 from the platinum commodity cluster mentioned that the motivation for adopting a technology solution would be to improve productivity, which he referred to as effectiveness. He also referred to another motive, which was improving efficiency and safety by removing people from harm, as well as sustainability.

> *"Where technology will influence me is in terms of capital requirements, how we can do it more effectively and efficiently, but the thing about sustainability is it's not only about safety or removing a person." [Platinum 2]*

5.3.1.1 Safety Improvement

Safety and health were found to be a common theme mentioned by most of the respondents across all the four commodity clusters. The following comment from Platinum 2, who is the general manager for one of the mines in the platinum commodity cluster, mentions safety and health as the most critical according to him. Expert 4, who is the head

of the Mosh Learning Hub at the Minerals Council, concurred with this statement and further mentioned that the failure to comply with safety and health standards can lead to a mining licence being revoked. This is usually referred to as the application of a section 54 by the Department of Mineral Resources (DMR).

> *"I mean health and safety is an absolute most critical thing. Looking at ergonomics, looking at noise levels, dust exposure from a health perspective, but then looking at safety, what does it mean for us to connect with our actual vision?" [Platinum 2]*

Iron two, who is a senior technology specialist from the iron ore cluster also confirmed the significance of safety being an important motivation for adoption of technology in mining. All respondents agreed that all mining companies need to meet the required safety standards set as part of regulatory control requirements for the operating mining licence. The South African Department of Mineral Resources (DMR) acts as a regulatory body to administer and monitor that mining companies adhere to the Mine and Safety Act of 1996. The need to create safer work environments through safety improvements in the mining value chain was mentioned as a critical value driver by most of the respondents.

> *"So, I think more so those in my recollection have been mainly around safety and how do you mitigate the risk so with my knowledgeable solution readily available, but the solution potential that we as the mining operations." [Iron Two]*

5.3.1.2 Efficiency and Productivity Improvement

All respondents mentioned that there is an urgent need for mining to improve efficiency and productivity and that these motivators were the main reasons for implementing automation technologies to modernise the mining value chain. The mechanisation of mines has been influenced by the industrialisation of factories to achieve more output by extending operating hours to almost 24 hours daily, resulting in less stoppages and defects in the final products produced. All the respondents agreed on realising value or benefits from implementing technology solutions, as shown by the following quotation by Iron Ore 1:

> *"We are also seeking technology to help us improve our productivity. So, productivity improvement targets are driving technology innovation for us." [Iron Ore 1]*

5.3.1.3 Cost Savings

The mining industry has been under pressure due to high production costs and most of the respondents highlighted cost reduction as a key focus area across the value chain. The majority of the respondents confirmed that mining companies compete with industry

peers mainly on cost and product quality to ensure financial benefits for their investors. The respondents also mentioned that the cost driver is used as a key performance indicator to monitor and measure how well the business improvement initiatives are performing, as confirmed by this quotation from Expert 2.

> *"It shows the parameters, KPIs all based on square meter cost times." [Expert 2]*

All respondents agreed that the cost reduction driver is subsequent to efficiency and productivity improvements and hence there are direct linkages between safety improvements, productivity, efficiency and cost driver elements. Some of the respondents mentioned two main areas that may contribute to the high production costs, namely labour and energy costs.

<u>High labour Costs</u>

Expert 2 made specific mention of the high labour costs in the platinum commodity cluster. This statement was confirmed by respondents from the platinum commodity cluster, who mentioned that the high cost of labour in the platinum industry can be attributed to the high amount of labour required to operate the manual processes in the current value chain.

> *"What happened is if you look at the cost components today, South African gold mines are the most expensive production, cash cost, I am talking cash operating cost, the most expensive operations worldwide. When you look at platinum, actually it's the same story, but the major cost component of 52% is labour." [Expert 2]*

<u>Energy Costs</u>

The increasing cost of electricity and energy security has been a topical concern for investors in South Africa. Some of the respondents from the platinum sector have referred to the high cost of electricity as a major contributor to high production cost.

> *"Because, as you get deeper you have mining inflation the cost increases. Energy costs are going up; you want something which is less energy intensive." [Platinum 3]*

5.3.1.4 Environmental Sustainability

Platinum 3, who is an executive in the platinum commodity cluster mentioned that the company targets the reduction of energy consumption and that specific technologies are investigated to enable the company to achieve their sustainability targets. Most respondents from the platinum, iron ore and coal commodity clusters identified environmental sustainability as a motivation for mining companies to make commitments towards investigating and implementing technology solutions to minimise their carbon footprint and water usage.

> *"But we trigger it through the sustainability envelope. So, what I do I basically say we have a thirty percent reduction in energy consumption in our group sustainability targets. What we are doing in the sustainability targets, using water as an example, you could use whatever you want, but using the inputs to the business." [Platinum 3]*

Iron Ore 1 mentioned the unlocking of future resource value as a strategic value driver that can be included under the sustainability value driver. The motivation for securing the future of mining comes as a unique finding from the data gathered, as most respondents were looking at surviving today and not necessarily at securing future resources given the depressed state of the economy. The unlocking of future value from resources was a motivational factor for some of the mining businesses to commit towards investigating technology solutions that improve treatment or beneficiation of low-grade resources to improve resource utilisation and secure the future of mining.

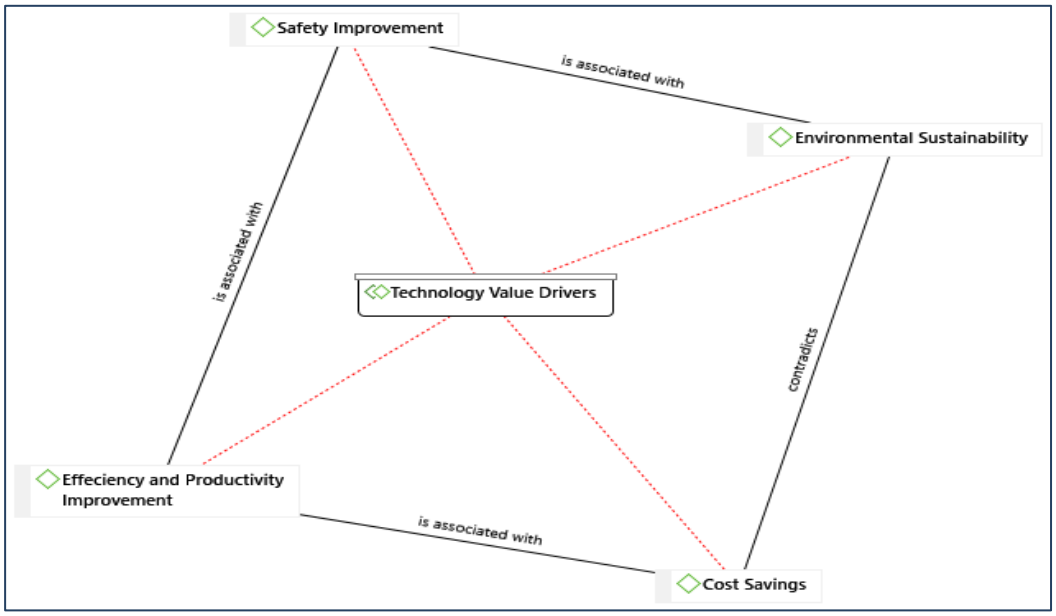
> *"There will obviously be financial metrics that have to be achieved like NPV and IRR and so on, but you would also consider the strategic value of the project and that strategic value could lie in the fact that it will unlock maybe future resources in the future." [Iron Ore 1]*

The four main categories of the technology value drivers and associations are presented in Figure 5-2, which indicates an association between safety improvement and improving productivity and environmental sustainability.

Figure 5-2 shows an association between cost savings and efficiency and productivity improvement. This follows a quote from Diamond 1 that there was a need for mining companies to introduce technology solutions aimed at improving efficiencies and productivity, which ultimately lowers operational costs.

Iron Two from the iron ore commodity cluster indicated the association between safety improvement and efficiency being driving factors for implementing technology innovation. Platinum 1 from the platinum commodity cluster, on the other hand, mentioned the importance of proving how technology contributes to improvements before implementation is undertaken.

Figure 5-2: Thematic diagram for technology value drivers



Iron Ore 1 from the iron ore commodity cluster mentioned the unlocking of future resources as a strategic value driver. There is however a contradiction between cost savings and environmental sustainability value drivers as the investment in safety might be more costly than the value accrued and may not result in improved margins. It is the researcher's view that it is not easy to measure the safety value driver as it is largely behaviour based, which makes it difficult to quantify in a mining environment.

5.3.2 Theme 2: Technology readiness and Appropriate Innovation Solutions

The theme of technology readiness and adoption of appropriate technology solutions elaborates on the risk associated with technology selection, which includes the process followed by mining companies in selecting relevant and appropriate technology solutions. This theme also discusses how companies go about demonstrating the feasibility of a technology innovation and how the availability of appropriate skills have influenced South African mining companies to either adopt or reject a technology solution. The intention is to understand how modernisation can be effectively adopted to achieve desired industry goals.

This theme is made up of three categories, which are: technology readiness level, the feasibility and appropriateness of the technology solution, and the technical skills required to operate and maintain the technology solution.

5.3.2.1 Technology Readiness Levels

Technology readiness was described by most respondents as the level of maturity of a technology innovation, either tested or implemented in a mining production environment, and whether the technology solution is commercially readily available. Low technology readiness level is associated with high risk of introducing an unproven technology into an operational business value chain. The readiness level for a company was described as the extent to which the business can take the risk associated with introducing a technology innovation that is still in development into the production value chain.

> *"I think technology readiness is a very interesting concept to be honest or availability of technologies." [Iron Ore 1]*

Most of the respondents from the different mining clusters agreed with Expert 1, stating that there is a low impetus for mining companies in South Africa to take up the risk associated with making the commitment to adopt low technology solutions into their process value chain. Expert 1, who is regarded as a global expert, agreed with most of the respondents in saying that the majority of mining companies are most likely not going to take the risk of introducing new technology unless it is critical. The risk depends on the degree of reliance on the value to be delivered and the available alternative solutions to unlock value for the business. The level of risk and commitment taken depends on the need for the solution and the value associated with unlocking the value.

> *"So again, this is very much also related to how critical is that technology to your own business. So, if it is less critical then probably it needs to be very available, because you are not willing to take as much risk. There needs to be very much technology and much support." [Expert 1]*

Platinum 3, who is a mining executive, mentioned contrarily to most respondents that his company is committed to taking risks associated with technology innovation in order to adopt appropriate technologies across their operations. Only a few of the respondents agreed with Platinum 3 and were mostly from companies that were part of large organisations.

> *"Technology readiness level (TRL) scale from one to nine. We take stuff from six onwards and what we have done is we have established sites where we do the trialling. We have actually just put it on pure remoteness at the moment, but we have a trail mine." [Platinum 3]*

5.3.2.2 Feasibility and availability of technology solutions

Most of the respondents agreed with Diamond 2 and with Platinum 1 that it is the responsibility of mining operators to identify, test the viability and implement technology solutions within an existing operation's value chain process. Respondents mentioned technology testing as a critical factor in demonstrating the feasibility and viability of the technology solution, which leads to acceptance of the technology.

The process of demonstrating the technology was important in minimising the risk associated with low readiness of the new technology. Respondents mentioned that larger mining organisations usually have dedicated resources in their structure that are responsible for conducting feasibility testing of technology innovation before introducing it into the process value chain. Similar comments to those below were mentioned by most of the respondents who were employed by larger corporate mining companies regardless of the commodity cluster.

> *"We spend a lot of time making sure that when we give that technology to the customer it has a really good chance of success, so the acceptance by then, if we can prove the benefits of the technology to the customer, our customer is very ready to accept it." [Diamond 2]*

> *"We don't roll it out and we don't implement anything if we have not tested it thoroughly and proven that it does work and that it's safe number one, number two cost effective and number three productive enough so that we roll it out." [Platinum 1]*

Expert 1 agreed with most of the respondents that organisations generally prefer a pipeline of projects distributed across the readiness level scale, with some projects still at a low readiness level which can be classified as being in the research and development stage. This was to enable sufficient testing of technology solutions in proving them to be viable and being available when required. The majority of respondents agreed with Expert 1 in having accepted technology solutions with a higher readiness level, which can easily be modified and retrofitted into their existing value chain processes.

> *"Therefore if you understand about the technology readiness level you can go inside of the pipe and take technology which is likely not ready, not now, it could be tier L7, and develop that and take risks to actually make that technology in order to be successful, but investing in deputing and working with the guys that developed the technology to actually make it robust and good enough for your own business." [Expert 1]*

Some of the respondents, including Platinum 2 who agreed on accepting low readiness-level technology solutions mentioned the importance of having site champions at the

operational level. The champion's role is to support the technology technically and ensure that the necessary requirements are made available to offer sufficient opportunity to prove the viability of the technology. The respondents also agreed that the champions need to occupy the right level in the organisation in order to have the correct influence, and also mentioned that the mining culture is still traditionally hierarchical in nature.

> *"The other thing here is in terms of your technology readiness levels, you know with that we particularly put a hierarchy in place. I'm the designer, I'm the boss or here comes the boss, I'm the only operator or I'm the only supporter that equipment around it." [Platinum 2]*

5.3.2.3 Appropriateness of technology solutions

Appropriateness of technology was described by Platinum 3 as technology that has technical and economic viability. The appropriateness of the technology was associated with value drivers that support the business in achieving its goals.

> *"It is no good coming up with a really smart exciting idea if it does not make money. [We need to ask] what is the uncertainty on the estimates? How much risk are we prepared to take? I think that goes into the hard basic option of identification and scanning through the idea and process." [Platinum 3]*

Most of the respondents including experts agreed on forming strategic partnerships with equipment and technology suppliers to determine the best fit-for-purpose technology solutions for their operations.

> *"ecosystem of partners that you tick, we have been working with so on a special database of as I said" [Diamond 3]*

5.3.2.4 Availability of technical skills

Most respondents agreed with Platinum 3 that digital and STEM subjects (science, technology, engineering and mathematics) were necessary skills for adoption of technology solutions and that there was a shortage of these skills in South Africa especially. The respondents agreed that it was not easy to recruit people with the required skills due to the demand for such people and the low skills levels in general.

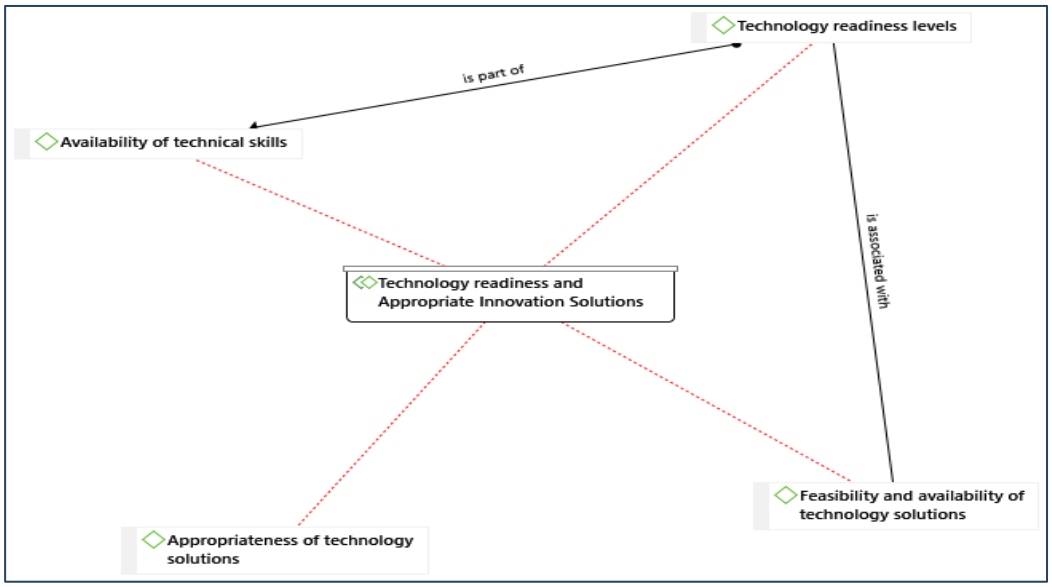
> *"You need computing skills, or engineering skills or chemical skills and stuff like that. It depends on the technology. I believe anybody is capable of learning that, okay, but you need to identify [those people], and you need to identify [them] upfront. And you almost need to be like with the benefit of hindsight." [Platinum 3]*

Some of the respondents mentioned the mismatch between the skills development, training and the skills demanded by the job market. Expert 3 mentioned the importance of understanding the specific skills requirements needed or drawing a skills plan as a part of technology readiness and addressing the readiness of operations for adopting the technology solution.

> *"I think the one mistake that we often make is that we don't understand the technology fully before we determine what the skills program should be. So, we need to understand our future and the future technologies, we need to understand that very well before we start, so it is the skill about the specific technology that you want to introduce." [Expert 3]*

Figure 5-3 presents the technology readiness and appropriate innovation solutions thematic network and shows the association between the four categories. The thematic map indicates that availability of skills is an element of technology readiness levels.

Figure 5-3: Thematic for technology readiness and appropriate innovation solutions



Most respondents agreed that the low readiness levels of technology solutions negatively influence or inhibits technology adoption. There was an association between the readiness level and the feasibility and availability of technology solutions. The majority of respondents agreed on avoiding the risk associated with low readiness levels and not considering whether the solution is viable. Some of the organisations agreed on accepting low readiness level technology associated with the need to solving a problem with no solution. The researcher's view is that larger organisations are able to spread the risk

across the different commodity sectors, which allows them the opportunity to invest in technology innovation and taking up technologies with a low readiness level.

The demonstration or testing of technology was identified as one of the means of understanding the viability of the solution and reducing the risk associated with the readiness of the technology. There was mention of the importance of having site champions with the right influence to provide support for the technology at operational level, thereby affording an equal chance for the technology to either succeed or fail.

An appropriate technology was described as one that is technically viable and also economically viable that is linked to the business value drivers and must support the business in achieving its goals. There was also an association between the viability of the technology and the availability of technical skills. The respondents elaborated on the need to align the future required skills with the education system to ensure that relevant skills are developed to satisfy the demand.

5.3.3 Theme 3: Investment funding for Modernisation

This section presents the results on the influence of investment funding required for modernisation of the mining process value chain. The theme consists of three categories, which are: 1. Capital requirements necessary for implementation of technology innovative solutions; 2. The funding structure of different organisations; and 3. Return on capital employed (ROCE), which is a financial output mostly used as a criterion for the allocation of capital.

5.3.3.1 Capital requirements

Most of the respondents agreed that capital funding is an integral process of implementing technology solutions across the mining value chain. Platinum 3 from the platinum mining cluster mentioned the importance of accepting the need for capital requirement as one of the elements in adopting technology innovation.

> *"I think importantly we have got to accept that capital requirement does affect technology adoption. You cannot separate the business of mining from technology. We are in the business of mining." [Platinum 3]*

Diamond 3 captured the views of most respondents of the requirement of a business case to justify technology capital. The capital allocation is generally justified using a business case which clarifies the need for the investment.

> *"You need to do things faster or better, it's not [because of] nice technology; you must be able to show that it's a business case otherwise we do not spend the money." [Diamond 3]*

5.3.3.2 Funding and Structure

Most the respondents shared the same response as Platinum 1 from the platinum commodity cluster, who spoke of a funding structure that evaluates capital funding based on a business case. Platinum 1 also mentioned that in most situations' executives were responsible for making the decision for capital allocation. This links to the next theme, which was the role of executive leadership in supporting technology adoption. The respondents elaborated that the funding model drives the types of projects that the business executes.

> *"Capital funding is allocated on business cases that go through to the executive, and the executive looks at the bottom line and they say, does this technology or modernisation or mechanisation pay for itself? They will not sign it off to go forward if there's no business case or a proper project scope on what it can deliver." [Platinum 1]*

Iron Ore 1 mentioned that during the annual capital budget process, value drivers are looked at as a criterion for allocation of capital according to the requirements per project as the determining factor.

> *"The company has come a long way to include technology projects in our capital funding, so on an annual basis we do capital budgeting and we look at capital required for sustained business projects, capital required for expansionary projects and also capital required for technology amongst others." [Iron Ore 1]*

The funding process involves evaluating the company's financial position which includes free cash flow and is then followed by the project business case which described the value to be delivered by the project when implemented. Funding approval includes a decision-making milestone, which includes the business case presentation in motivation of the project implementation. The business case should also include project deliverables linked to the associated key performance indicators for the offered solution. The motivation also includes an alignment of the project business case outputs with the business value drivers to demonstrate the value to be delivered.

> *"In terms of how capital funding is allocated we look at exactly that. We look at the strength of the business and identify what free cash flows generated from operations coupled with the debt coverage associated with the businesses." [Platinum 3]*

Coal 1, who is the CEO for one of the organisations in the coal cluster mentioned the application of a capital allocation framework that was used by his organisation in allocating and prioritising capital for their business. The unique reference of a capital allocation framework could be evaluated for adoption by the industry if applicable.

> *"Well, there is a capital allocation framework. And for us, I mean, if you had to look at the money that we generate, of course, first thing you need to do is you have to have service, your debt, so you need to have a business that's alive." [Coal 1]*

Diamond 1 from the diamond cluster mentioned that their funding source was not from a capital budget, but rather from the operational budget funded by their mining operations, also known as business units. He mentioned that their research and development budget was allocated from the operating budget and that it was generally determined as a certain percentage of the operating profits.

> *"We don't do technology development through capital, okay, first off. The Technology-- the funding for our technology development that we do is basically operating costs and the operating costs for that are derived equally from all the De Beers business units." [Diamond 1]*

5.3.3.3 Return on capital employed (ROCE)

Most respondents agreed that mining companies were in the business of making profit for their shareholders and that the industry uses KPIs to evaluate the capital allocation. Platinum 4 mentioned the use of return on capital employed (ROCE) as one of the financial measures employed to allocate the limited project capital across the business and to ensure business continuity.

> *"Absolutely, it doesn't help if you have a fantastic resource and you can't unlock it because you have social unrest every single day, all day because you've been thinking you've been smart and shifting a return on capital employed." [Platinum 4]*

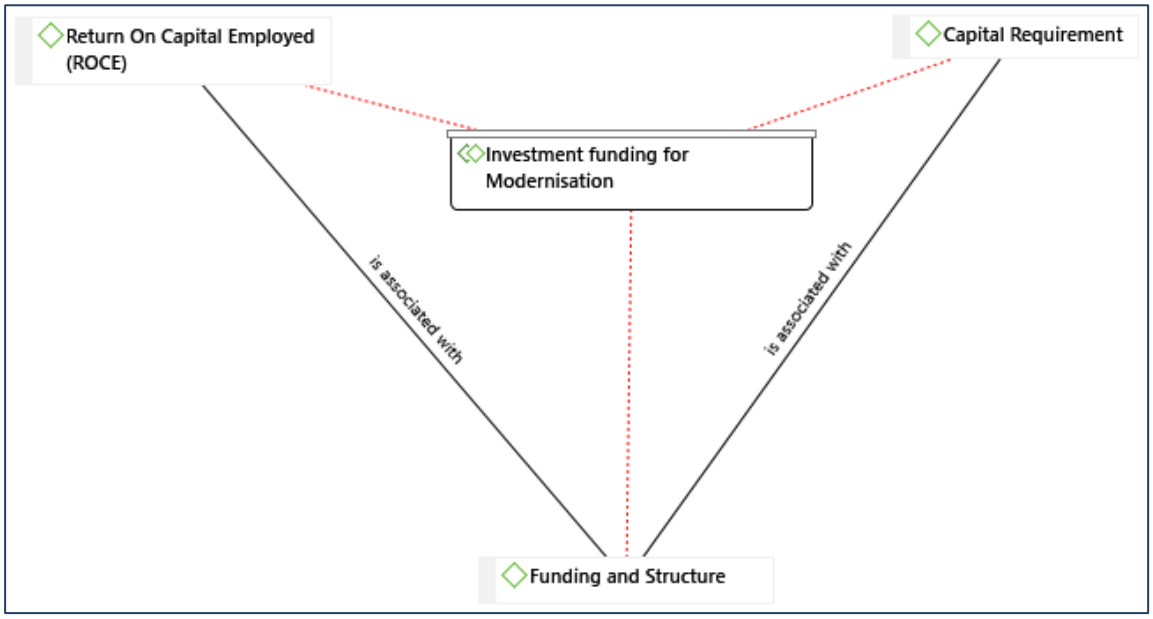
> *"I think it is very important and the context is that it is a long-term business and it takes years or two decades before you can start mining and getting a return on your capital." [Expert 3]*

The thematic map shown in Figure 5-4 below presents the investment funding required for modernisation and shows the association between three categories, namely: Capital requirement, Funding and structure, and Return on capital employed (ROCE).

Figure 5-4 indicates that there is an association between funding structure and capital requirement. The majority of respondents agreed that capital funding is an essential part of modernisation and that there is some form of a capital allocation process linked to the

business case for every project that requires capital. The project business case outputs were linked to the company's business value drivers to demonstrate the value to be delivered.

Figure 5-4: Thematic for investment funding for modernisation



Most respondents agreed that the ROCE was one of the financial measures used to allocate the limited project capital across the business. Thus, this can be regarded as an inhibitor for modernisation.

An interesting statement was made about executives being responsible for capital allocation, which links directly to the role of executive leadership in supporting technology adoption. The respondents elaborated that the funding model drives the types of projects that the business executes.

Diamond 1 from the diamond cluster mentioned a unique funding model for their research and development, in that their budget allocation was derived from the operating budget of the business units and was generally determined as a certain percentage of the operating profits.

Platinum 4 made a unique statement which linked capital requirement to social unrest in the local communities, which is linked to Theme 6. This challenge was brought about by social unrest influencing the decision for capital investment, which is measured using ROCE. This unique comment was related to the factors influencing the capital funding decision-making process, which includes risks that mining business executives must consider and evaluate in order to make informed decisions for the business.

5.3.4 Theme 4: Executive Support and Execution

This theme detailed the role played by executive and senior management in supporting successful adoption of modernisation for a mining organisation. The theme also detailed the necessary elements required in the implementation process for the adoption of technology solutions in an existing mining value chain.

5.3.4.1 Executive sponsorship and leadership

All the respondents agreed that executive sponsorship was necessary for the effective adoption of new initiatives including modernisation. Coal 1, who the CEO for one of the coal organisations acknowledged the critical role of being an executive sponsor for modernisation given the CEO's position and the responsibility of delivering value for shareholders. Following this assertion, it can be assumed that the role of executive sponsorship for modernisation is a critical one considering that the CEO chooses to drive the initiative himself, instead of delegating it to one of his executives.

> *"This is driven from the top by the CEO himself, and that is me." [Coal 1]*

Expert 2 also confirmed the executive support which he received while working for multinational companies. Thus, it can be confirmed from most of the respondents that the role of sponsorship for adoption of modernisation is mainly taken up by executives and in some cases by the CEO.

> *"Without any exceptions I get full support from the executives in each and every company I worked at." [Expert 2]*

The role of a sponsor includes being supportive, championing for the initiative at a senior level and initiating conversations to socialise the initiative with other executive and senior managers, including influencing the necessary committees in support of the initiative. Most of the respondents agreed that a sponsor needs to have the right approach, attributes and leadership skills in order to influence accordingly.

> *"In our business there is an executive sponsor who sits in our executive committee as the executive head of technical projects and, amongst other things, he focuses on the adoption of technology." [Iron Ore 1]*

5.3.4.2 Employee-Employer relations

Most of the respondents agreed that engagement with employees is a critical element from inception and throughout the process of selecting a technology solution until implementation has been completed. This can be confirmed by the finding from Coal 1,

who highlighted the importance of involving unions from inception as being part of the team. This finding shows the need for an inclusive culture that involves the end users right from the beginning as part of a solution design, taking them along as part of solution development and ensuring their ownership thereof.

> *"So, in these steering committees now, even at the operations [level], where this ends up being conceptualised, is new technology applications have been conceptualised and designed, you've got union people represented in those sessions. Because they are part of the team." [Coal 1]*

Platinum 2 agreed with most respondents that senior management needs to communicate regularly with employees about strategic objectives and initiatives to facilitate the translation of strategy into action and to acquire employee buy-in. Employee relations was discussed as a necessary element for successful acceptance of a new solution or for technology innovation. It was important for the end users to have a clear understanding about the need for the solution and how they will benefit or how it will improve their work environment

> *"I think from our business unit at Anglo American Platinum we put great executive sponsorship, and the reason for that is they actually started with the strategic vision in terms of we want to go with on new technology online." [Platinum 2]*

5.3.4.3 Technology implementation

Most respondents agreed with Expert 2 in that South African mining companies are lagging in adopting technologies compared to their counterparts due to the availability of cheap labour as an alternative. Thus, they agreed that they were not at the forefront of implementing cutting-edge technology, but rather catching up with adopting existing technologies.

> *"Why the South African mining industry they were not so keen about mechanisation in the last hundred years. I think the reason is so simple, cheap labour. What happened is, if you look at the cost components today, South African gold mines are the most expensive production, cash cost, I am talking cash operating cost, the most expensive operations worldwide." [Expert 2]*

All of the respondents agreed with Iron two in describing the integration of a technology solution as being incorporated into business processes or how business is conducted.

> *"I define as project integrated, I am looking at sustainability, so being sustainable is that it does not rely on any champion on site, it is how we do business." [Iron Two]*

Coal 1 described that there should be a holistic view when implementing the technology solution into a system instead of a single point solution.

> *"…a systems approach, because we want to have real time and information, at every particular part of that whole value chain." [Coal 1]*

All the respondents from commodity cluster agreed with Iron two and Coal 1 that the technology solutions need to be integrated into the current business value chain process to make them part the mining process system. The statement was confirmed and clearly articulated by Expert 1.

> *"…like an ecosystem for that technology. So that means it is very much a technology that is as business as usual and then you can have change for that technology." [Expert 1]*

Iron Ore 1 highlighted the importance of having enabling infrastructure available for technology data transfer, which can be described as equipment communication.

> *"If you do not have a communication backbone, then it is impossible to adopt that technology." [Iron Ore 1]*

Iron Two mentioned that the execution of technology projects should include post-implementation milestones to evaluate when a technological solution has been accepted and adopted by the end users. He also mentioned that the stage should be checked against the original business case KPIs versus the value delivered to the business

> *"…at a certain level that we consider installing something as a project completion, being, now once it is installed it's adopted. I think with understanding a bit more in terms of the requirements of adoption is something I think is still not clear." [Iron Two]*

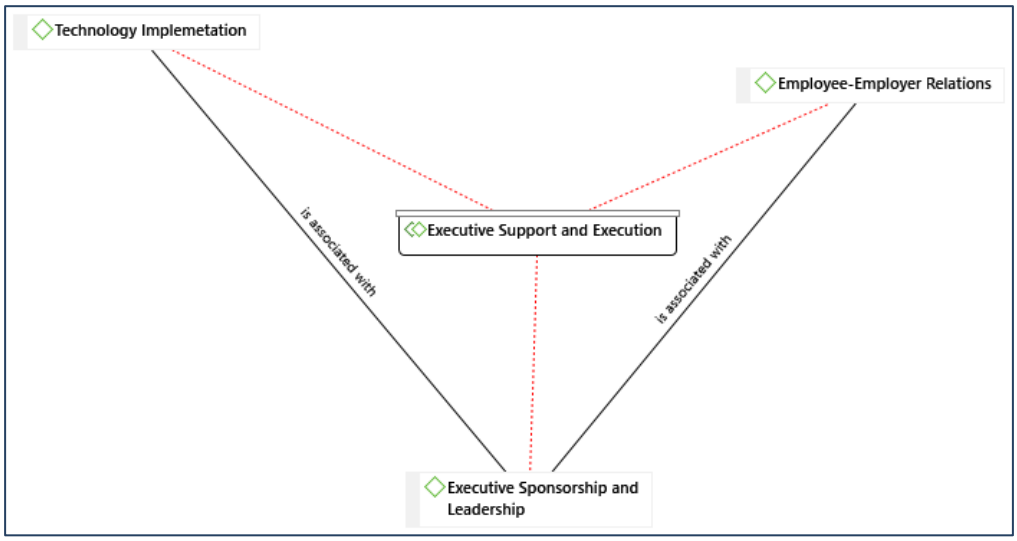
Figure 5-5 presents the associated categories, with a theme titled "Executive support and execution", and an understanding of how categories relate to one another. The network indicates the association between employee-employer relations and executive sponsorship and leadership.

Figure 5-5 also shows an association between technology implementation and executive sponsorship. Most of the respondents agreed that the executive sponsor's role is an important one in promoting, socialising and gaining acceptance of the technology solution in the organisation.

There was an interesting association mentioned in Theme 3 between executive support and capital funding, and that both factors were found to be important for technology acceptance. The respondents pointed out that part of the executive sponsor's

responsibility is to establish communication with executive members and to strengthen employee relations.

Figure 5-5: Thematic for executive support and execution



Iron two recommended that the execution of technology projects should include a completion milestone to mark when the adoption of the technological solution has been achieved. He also mentioned that the stage should be reviewed against the original KPIs presented in the business case versus the value delivered to the business.

All respondents referred to the importance of having the technology solutions integrated into business processes. Iron Ore 1 also highlighted the importance of having an enabling information systems infrastructure necessary for equipment communication and successful utilisation of the technology solutions.

5.3.5 Theme 5: Change management and behavioural factors

This theme presents the findings of the influencing factors associated with change management and the behaviour theme, consisting of four categories, namely: 1. Communication required for buy-in and support; 2. Contextualising the required change; 3. Organisational Culture; and 4. Behavioural change. The codes that make up these categories (see Appendix E) were found to be related to the process of change and the behavioural factors associated with making change.

5.3.5.1 Communication for buy-in and support

Both respondents from the iron ore cluster agreed with most of the respondents from the three commodity clusters, in highlighting the importance of using communication to make stakeholders aware of the strategy and modernisation roadmap.

> *"I think [it] is organisation in terms of adoption, but the main thing is communication and getting people aligned with the strategy, getting people aligned with what you are doing in the short term and in the future and that constant reminder [is needed]." [Iron Two]*

Iron ore 1 highlighted communication as an important element of change, as it facilitates alignment with stakeholders on the current and future plans to ensure that people are taken along.

> *"It is not just putting the hardware in or putting your system in place, it is about taking people through that change journey, which obviously you guys have learnt I'm sure at Gibbs as well, but for me the sooner you can start taking people along on the journey the better, and that's where the communication comes in." [Iron Ore 1]*

All respondents agreed with industry experts in mentioning the importance of communicating to employees and involving them from the start, as they are the "true" owners of the solution having to operate and maintain it. The respondents including the CEO mentioned the involvement of employees from the start.

> *"But the communication not only for management, top management to the employee including obviously labour, organised labour [is] extremely important. If they do not believe your intentions or support your idea, it does not matter how smart your idea is". [Expert 2]*

5.3.5.2 Contextualising the required change

All respondents described the change management process as involving communicating to all affected and impacted stakeholders, as mentioned by Diamond 3 about the change envisaged and what the impact of the change would mean for them.

> *"You should do serious change management that technology to look at everybody that will be affected." [Diamond 3]*

Iron Ore 1 mentioned that the change process was an important element necessary for acceptance of any new technology or process. He also emphasised the need for taking people along, which was confirmed by all respondents from all four commodity clusters.

> *"So you want to take them along as soon as you can and then, on the other side I guess of the change management journey, you want to show them the benefits and you want*

> *to make sure that the benefits you are deriving from the technology project actually help them address their KPIs or improve their day-to-day work environment." [Iron Ore 1]*

The importance of conducting a change process was also mentioned and confirmed by Expert 1, who highlighted the importance of involving all stakeholders and making sure that the entire workforce is made aware of the change, and not just the impacted individuals. Iron Ore 2 also confirmed that stakeholders need to be informed about the pros and cons expected as a result of accepting the technology solution to ensure taking people along.

> *"…a larger amount of people involved with that and then not just the directly involved people, which is a bigger, so your intervention of your workforce is larger, not just the immediate people connected the whole thing, the change is very important. So, it is a bigger change management program because you need to really turn a large wheel that is heavy and is going to take too long a time [so] you need to go to a different level." [Expert 1]*

5.3.5.3 Behavioural change

All respondents including Diamond 2 agreed that behavioural change was influenced and associated with organisational culture. Behavioural change was defined by most respondents as being the mindsets and perceptions of individuals regarding how beneficial the solution is for them.

> *"Behavioural changes--I think it depends on the technology, but most in general if you are happy with dealing with technology, a change in technology is not going to change that, but you have to have that inculcated culture upfront or else you're going to struggle." [Diamond 2]*

Platinum 3 mentioned that technology transfer is all about understanding problems faced and providing an appropriate solution that has the affected people in mind. There was an agreement from all the respondents that in their experience people are not threated by new technology, but that people are willing to make a change if the expected outcome is anticipated to benefit and be positive for them in the long term.

> *"Technology transfer is having people who understand the problem of people. No, people aren't the problem, but the problem of the human dimension in technology transfer and adoption is really important." [Gordon Smith]*

5.3.5.4 Organisational culture

All respondents agreed that an innovative organisational culture is an enabler for technology acceptance. Coal 1 mentioned that their company promotes the culture of

innovation and people are encouraged to come up with innovative solutions that would improve their work environment.

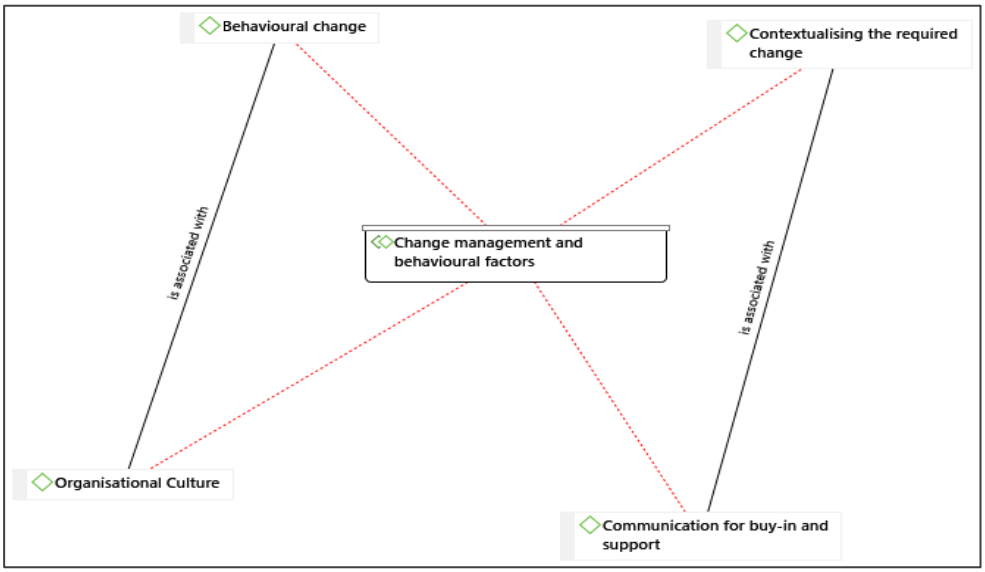
> *"Our culture supports the ability for people to be the innovators [and] come up with the right suggestions of solutions to business problems that we have." [Coal 1]*

Innovative culture was confirmed by Diamond 2 as forming a basis for enabling innovation thinking and adoption of technology in the mining value chain.

> *"You'll probably find the social aspects of the organisation quite difficult to live with, so there's a culture of innovation in the organisation which makes it easier for the technology adoption to happen." [Diamond 2]*

Figure 5-6 presents the code groups for change management and behavioural factors and their association between all categories. The four category factors shown in Figure 5-6 were found to influence one another and should not be looked at in isolation. There was an association between communication and contextualising change. Communication was said to facilitate change and, further, that communication is required from the start of the technology project to ensure that all stakeholders are made aware of the challenges and the need for change in order to stay in business.

Figure 5-6: Thematic for change management and behavioural factors



The process of taking people along facilitates change and leads to acceptance of a technology solution. Communication was also highlighted in Theme 4 as being an important factor in fostering good relationships with employees, which forms part of employee relations and enables change.

There was an association between behavioural change and organisational culture, as shown in Figure 5-6. This innovative culture is required in order to enable stakeholders to be taken along through communicating to them and allowing them to make up their minds about the technology adoption. Organisational culture ultimately determines the level of ease during the adoption stage and the process of change requires a behavioural and mindset change.

There was agreement from all the respondents regarding their experience that people were not the threat when it comes to new technology, but that people were willing to make a change if the expected outcome was anticipated to benefit and be positive for them in the long term.

5.3.6 Theme 6: Mining Communities and Sustainability

This section presents the results of Theme 6, which details the influencing factors related to local communities in and around mining operations and the sustainability of mining. This section discusses how these factors influence technology adoption for mining organisations. This section further provides detailed results on the three categories which makes up the theme, which are: 1. Community and stakeholder engagement; 2. Socio-economic development for the mining communities; and 3. Ethics of conducting business.

5.3.6.1 Community and stakeholder engagement

There was agreement from all the respondents in the platinum commodity cluster that they have experienced increased engagement with local mining communities. This was confirmed by quotes from Platinum 3 and Platinum 4. Platinum 4 made a comment in Theme 3 that social unrest was being used as an investment selection criterion over and above financial returns. This follows the ongoing social unrest experienced in the past, which meant that the company lost revenue following production downtime.

> *"Absolutely, it doesn't help if you have a fantastic resource and you can't unlock it because you have social unrest every single day, all day because of you've been thinking you've been smart and shifting a return on capital employed." [Platinum 4]*

Platinum 3 also mentioned that they have faced challenges as they continued to mine too close to a community area and have since been forced to put up the mine for sale.

> *"We have closed that down this year because of the challenges of running it inside the community there at the moment and we are actually putting the mine up for sale." [Platinum 3]*

Following the regional challenges experienced by mining organisations and especially by the platinum commodity sector, the mining industry has put plans in place to help address the issue nationally. Having recognised the challenge, Expert 3 mentioned that the mining industry's employers' organisation has also recognised the important role played by the local mining communities.

> *"We have started with some community development. The industry council was national competence. So, we only deal with national problems but at some point, there was a recognition of the challenges that companies face regionally." [Expert 3]*

Some of the respondents referred to their awareness of attaining government endorsement when getting involved and investing in local communities. Such endorsement enables them to have good relations with government, which is important for business.

> *"We got these opportunities potentially with this communities. The Mayor or the MEC and the President will say that's fantastic guys," [Platinum 4]*

5.3.6.2 Socio-economic development for the mining communities

Most of the respondents agreed with Platinum 2 that it would be game changing if they could find an opportunity to partner with local communities and involve them as manufactures in the mining value chain. These challenges with mining communities mentioned in section 5.3.6.1 have necessitated mining companies to look at involving communities and finding economic opportunities for shared value.

> *"Do you know what a big opportunity there is out there to actually have the communities involved from a potential infrastructure [perspective] where they can do supplies and local manufacturing." [Platinum 2]*

Most respondents in all the commodity clusters referred to the potential importance and involvement of mining operations on the economic and social viability of the communities living in and around these mining operations. Diamond 3 confirmed and agreed with Platinum 2 in saying that mining companies are encouraged to invest in local mining communities in order to attain social endorsement for operating in the area. This was described by the respondents as a social licence to operate.

Some of the respondents agreed with Diamond 3 when he mentioned that the future of mining is expected to have a smaller workforce, alluding to the prominence of automation in the value chain. However, he also mentioned that mining companies should include

social investment for infrastructure and social development of local communities to ensure a sustainable livelihood for the community.

> *"The mine of the future is not going to provide a lot of jobs necessarily, but it can provide thriving [communities]… it can provide social services, whatever, simplicity in some benefit from the community in terms of the financials as well." [Diamond 3]*

Some of the respondents agreed with Platinum 2 in mentioning that mining companies need to introduce environmentally friendly processes in order to comply with sustainable development goals.

> *"Now don't forget the green mining option, because we are talking about our social licence to operate." [Platinum 2]*

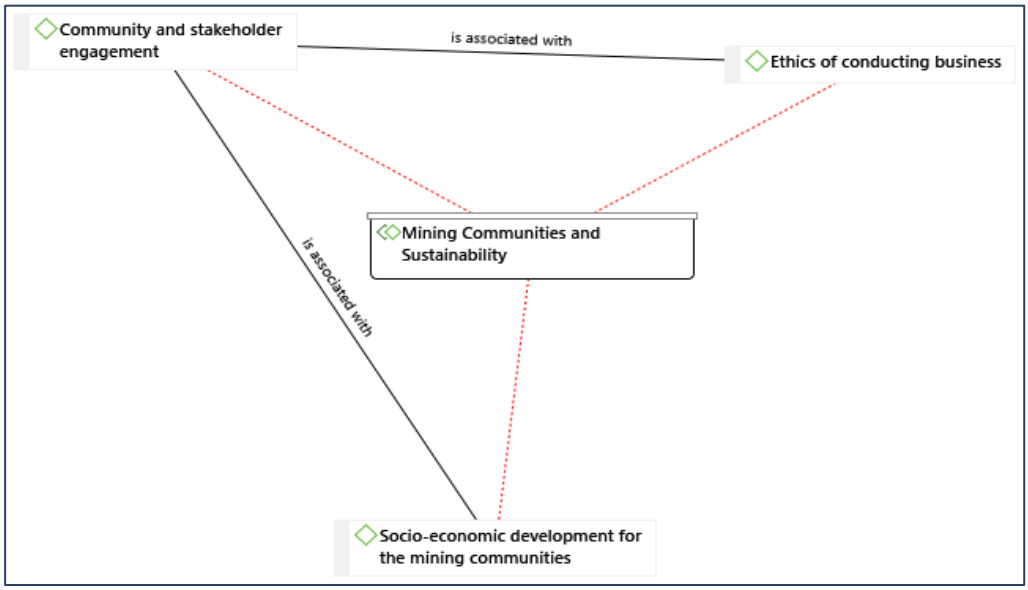
5.3.6.3 Ethics of conducting business

Expert 2 agreed with Platinum 2 and some of the respondents about the need to introduce environmentally friendly processes in order to retain their social company brand and to account to stakeholders. Expert 2 also made an interesting reference to the importance of companies conducting their business in an ethical manner.

> *"The community and organisations are so sensitive to the environment and the operations and ethics of the operations, I think we should create this awareness." [Expert 2]*

Figure 5-7 presents the associations of the mining communities and the sustainability theme.

Figure 5-7: Network diagram for the mining communities and sustainability theme



There was an association between community and stakeholder engagement and socio-economic development for the mining communities. Most respondents agreed that mining companies need to lead in engaging the local communities and getting involved in identifying opportunities for communities to be involved in the business value chain.

Some respondents alluded to a shared value model where mining companies seek for opportunities to invest in community services and infrastructure for the sustainability of local communities. Figure 5-7 shows an association between ethics of conducting business and socio-economic development for the mining communities. Mining companies were expected to demonstrate ethical conduct as they went about investing in local communities and in applying environmentally friendly processes that demonstrate their commitment to the local environment.

5.3.7 Summary of the Six Themes

Tables 5-3 to 5-8 present the themes and categories in association with the research questions and refer to the agreement of respondents on the data captured. These tables will be used in section 5.4 to answer the research questions detailed in Chapter 3.

Theme 1 Summary: Value Drivers

Table 5-3 shows that all respondents from the various commodity clusters agreed that mining companies are motivated to make changes to their process value chain by adopting technology solutions. Mining companies are motivated to invest in technology because they need to achieve certain business goals through driving particular initiatives related to the value drivers. Value drivers can be said to be the burning platform and detail the key influencing factors for mining companies in need of modernising their operations. All respondents agreed on introducing technology solutions to improve the safety and health working environment including complying with legislative requirements in this regard.

The second and third value drivers for implementing technology were to improve efficiency and productivity in order to drive down costs, which was agreed upon by all respondents including being confirmed by industry experts. Most respondents mentioned that they have been under pressure due to high production during the low commodity price cycles and that now they needed to focus on reducing costs in order to improve profit margins.

Some of the respondents agreed on investing in technology solutions that would enable them to decrease energy consumption, which would result in reducing their carbon footprint and using less water in their processes.

Some of the respondents referred to investing in technologies that would unlock future resource value, which was a medium- to long-term strategy objective depending on the life of the mine. Mining organisations that were investing in longer-term objectives were understood to have achieved short-term business objectives, which allowed them to then make long-term investments and commitments.

Figure 5-2 indicates a contradicting association between cost savings and environmental sustainability value drivers. The reason for this is that an investment into safety and health improvement is usually a costly exercise and might not result in improved margins.

Table 5-3: Association between Theme 1 categories, respondents' agreement and the research questions

Theme 1	Categories	Respondents agreement	Organisation factors	Critical factors	Enabling factors	Inhibiting factors
Technology Value Drivers	Safety improvement	**All**	**X**	**X**	**-**	**-**
	Efficiency and productivity improvement	**All**	**X**	**X**	**-**	**-**
	Cost savings	**All**	**X**	**X**	**-**	**-**
	Environmental sustainability	**Some**	**X**	**X**	**X**	

Theme 2 Summary: Technology readiness and Appropriate Innovation Solutions

The reason for companies needing to invest in research and development specifically was to determine environmentally friendly solutions that are commercially lacking or not readily available. This sentiment was mentioned by most respondents, as shown in Table 5-4, which creates a burning platform for investments into research and development and to fulfil the innovative nature of the solution required. However, only some respondents agreed on making investments into research and development.

The majority of the respondents agreed that there was a low impetus for mining companies in South Africa to take up the risk associated with making the commitment to adopt low maturity solutions into their process value chain. All respondents agreed that it was important for mining companies to test and demonstrate the feasibility and viability of a technology solution in order to make stakeholders aware thereof and to receive their buy-in. This process was necessary for acceptance of the technology.

An appropriate technology was described as one that was technically viable. All respondents agreed to implementing technology solutions that were technically and economically viable, linked to the business value drivers and goals.

Some respondents who accepted technology solutions with low readiness levels referred to the importance of having site champions at the correct level in the organisation for effective influence regarding the technology solution. The champions' role was highlighted as having to support the technology and ensure that it is well tested for its appropriateness and proven to be financially viable.

Most respondents agreed that it was necessary to possess skills such as computing and engineering, also known as digital skills that would enable the adoption of technology solutions and that there was a shortage of these skills in South Africa.

Table 5-4: Association between Theme 2 categories, respondents' agreement and the research questions

Theme 2	Categories	Respondents agreement	Organisation factors	Critical factors	Enabling factors	Inhibiting factors
Technology readiness and Appropriate Innovation Solutions	Technology readiness	**Most**	**-**	**X**	**-**	**X**
	Feasibility and availability of technology solutions	**All**	**X**	**X**	**X**	
	Appropriateness of technology solutions	**All**	**X**	**X**	**-**	**-**
	Availability of technical skills	**Most**	**-**	**X**	**-**	**X**

Theme 3 Summary: Investment funding for Modernisation

Table 5-5 below shows that most respondents agreed that it was necessary to make some form of investment towards introducing a technology solution and that some form of structure was needed in terms of how mining organisations allocated funds for this investment. The funding process involves evaluating the company's financial position and allocating funds according to the order of business priorities and value delivery.

The most commonly used term to evaluate the value to be delivered for the business was the business case. Most respondents regarded the use of ROCE as an inhibitor for modernisation, as it is one of the financial measures used to measure value delivered which does not support new technology innovation. It is difficult to prove value for a new solution as it does not have a proven historical value delivered.

Table 5-5: Association between Theme 3 categories, respondents' agreement and the research questions

Theme 3	Categories	Respondents agreement	Organisation factors	Critical factors	Enabling factors	Inhibiting factors
Investment funding for Modernisation	Capital requirements	**Most**	**X**	**X**	**-**	**X -**
	Funding and Structure	**Most**	**X**	**-**	**-**	**X**
	Return on capital employed (ROCE)	**Most**	**X**	**-**	**-**	**X**

5.3.8 Theme 4 Summary: Executive Support and Execution

Table 5-6 below shows that all respondents agreed that executives were normally involved in approval of funds necessary for technology implementation and in leading awareness about the technology to other executives. The role of a sponsor includes being supportive, championing for the initiative at a senior level and initiating conversations to socialise the initiative with other executive and senior managers, including influencing the necessary committees to support the initiative. Most of the respondents agreed that a sponsor must have the right approach, attributes and leadership skills in order to influence accordingly.

All respondents agreed that employee relations was an important element for successful acceptance of a new solution or for technology innovation. The results also indicated that it was necessary to have an inclusive culture that involved the employees from the start and throughout the process to ensure their involvement along the way, resulting in their ownership of the solution.

The execution of technology projects should include enabling infrastructure for equipment communication and completion of milestones to mark achievements of value by adopting technology. All the respondents mentioned that technology implementation should be looked at as a system and that it was necessary to have the technology solutions integrated into business processes in order to achieve full adoption.

Table 5-6: Association between Theme 4 categories, respondents' agreement and the research questions

Themes 4	Categories	Respondents agreement	Organisation factors	Critical factors	Enabling factors	Inhibiting factors
Executive Support	Executive sponsorship and leadership	**All**	**X**	**X**	**X**	**-**

and Execution	Employee-Employer relations	**All**	**X**	**X**	**X**	**-**
	Technology Implementation	**All**	**X**	**X**	**-**	**X**

Theme 5 Summary: Change management and behavioural factors

Table 5-7 shows that all respondents identified communication as being an important factor necessary to facilitate change for acceptance of technology solutions. All respondents agreed that communication was required from the start of the technology project in order to make a case for why the change or solution was required for the business.

All respondents agreed that people were not the threat when it comes to new technology, but that people were willing to make the necessary change if the expected outcome was anticipated to benefit and be positive for them in the long term.

There was an agreement by all the respondents that an innovative culture was required to enable change by communicating to stakeholders and allowing them to make decisions in terms of how they perceive the technology solution. It was agreed that organisational culture ultimately determines the level of ease during the change adoption process and that behavioural and mindset change were elements of change.

Table 5-7: Association between Theme 5 categories, respondents' agreement and the research questions

Theme 5	Categories	Respondents agreement	Organisation factors	Critical factors	Enabling factors	Inhibiting factors
Change management and behavioural factors	Communication for buy-in and support	All	X	X	X	-
	Contextualising the required change	All	X	X	X	-
	Organisational culture	All	X	-	X	-
	Behavioural change	All	-	X	X	X

Theme 6 Summary: Mining Communities and Sustainability

There was agreement from some respondents from the platinum cluster that there were increased engagements with local mining communities, following the ongoing social unrest experienced in the past which resulted in platinum mining companies losing revenue due to production downtimes. Table 5-8 shows that most respondents agreed that mining companies need to lead engagements with local communities and in identifying economic

opportunities for the community's sustainability. Some respondents alluded to a shared value model where mining companies seek for opportunities to invest in community services and infrastructure for the sustainability of local communities. Some of the respondents mentioned that mining companies were expected to demonstrate ethical conduct in investing in local communities and in applying environmentally friendly processes.

Table 5-8: Association between Theme 6 categories, respondents' agreement and the research questions

Theme 6	Categories	Respondents agreement	Organisation factors	Critical factors	Enabling factors	Inhibiting factors
Mining Communities and Sustainability	Community and stakeholder engagement	**Most**	**-**	**X**	**X**	**-**
	Socio-economic development for the mining communities	**Most**	**-**	**X**	**-**	**X**
	Ethics of conducting business	**Some**	**X**		**X**	

5.4 Answering the Research Questions

The primary research question for this study was to understand the critical organisational factors that support or inhibit the acceptance of technology solutions for effective adoption of modernisation in the mining industry of South Africa.

5.4.1 Factors that influence the acceptance of technology solutions in the mining industry, limited to South Africa

Based on the findings of the study, it is evident that the factors for acceptance of technology-based solutions were linked to the delivery of the organisations' business strategic goals in delivering value for all stakeholders in the short, medium and long term. These factors were derived following the respondents use of emphasised wording such as "this is key" or "it is crucial". This emphasis was also made following an understanding of the level of seniority and the experience gathered by the respondents, some of whom are deemed to be industry experts specifically in modernisation.

These factors have been further classified into organisational and external factors, which are believed to assist mining organisations to also classify resources according to internal

and external factors, including providing a guide to industry representatives to focus on the external factors in support of mining organisations collectively.

5.4.1.1 Business Value Driver factors

Table 5-9 shows the organisational value driver factors that influence and motivate mining companies to introduce technology solutions as part of their company initiatives or plans, to support business strategic goals that influence the acceptance of technology solutions. All respondents including industry experts agreed that mining companies need to adopt technology solutions driven by the value that is expected from them. All respondents confirmed that they were motivated by safety and health improvements, including the need to comply with the safety regulations enforced by the Department of Mineral Resources (DMR).

Table 5-9: Business value drivers that influence companies to adopt technology

Organisational factors that influence the acceptance of technology solutions		**Details of organisation value drivers**
Business Value Drivers	Safety, health & legislative requirements	✓ All respondents agreed that mining companies are required to ensure safe and healthy working environments for their employees ✓ All respondents agreed that mining companies need to comply with the Mine and Safety Act of 1996 and to meet the required safety and health standards set as part of regulatory control requirements for the operating mining licence
	Efficiency & productivity improvements	✓ All respondents agreed that mining companies must continuously improve their processes in order to achieve more production output with minimum input, which refers to improving efficiencies. The organisations also need to become more productive in order to be competitive
	Cost reduction	✓ All respondents agreed that mining companies have been under pressure to reduce their high production costs in order to improve their margins and be competitive. Reducing cost has been a key focus area for being profitable and staying in business
	Environmental sustainability	✓ Some respondents mentioned that mining companies need to introduce environmentally friendly processes in order to comply with sustainable development goals ✓ Some of the respondents agreed to investing in technology solutions that would enable them to decrease energy consumption, which would result in having a reduced carbon footprint and using less water in their processes
	Unlocking future resources	✓ Some of the respondents referred to investing in technologies that would unlock future resource value, which was a medium- to long-term strategy objective depending on the life of the mine

5.4.1.2 Technology execution and adoption factors

Table 5-10 displays the organisational factors that influence the implementation of technology solutions and integration of these solutions as part of the mining process value chain. These factors include investment funding that is required to procure and implement technology solutions. Most respondents agreed that investment funding was an essential part of modernisation and that there was some form of a capital allocation process linked to the business case for every project that required capital. Some of the respondents mentioned that funding models drive the types of projects that the business executes.

All the respondents agreed that the executive sponsor's role was important for promoting, socialising and acquiring acceptance of the technology solution in the organisation.

Table 5-10: Organisational factors that influence the execution and adoption of technology solutions

Organisational factors that influence the acceptance of technology solutions		**Details of organisation value drivers**
Technology Execution and Adoption	Investment funding	✓ Investment funding was an integral process of implementing technology solutions across the mining value chain, as funding is required for automation or procuring technology required
	Executive sponsorship	✓ All the respondents agreed that the executive sponsor's role was important for promoting, socialising and gaining acceptance of the technology solution in the organisation
	Demonstrate for feasibility & viability	✓
	Integrate technology implementation into the business process	✓ All respondents referred to the importance of having the technology solutions integrated into the business processes

5.4.1.3 Change behavioural factors

The change and behavioural factors that influence the acceptance of technology solutions are outlined in Table 5-11 below. These factors include 1. Communication which was agreed to be an important factor necessary to facilitate change for acceptance of technology solutions 2. Employee engagement which is facilitated by communication and 3. Change management to contextualise and drive behavioural change

Table 5-11: Change and behavioural organisational factors that influence acceptance of technology solutions

Organisational factors that influence the acceptance of technology solutions		**Details of organisation value drivers**
Change Behavioural Factors	Communication	✓ Communication as being an important factor necessary to facilitate change for acceptance of technology solutions.
	Employee engagement	✓ There was agreement that it was important to communicate widely to affected and impacted employees in order to take employees along, to gain their trust and acceptance.
	Change management	✓ All the respondents agreed that change management was a critical process that required a great deal of focused resources in order to properly understand the impact caused by introducing the new technology and to drive the necessary change to influence the acceptance of the technology solution. ✓ Most respondents described behavioural change as an individual's mindsets and perceptions towards the benefits of the technology innovation, pertaining to them. It was necessary in ensuring that individuals formulate their own opinions which is necessary for change.

5.4.1.4 Factors External to the organisation

Table 5-12 details the factors that are external to the organisation, that influence acceptance of technology solution in a mining environment. These external factors include 1. Stakeholder engagement and 2. Social licence to operate

Table 5-12: External factors that influence the acceptance of technology adoption in mining

Factors that influence the acceptance of technology solutions		**Details of organisation value drivers**
Factors that are external to the organisation	Stakeholder engagement	✓ The involvement of mining communities was mentioned to be an important factor for mining organisation wanting to achieve stability, which is linked to the sustainability of mining operations. ✓ Mining communities form part of the stakeholders who should be made aware of the drive for modernisation, in order to consider what it means for them in terms of contributing to the sustainable socio-economic status of their communities. ✓ Mining companies were encouraged to drive the engagements with government in order to build good relations.
	Social licence to operate	✓ Mining companies are encouraged to invest in local mining communities in order to attain social endorsement for operating in the area, which was described by the respondents as a social licence to operate.

5.4.2 Factors that enable acceptance of technology solutions in the mining industry, limited to South Africa

In addition to the main factors that support the acceptance of technology for effective modernisation, there are enabling factors that also support the acceptance of technology and these are outlined in Table 5-13.

Table 5-13: Factors that enable acceptance of technology solutions

Enabling factors	Details of the factors
Research and development	✓ Research and development is required in order to develop appropriate technology solutions through a process of testing, developing and demonstrating that a technology solution is fit for providing the solution
Funds dedicated for modernisation	✓ Most respondents agreed that capital funding was an essential part of modernisation and that funds that are dedicated to technology adoption enable the process of investigating appropriate technologies to drive value for the business
IS infrastructure	✓ Some of the respondents highlighted the importance of having enabling information systems infrastructure necessary for equipment communication and successful utilisation of the technology solutions
Organisational culture	✓ An innovative culture that enables a collaborative environment where information is shared and where employees are encouraged to discuss their ideas was mentioned by many respondents
Business ethics	✓ Some of the respondents mentioned that mining companies were expected to demonstrate ethical conduct

5.4.3 Factors that inhibit the acceptance of technology solutions in the mining industry, limited to South Africa

This section details the factors identified by respondents as potentially inhibiting and preventing technology solutions from being widely accepted, thus preventing mining companies from being effective in their modernisation drive. These inhibiting factors are detailed as follows:

- Low technology readiness levels
- Capital funding
- The lack of required digital skills necessary for executing technology functions
- Behavioural change

Technology readiness was cited by most respondents as the level of maturity of a technology innovation, either tested or implemented in a mining production environment.

Most of the respondents agreed that there was low impetus for mining companies to accept low readiness level technology, which was associated with high risk of introducing an unproven technology into an operational business value chain. This was described as an inhibitor for technology adoption as companies avoid accepting technologies that have a low readiness level.

According to the respondents and industry experts, a lack of funding was a definite inhibitor for introducing a technology solution. This follows comments by some of the respondents that machine automation was a significant area of technology implementation. However, this cannot be achieved unless companies invest capital in automating or replacing existing equipment with autonomous equipment, which was confirmed to require additional capital that companies need to avail funds for.

The effective adoption of technology also requires the right skills, hence a lack of skills for the implementation of the technology serves as an inhibitor to the effective adoption of the modernisation technology.

Behavioural change can also be an inhibitor to the effective adoption of technology as there could be resistance to change amongst the employees, who are the main implementers of the technology solution. It is therefore critical that there is proper change management of any technology solution, as a lack thereof can be an inhibitor to the effective adoption of the modernisation technology.

5.5 Conclusion

In conclusion, there was agreement by most respondents that mining companies should be guided by organisational factors highlighted as driving the acceptance of technology solutions in mining. Respondents agreed that equal attention should be given to addressing external factors necessary for modernisation and that industry representatives should seek opportunities for addressing these factors as a collective. The following chapter discusses the results of the study, with reference to confirming or contradicting the findings from academic and business literature detailed in Chapter 2.

Chapter 6:DISCUSSION OF RESULTS

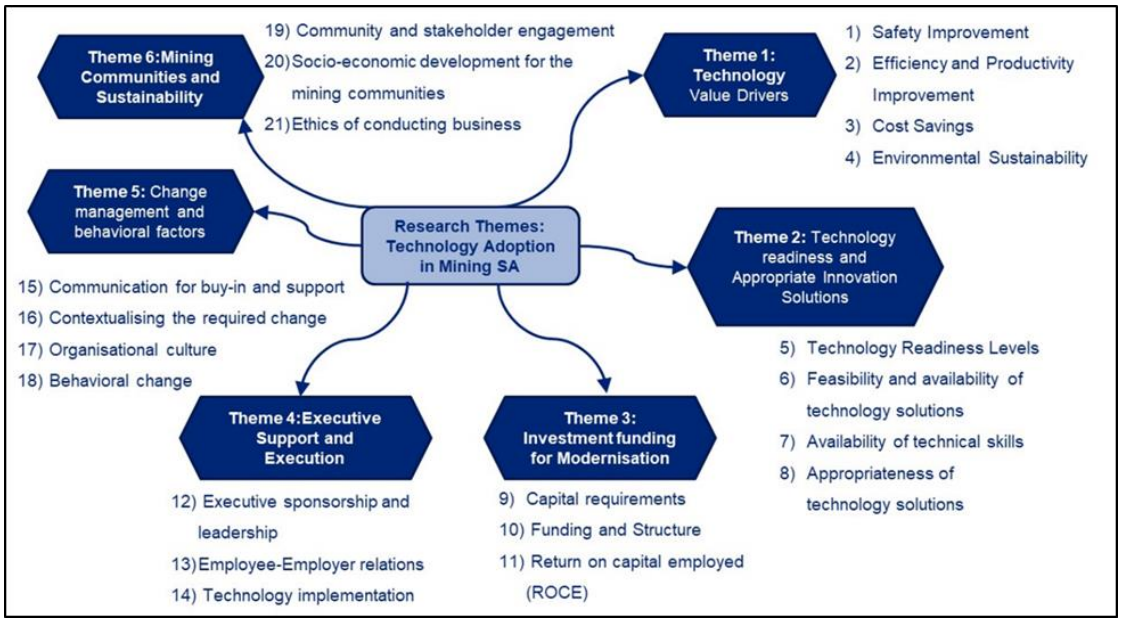
6.1 Introduction

This chapter discusses the results of the findings in reference to the research study, the questions detailed in Chapter 3 and contrasts them with issues appearing in the literature. This research study aims to explore the factors that influence the acceptance of technology-based solutions across the mining value chain, limited to South Africa. The sequence for Chapter 5 will be kept and used for Chapter 6, as this chapter aims to discuss the results in context of the literature review outlined in Chapter 2. This chapter will compare the findings in Chapter 5 and will confirm or contradict the findings with characteristics and factors from academic and business literature detailed in Chapter 2. This chapter also provides a discussion on the new findings discovered by the research study as a new contribution towards expanding the body of knowledge in the field of technology management.

6.2 Theme Findings

The findings from the data gathered were classified into six themes detailed in Chapter 5. The following themes shown in Figure 6-1 will be discussed in reference to the literature in order to analyse and understand the influence of these themes on the acceptance of technological solutions for the mining industry in South Africa. This synthesis will then be used in answering the three sub-research questions to answer the principal research question outlined in Chapter 3.

Figure 6-1: Diagram showing Research Themes and groups of codes (Researcher, 2019)



6.2.1 Theme 1: The influence of business value drivers

This section discusses the results presented in Chapter 5, section 5.3.1 and refers to literature in order to confirm or dispute or add to the existing body of knowledge. The objective is to understand the influence of value drivers on effective adoption of modernisation across mining operations. This section also discusses each value driver comprehensively in order to provide conclusions for readers on how to approach technology investments.

In the findings of section 5.1, the transcript extract from Diamond 3 from the diamond commodity cluster articulated and captured what most of the respondents stated regarding how critical business value drivers are for acceptance of technology in their organisations. He made mention that everything starts with a business need, which explains the drive for companies to make a commitment towards a specific solution to fulfil a business requirement. According to the researcher's experience, having worked in the industry for fifteen years, mining organisations make use of a value driver tree-process to link operational key performance indicators (KPIs) such as efficiencies and production outputs to company financials and business targets.

There was consensus between all three industry experts and the respondents from the various mining commodity clusters regarding the importance of business value as a motivating factor for adoption of technology by organisations. They agreed that the main motivation for mining organisations to adopt technology solutions is driven by the need to meet strategic business goals, also referred to as business value drivers.

These value drivers have been identified by Iacovou et al. (1995) as being the key consequent or perceived benefits that influence mining companies to adopt technology innovations. This theory is also supported by Aizstrauta et al. (2015), who discuss relative advantage as one of the five attributes of innovation, which is a concept related to perceived value. Organisations tend to adopt technology due to relative advantage, which may be associated with economic profitability, low initial cost or whatever driver a business intends to achieve (Aizstrauta et al., 2015). This therefore confirms the statement made by Mavroudis and Pierburg (2017) that parallels exist between key elements or characteristics in adopting technology for the information systems (IS) and mining industry. This is due to the IS infrastructure required as a basis to enable technology innovation in mining.

Expert 3 agreed that the adoption of modernisation in mining is driven by the need for mining businesses to recover from their current state and become profitable in the future. According to Lane et al. (2015), South African mining companies are worse off compared to their global counterparts as they are faced with additional pressures brought about by the local environment, as confirmed by Oliveira and Martins (2010).

The Minerals Council South Africa acts as a representative body for mining organisations in the country and can thus be assumed to have a mandate to speak on behalf of the mining industry. This confirms that South African mining companies are motivated by the benefits of improving safety and health by creating safer working environments, as well as improving efficiencies and productivity to drive down operational costs.

Value drivers were mentioned by most respondents from all the commodity clusters as the foremost motivating factor used by organisations to justify their decision to commit towards the adoption of technology and innovative solutions in order to deliver value for their shareholders. These findings confirm the academic theory by Iacovou et al. (1995), who argued that the perceived benefit is one of the main drivers that influence organisations to adopt information technology (IT) innovation. This argument is further confirmed by Aizstrauta et al. (2015), Bryant (2015) and Lane et al. (2015), who also argue for the motivation for technology adoption and recommend the adoption of technology solutions as a way for mining companies to redress the recent state of economic decline experienced within the industry.

The majority of respondents identified four main strategic drivers as being the primary reasons why mining companies adopt automation and other innovation technology solutions to achieve business goals. The respondents highlighted the key value drivers as safety improvements, efficiency and productivity improvements, the reduction of operational costs and environmental sustainability. These key value drivers were confirmed by Bryant (2015), Lane et al. (2015), Mavroudis and Pierburg (2017), Stanway et al. (2017) and other authors in Chapter 2. These drivers were identified as being key benefits that influence mining companies to transform their way of doing things by introducing technology innovations to ensure that they redress the current economic reality.

Safety improvement

All respondents from the mining organisations across the commodity clusters agreed that there has been a focus to improve safety and health conditions in the sector. Iron two from the iron ore cluster together with Platinum 2 from the platinum commodity cluster emphasised the importance of safety improvements and also mentioned that this is a regulatory requirement. This data was confirmed from literature by Mavroudis and Pierburg (2017) and Stanway et al. (2017) that mining modernisation is focused on meeting regulatory requirements and maintaining safer a work environment for employees and to maintain equipment standards.

It is the researcher's opinion that the drive for zero harm and to create a safer working environment has recently become a leading focus for the South African mining industry. This follows the enforcement of safety and health regulations by the Department of Mineral Resources (DMR), with failure to comply to these regulations leading to the possible revocation of the operations licence (Department of Mineral Resources, 2016).

Expert 4 mentioned that the failure to comply with safety and health regulations has previously resulted in high cost for the mining company due to lost production time which can never be recovered. The consequences of failure to comply with safety and health regulations can thus be detrimental for a mining company, as it may also result in reputational damage for the company as employees might enforce legal actions in this regard.

As concluded from the data in Chapter 5, section 5.3, the statement that the safety value driver may contradict the cost savings value driver is not entirely true, as there is a cost avoidance benefit that is associated with ensuring the safety of employees. Accordingly, this statement should be reviewed. As mentioned by one of the expert respondents in a published report, there is more emphasis on the safety of employees as they play a critical role in the mining industry and, furthermore, that modernisation should be driven to include safety and health benefits for employees (Van Der Woude & MacFarlane, 2016). There is a need to create a safer and healthier working environment for all stakeholders, as this will enable stakeholders to realise the value brought by modernisation (Minerals Council South Africa, 2016).

Efficiency and productivity improvement

Iron Ore 1 from the iron ore cluster agreed with most respondents from all mining commodity clusters that mining companies are adopting technology-based solutions with

the aim of improving productivity targets. This was also confirmed by industry Expert 1 and Expert 3. There was consensus among most authors including Ernst and Young (2015) and Mavroudis and Pierburg (2017) that most companies are focused on technology solutions that would assist them to redress their productivity and efficiency losses, which have eroded in recent years due to chasing tonnage increases during the commodity boom cycle. The conclusion from the research is that mining companies are focusing on technology solutions to address immediate challenges and that their investment is focused on the short term.

Cost savings

Most of the respondents mentioned high labour and energy cost for mining operators as the two main contributors of high operational cost. These energy and labour cost drivers were confirmed by Lane et al. (2015) and the Facts and Figures 2017 report released by the Minerals Council South Africa (2018). South African mining companies are driving efforts to reduce operating costs in an attempt to improve profit margins and become competitive again. The influence of the cost value driver as a motivation for mining companies to adopt modernisation was confirmed by Lane et al. (2015), Bryant (2015) and Jacobs and Webber-Youngman (2017). The reason for this is that mining operations are mechanised in efforts to increase efficiencies and productivity, which translates to more profit with less inputs as articulated by Mavroudis and Pierburg (2017).

Environmental Sustainability

Most of the respondents from the platinum commodity cluster mentioned that environmental sustainability was one of the drivers for implementing technology solutions with the objective to minimise their carbon footprint and water utilisation. Platinum 3 made a comment in section 5.3.1.3 that energy costs were on the increase and they were therefore looking for technologies with less intensive energy requirements. This statement was confirmed by Bryant (2015), who noted that energy inefficiencies have been alarming as only 12% of the energy from equipment is contributing towards delivering production, while the rest of the energy is dissipated as heat or friction etc.

The Minerals Council South Africa confirmed environmental sustainability as one of the drivers for modernisation and defined the scope for modernisation in six areas, one of which is environmental sustainably (Minerals Council South Africa, 2016). The objective of conservation of finite valuable natural resources and restoration of the environment was mentioned as follows:

> *"Conservation of natural resources, preservation and restoration of the environment"* (Minerals Council South Africa, 2016, p.1).

The above statement confirms the important of preserving natural resources to deliver environmentally friendly solutions that will ensure sustainability in the long term. According to Basu et al. (2015), mining operations have historically resulted in seriously damaging impacts on the environment and society, especially local mining communities. This statement has been confirmed by Bryant (2015), who noted that mining communities and governmental regulatory bodies have growing concerns regarding the historical damage that mining organisations have caused and, as a result, are enforcing stricter laws on mining companies to apply environmentally friendly processes.

Unlocking future resources value

Iron Ore 1 from the iron ore cluster mentioned the unlocking of future resource value as a strategic value driver. This motivation for securing the future of mining comes as a unique finding when compared with the other respondents, as most respondents are looking at surviving today and not necessary at securing future resources given the depressed state of the economy. However, this contradicts the value driver as highlighted by Lane et al. (2015), the Minerals Council South Africa (2016) and Jacobs and Webber-Youngman (2017), who noted that mining companies ought to secure future resources by investing in more rapid discovery of resources and investigating new beneficiation methods to mine low grade ores. The conclusion from the research is that mining companies that commit investments into the future have achieved some of their targets, such as improved efficiencies and having achieved profitability targets and commodity price recovery. They have overcome their immediate challenge and have therefore made sufficient funds available for paying their operational costs, including investing for the long term.

According to Mavroudis (2017) and Stanway et al. (2017), mining companies operate their business as guided by the company's strategic goals, which direct the investments made by the business in order to maximise returns for shareholders. According to key literature, the unlocking of future value from resources is a motivational factor for some of the mining businesses to commit towards investigating technology solutions for the treatment or beneficiation of low grade resources to improve resource utilisation and secure the future of mining (Lane et al., 2015; Jacobs & Webber-Youngman, 2017).

Conclusion

In conclusion, the mining companies are motivated by the need to achieve certain benefits that are linked to business goals, and these are called value drivers. This value driver factor was supported and confirmed by the model of Iacovou et al. (1995), which details the perceived benefit that motivates organisations to adopt technologies.

6.2.2 The influence of technology readiness and appropriate solutions

This section discusses the results presented in Chapter 5, section 5.3.2 and refers to literature in order to confirm or contradict or add to the existing body of knowledge. The objective was to understand the influence of technology readiness and appropriate solutions for effective adoption of modernisation across mining operations. This section also discusses the four contributing factors in this regard, which are as follows: 1. Technology readiness Levels; 2. Feasibility and availability of technology solutions; 3. Availability of technical skills; and 4. Appropriateness of the technology solutions. These factors are discussed in order to provide conclusions for readers on how to approach technology adoption in the mining sector.

Most respondents agreed that the availability of new technology solutions is important and enables adoption of appropriate solutions. They also elaborated on the risk associated with introducing new technology into their processes. Most respondents explained the process followed in benchmarking, selecting relevant suppliers and adopting appropriate technology solutions. Platinum 3 is a mining executive who agreed that their company is committed to taking up some level of risk associated with technology innovation, and they therefore use a test mine to minimise the risk of introducing low maturity solutions into their production process.

The majority of respondents agreed with industry experts in saying that mining companies in South Africa have been reluctant in taking up technology innovation that has not been proven and has a low readiness level due to the risk of adopting it into the mining value chain. The reason for this is because the industry is already under pressure having to manage operational challenges to meet production targets, including external pressures of competing with their peers.

Technology readiness level has been defined by Jacobs and Webber-Youngman (2017) as the maturity level of an innovation, which is associated with the risk of adopting the technology component integration into a system application. This fact was confirmed by Lane et al. (2015) in discussing the state that South African mining companies find

themselves in today and the additional pressures faced such as labour unrests, uncertain regulatory environment and rising government demands.

Most of the respondents agreed on the importance of technology innovation and research and development required to develop appropriate innovative solutions. The researcher's opinion is that the industry has missed an opportunity to invest in and establish the necessary research and development centres similar to CSIRO Australia. Australia's national science research agency, CSIRO was formed in 1916 and is now a global leader in science and technology research (CSIRO Australia, 2017). The institution's main focus is to develop innovative solutions for Australia's mining and manufacturing sectors to ensure that they remains productive, competitive and sustainable (CSIRO Australia, 2017). This finding was confirmed by Jacobs and Webber-Youngman (2017) and Mavroudis and Pierburg (2017), who indicated the importance of having original equipment manufacturers (OEM) in partnership with mining operators in order to develop appropriate technology solutions that would solve the required operational challenges.

Most of the respondents agreed that it is the responsibility of mining operators to identify, test the viability of and implement technology solutions within an existing operations value chain process. Platinum 3 confirmed that they have invested in a test mine where most of the technology innovations are tested before adopted into a production value chain, thus reducing the risk significantly. These developments require commitment of resources from both technology suppliers and mining operations to take the technology innovation to the commercialisation stage. This finding was confirmed by Jacobs and Webber-Youngman (2017), Mavroudis and Pierburg (2017) and Stanway et al. (2017).

The majority of respondents mentioned the need for mining companies to possess relevant digital skills such as computer, engineering, chemical, analytics and coding skills as part of preparing their organisations for the digital age and the adoption of technology solutions. Companies encounter difficulty in filling vacancies with competent and skilled individuals, as these skills are not easily attainable given the low levels of qualifications in the country.

This also explains the difficulty in addressing the unemployment rate. According to the unskilled labour report released in 2018, South Africa had a 27,7% unemployment rate with 59% of individuals having less than a matric qualification, though the report excluded discouraged work seekers who were not economically active (Laubscher, 2018). The data further showed that 77% of the individuals who were not active economically had less than a matric qualification (Laubscher, 2018).

Platinum 3 specifically mentioned that their business has advanced in empowering their employees together with students in local mining communities with the necessary digital skills required by their organisation. These findings were confirmed by Sirinanda (2019), who noted that mining companies should add professional dynamic capabilities in technology to understand the integration of technology innovations into the mining value chain. This includes an understanding of digital strategy, analytics, software development, optimisation and innovation.

The researcher's opinion is that it is easier for larger size mining companies to develop innovation, as they have the capability in terms of resources and skills required to partner with technology suppliers to sustain their competitiveness. However, this task is daunting for smaller mining companies to justify, as they are required to invest capital that might be sunk eventually due to the uncertain nature of research and development.

Conclusion

In conclusion, there was a clear association between technology readiness and the availability of technology innovation, as the need exists to ensure that mining organisations possess the necessary digital skills available for implementing appropriate technology solutions across the mining value chain.

6.2.3 The influence of investment funding for modernisation

This section discusses the results presented in Chapter 5, section 5.3.3 and refers to literature in order to confirm or dispute or add to the existing body of knowledge. The objective is to understand the influence of investment funding for effective adoption of modernisation across mining operations. This section also discusses the three contributing factors for modernisation in order to provide conclusions for readers on how to approach technology adoption in the mining sector. These factors are: 1. Capital requirements; 2. Funding and structure; and 3. Return on capital employed (ROCE).

Most respondents agreed with Platinum 3 on the importance of capital requirement as a critical element for adopting technology innovation. The majority of respondents agreed on the requirement of a business case to justify technology capital. The researcher's experience is that the process of capital allocation is generally justified using a business case which clarifies the need for the investment. These findings were confirmed by Bryant (2015) and Mavroudis and Pierburg (2017), who mentioned the need to spend capital in

order to implement required infrastructure and, in the case of automation, that capital is also required for procurement of hardware to be installed.

According to Bryant (2015), technology innovation has been disadvantaged by cost savings drives, which have resulted in a capital restriction and industry consolidation following economic pressures on commodity prices. This capital dilemma is echoed by Ernst and Young (2015) as a major risk for the mining industry. In their report, they mention that most major mining companies have implemented the discipline of capital management and the allocation of capital according to company financial investment criteria (Ernst & Young, 2015). What this means is that major mining companies have been able to save up some healthy cash reserves to progress in recovering from the depressed commodity cycles.

Most of the respondents spoke of a similar funding process that is applied to capital cost projects across their businesses. The researcher's experience is that the process involves decision-making where a submission is made in motivation of the funds to be approved and linked to the project deliverables, including KPIs. This is supported by Rogers (1983), who mentions the innovation-decision process as a critical element of diffusion of the innovation process. According to Rogers (1983), the application of this process allows decision-makers to be informed beforehand about the technology innovation, and to formulate an opinion by understanding the risks and benefits brought about by the technology. This approach ensures that all the stakeholders including operations personnel are kept abreast regarding what will be required in operating and integrating the technology innovation as part of the business process. The application of the innovation-decision process allows the technology owners to take the organisation along, which was a critical requirement mentioned by most of the respondents.

Coal 1 from the coal commodity cluster mentioned the application of a capital allocation framework for allocating and prioritising capital for their business. The capital allocation framework is used to actively manage capital outflow as part of the cost savings drive. He mentioned that priority is given to servicing company debt, followed by staying in business. He also mentioned that their company has adopted innovation across the business, including allocation of capital to ensure that the efficiency drive is applied across all parts of the business. The need for stringent management of capital funds is confirmed by Bryant (2015), Lane et al. (2015) and Stanway et al. (2017), all of whom agree that there is a lack of capital available in the industry when compared to the past due to the current global economic pressure.

Accroding to Ernst and Young (2015), there is a real dilemma associated with the strategy of deploying the limited capital that exists. The challenge faced by decision-makers is the allocation of the available capital. Accordingly, the capital allocation framework mentioned by Coal 1 should be looked at as one of the innovations that can be standardised and applied in the industry.

Some of the respondents, specifically in the diamond cluster mentioned that the funding for technology innovation is allocated from operating costs and is generally determined as a certain percentage of the operating profits. This situation is unique, as no mention was made thereof by the respondents from the other commodity clusters. This warrants further research to understand the dynamics of the uniqueness of this funding model and what makes it successful in order to take learnings therefrom.

Most respondents confirmed that the return on capital employed was one such measure used to allocate and distribute capital to ensure business continuity. This is confirmed by authors including Ernst and Young (2015), Bryant (2015) and Mavroudis and Pierburg (2017), who note that mining companies have implemented strict financial measures such as return on capital employed, NPV IRR, ROCE etc. to control capital expenditure. This fact was confirmed by most respondents including Platinum and Platinum 3, who are company executives and are responsible for funding approval.

Platinum 3 and Platinum 4 referred to the local challenges faced by mining companies which operate near local communities. Platinum 4 made a unique comment when compared to the data collected from other respondents, which explained the risk associated with mining companies making capital investment for mining of resources close to local communities. Following the social unrest particularly in the platinum commodity sector, mining organisations have been forced to evaluate capital investments that might carry the risk of unsettling local communities and resulting in unrest. Mining companies have also had to improve engagements with local communities to ensure that they are involved with initiatives that might impact them. Social unrest is undesirable because is contributes negatively to mining production following the loss of production and revenue thereby caused, which cannot be recovered.

Platinum 3 made a similar comment related to the influence of local communities, in that he mentioned that the mine had to consider the sale of its operations due to mining activities being close to the community with resultant unrest. According to Lane et al. (2015), there is ongoing pressure from the government for mining companies to increase

their social commitment for resources such as access to basic services, education and health care for the mining communities.

According to a Reuters report by Stoddard (2018), the platinum eastern belt has experienced over 400 social unrest incidents since 2016. This confirms that over the past few years there has been an increase in the number of social unrest incidents, specifically in the platinum commodity cluster which has experienced violent protests in and around their operations. This calls for research to understand the different social impacts, especially for the platinum cluster in comparison to the other commodity clusters.

A unique comment made by Platinum 4 relative to the other respondents pertains to the factors influencing the decision-making process for capital funding, in that the business must consider the risk of social unrest brought about by labour unrest and communities demanding basic services. Such unrest causes a dilemma for the day-to-day running of the operations, as emergency evacuations are often required, and unrecoverable downtime is experienced.

6.2.4 The Influence of Executive support and Execution

This section discusses the results presented in Chapter 5, section 5.3.4 and refers to literature in order to confirm or dispute or add to the existing body of knowledge. The objective is to understand the role of executive and senior management in supporting the execution of technology solutions for effective adoption of modernisation in mining. This section also discusses the three contributing factors in this regard in order to provide conclusions for readers on the role of sponsors in the execution of technology solutions in mining.

All the respondents agreed that executive sponsorship was necessary for effective adoption of new initiatives including modernisation of the mining value chain. The respondents elaborated on the role of an executive sponsor as being responsible to ensure alignment of the digital or technology innovation roadmap to the business strategy and being a champion for the initiative at an executive and board level, thus elevating the initiative and leading the awareness about the initiative across the organisation.

According to Rogers' (1983) diffusion theory, an individual is referred to as an opinion leader if the individual is able to influence the attitudes of others or their behaviour informally, as anticipated. Thus, according to diffusion theory anyone has the capability of being an opinion leader if they have the necessary influence.

The theory on eight components of strategy by Thompson et al. (2008) was found to be more relevant with regard to the role of a sponsor for technology adoption, as it also emphasises the role of executive leadership in executing strategy for an organisation, which is hierarchical.

Most of the respondents agreed that a sponsor must have the right approach, attributes and leadership skills in order to influence accordingly from their level and across the organisation. This has been confirmed by Thompson et al. (2008), who mentioned that a leader needs to possess certain attributes such as being an adaptable thinker, having the ability to solve complex problems and possessing the right attitude for change, which was also highlighted by Rogers (1983) as important elements for diffusion of innovation.

Most of the respondents agreed that the engagement with employees was important from inception and throughout the process of selecting a technology solution until implementation has been completed. This was confirmed by Rogers' (1983) innovation-decision process, which recommends that early awareness regarding the technology innovation is necessary for employees to formulate their own opinions about the technology solutions. The reason for this is to ensure buy-in from all stakeholders, which includes employees as being part of the team, as mentioned by Coal 1. There was agreement by all respondents that senior management need to communicate regularly with employees about strategic objectives and initiatives to facilitate the translation of strategy into action and to achieve employee ownership thereof. The awareness of the technology at middle and senior management level can be diffused by an opinion leader, also referred to as a site champion.

Figure 5-5 indicated a direct link between executive support and effective execution for adoption of modernisation in a mining organisation. There was also mention of a link between executive support and capital funding, as the capital funding structure mainly consists of executive members. Thus, the role of the executive sponsor is important in socialising the modernisation roadmap in advance in order to facilitate the process of awareness to assist decision-makers in formulating the right perceptions about the initiative. According to the researcher, the diffusion theory can be adopted in mining, with opinion leaders identified to support the sponsor in promoting the initiative across the organisation.

6.2.5 Change management and behavioural factors

This section discusses the results presented in Chapter 5, section 5.3.5 and refers to literature in order to confirm or dispute or add to the existing body of knowledge. The objective of this section is to understand the influence of change management and behavioural factors on the adoption of modernisation across mining operations. This section also discusses the four contributing factors in this regard, which are: 1. Communication for buy-in and support; 2. Contextualising the required change; 3. Organisational culture; and 4. Behavioural change. This discussion will be used to provide conclusions for the readers on how to approach technology adoption in the mining sector.

All respondents identified communication as being an important factor necessary to facilitate change for acceptance of technology solutions. All respondents agreed with industry experts in mentioning the importance of communicating to employees and involving them from the start, as they are the “true” owners of the solution having to operate and maintain it. There was also agreement by experts that it is important to communicate widely to affected and impacted employees. The importance of communication for adoption of technology was confirmed and emphasised by Rogers (1983), who noted communication as being an integral element of diffusion of the innovation process. According to Rogers (1983), diffusion is described as a process of introducing a new innovation or technological solution through communication with participants within a defined social system. Most respondents referred to the role of the sponsor in taking the lead to actively share information with other executive members, which then filters through to the rest of the organisation to create a mutual understanding (Rogers, 1983).

Communication was also pointed out by Rogers (1983) as being important during the innovation-decision process described in Chapter 2, Figure 2-3. The innovation-decision process provides sufficient information for decision-makers to formulate their own opinions about the technology innovation, which may lead stakeholders into making complete use of the technology innovation. Respondents agreed that executives were normally involved in approval of funds necessary for technology implementation and in leading awareness about the technology to other executives. This statement is confirmed by Rogers’ (1983) innovation-diffusion process, which also refers to communicating with decision-makers and providing necessary information to enable them to make an informed decision about the technology innovation.

All the respondents agreed that change management was a critical process that required a great deal of focused resources in order to properly understand the impact caused by

introducing the new technology into an existing value chain process. There was consensus amongst the respondents that the physical implementation of a technological solution does not equate to it being accepted by the end users as an operational solution, but rather that change management is what facilitates the acceptance and embedding of a technology solution.

Most respondents described behavioural change as an individual's mindsets and perceptions towards the benefits of the technology innovation, pertaining to them. Most of the respondents referred to the need for an innovative culture to enable the sharing of information about the technology and to allow employees to freely share their thoughts regarding the technology, which will assist them to make up their minds about whether to accept or reject the technology. Organisational culture ultimately determines the level of ease during the adoption process, while the process of change requires a behavioural and mindset change.

The need for change is confirmed by Koul and Eydgahi (2018), who note that technological change influences social and behavioural changes. The need for social and behavioural change was also mentioned by Ghazizadeh et al. (2011), who argue that automation technology cannot be effective unless the users have socially accepted and adopted the technology solution. Bryant (2015) confirmed that it is a rare phenomenon to see the effective application of technology for driving the required transformation in the mining industry, which follows from not applying change to ensure that proper change is achieved.

6.2.6 The influence of Mining Communities and Sustainability

This section discusses the results presented in Chapter 5, section 5.3.6 and refers to literature in order to confirm or dispute or add to the existing body of knowledge. The objective was to understand the influence of mining communities and sustainability for effective adoption of modernisation across mining operations. This section also discusses the three contributing factors in this regard, which are: 1. Community and stakeholder engagement; 2. Socio-economic development for the mining communities; and 3. Ethics of conducting business, in order to provide conclusions for readers on how to approach technology adoption in the mining sector.

There was agreement from all the respondents in the platinum commodity cluster that they have experienced increased engagements with local mining local communities, as confirmed by quotes from Platinum 3 and Platinum 4. The involvement of mining communities was mentioned by most respondents to be an important factor for mining

organisation wanting to achieve stability, which is linked to the sustainability of mining operations. Mining communities form part of the stakeholders who should be made aware of the drive for modernisation to consider what it means for them in terms of contributing to the sustainable socio-economic status of their communities.

The respondents also agreed that mining companies are encouraged to invest in local mining communities in order to attain social endorsement for operating in the area, which was described by the respondents as a social licence to operate.

Community awareness of water scarcity and high cost of water has led to public scrutiny of corporate water usage and communities resisting water usage by corporates (Morrison et al., 2009). Local communities are becoming aware of the impact on the environment of mining and local mining communities have increased their interaction with mining organisations in order to improve and sustain their socio-economic status. Thus, most respondents agreed that community engagement forms part of a company's strategic partnerships, as fostered and managed by the mining companies.

The influence of technology adoption on local mining communities was not identified in the literature as an important factor for consideration in the field of technology adoption and hence is identified as a new finding of the study. This finding is regarded to be new as there is no mention thereof in the technology adoption literature. Additional new findings include the influence of communities and their impact on the social licence to operate for the mines and the importance of companies to conduct business in an ethical manner.

6.2.7 Summary of the findings

The acceptance of technology solutions in mining was found to be influenced by several factors, both internal and external to the organisation. These value drivers were confirmed by Iacovou et al. (1995) and other academic literature outlined in Chapter 2 as being the key consequent benefits that influence mining organisations in adopting technology innovations. Bryant (2015), Lane et al.(2015) and Mavroudis and Pierburg (2017) confirmed that mining organisations are motivated to adopt technology solutions by key business value drivers, which are as follows: improving safety and health for all working environments, efficiency and productivity improvements that drive down costs, and environmental sustainability.

Technology innovation has been disadvantaged by cost savings drives, which have resulted in a capital restriction that has inhibited technology adoption for mining companies, especially in South Africa following low profit margins, as mentioned by Lane

et al. (2015). There was agreement that mining companies have the responsibility to identify, test the viability of, and implement technology solutions within an existing operations value chain process.

There was consensus from literature and the data analysed that return on capital employed was one such measure used to allocate and distribute capital to ensure business continuity. However, this measure was an inhibitor for technology evaluation and adoption due to the risk associated with determining appropriate technology solutions

The was consensus about the important role of executive sponsorship for effective adoption of new initiatives including modernisation of the mining value chain. Most of the respondents agreed that a sponsor must have the right approach, attributes and leadership skills in order to influence accordingly from their level and across the organisation.

There was consensus that an innovative culture was important to support technology acceptance in mining. Organisational culture ultimately determines the level of ease during the adoption process and the process of change requires behavioural and mindset change. There was consensus from respondents that community engagement forms part of a company's strategic partnerships, which need to be fostered and managed by the mining companies in order to maintain their social licence to operate.

6.3 Answering the Research Questions

6.3.1 Factors that influence effective adoption of technology solutions across the mining value chain of South Africa

Table 6-1 below provides a summary of the factors highlighted by the respondents in Chapter 5 as being important for the acceptance of technology-based solutions in the mining industry, limited to South Africa.

Table 6-1: Organisational value driver factors

Factors that influence the acceptance of technology solutions	Elements of factors	Supporting Literature	Reference sections with detailed discussions
Organisational business value drivers	✓ Safety & health, legislative requirement ✓ Efficiency & productivity improvements ✓ Cost reduction	Bryant (2015), Iacovou et al. (1995), Rogers (1983)	Section 6.2.1

	✓ Environmental sustainability ✓ Unlocking future resources		
Organisational factors that influence Technology execution and adoption	✓ Investment funding ✓ Executive sponsorship ✓ Demonstrate for Feasibility & viability ✓ Integrating technology implementation into business process	Bryant (2015) Jacobs & Webber-Youngman (2017), Sirinanda (2019), Stanway et al. (2017)	6.2.2 6.2.3 6.2.4
Organisational change Behavioural factors	✓ Communication ✓ Employee engagement ✓ Change management	Koul & Eydgahi (2018), Ghazizadeh et al. (2011)	6.2.5
Factors external to the organisation	✓ Stakeholder engagement ✓ Community ✓ Government ✓ Social licence to operate		6.2.6

6.4 Factors that enable the acceptance of technology solutions in the mining industry, limited to South Africa

The factors that enable or support the acceptance of technology solutions in mining are detailed in table 6-2 below.

Table 6-2: Factors enabling technology acceptance

Enabling factors	Details of the factors
Research and development	✓ Research and development was required in order to develop appropriate technology solutions through a process of testing, developing and demonstrating that a technology solution was fit for providing the solution
Funds dedicated for modernisation	✓ Most respondents agreed that capital funding was an essential part of modernisation and that funds that are dedicated for technology adoption enable the process of investigating for appropriate technologies to drive value for the business
IS infrastructure	✓ Some of the respondents highlighted the importance of having enabling information systems infrastructure necessary for equipment communication and successful utilisation of the technology solutions

Organisational culture	✓ Innovative culture that enables a collaborative environment where information is shared and where employees are encouraged to discuss their ideas
Business ethics	✓ Some of the respondents mentioned that mining companies were expected to demonstrate ethical conduct

6.5 Factors that inhibit the acceptance of technology solutions in the mining industry, limited to South Africa

There were four factors identified from the findings as hindering or preventing the acceptance of technology solutions. These inhibiting factors are detailed as follows:

1. Low technology readiness levels for technology innovation in the mining industry can be described as technology solutions that have low maturity levels or those that have not be proven in a mining production environment. Most of the respondents agreed that there was low impetus from mining companies to accept low readiness level technology, which was associated with high risk of introducing an unproven technology into an operational business value chain. The reasons provided were that unproven solutions are expected to require production downtime, which would translate to production losses resulting in loss of revenue. This is undesirable for mining organisations, which prefer to adopt proven and tested solutions that can add value following implementation.
2. Capital funding was mentioned as being an important factor by most respondents and industry experts. This is because a lack of funding is a definite inhibitor for introducing technology solutions in the mining environment, which according to Bryant (2015) has had limited funding due to being disadvantaged by the cost savings drive. Some of the respondents mentioned that machine automation was a significant area of implementation for technology adoption.
3. The lack of required digital skills necessary for executing technology functions. Most respondents mentioned the need for mining companies to have relevant digital skills such as computer, engineering, chemical, analytics and coding as part of preparation for the fourth industrial revolution and the adoption of technology solutions. According to Laubscher (2018), these skills were not easily achievable given the low levels of qualifications in the country, which also explains the difficulty in addressing the unemployment rate. These findings were confirmed by Sirinanda (2019), who noted

that mining companies should add professional dynamic capabilities in technology to understand the integration of technology innovations into the mining value chain.

4. Behavioural change was described as the individuals' mindsets and perceptions about the benefit that will be brought about by the technology solutions. According to Koul and Eydgahi (2018), technological change influences social and behavioural changes, and if the individual's behaviour does not change accordingly there will be failure of acceptance.

6.6 Conclusion

In conclusion, the acceptance of technology is influenced by organisational and external factors as mentioned in this chapter, which can be used as a guide for going forward. Chapter seven discusses the conclusion and recommendations for the research study and provides a model that may be used as a guide for readers.

Chapter 7:CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The aim of this research study was to explore and clearly identify factors that support or inhibit effective adoption of modernisation technology in the mining industry, limited to South African mining companies. This chapter presents a summary of the key findings from Chapter 5 and 6, which are discussed in relation to the research question outlined in Chapter 3. The intention is to provide the mining organisations including other stakeholders with an understanding about the factors that they need to consider as they embark on their modernisation journey, including a proposed adoption model for consideration. This chapter also highlights the main limitations of the research, which should be considered for further research to contribute to the limited documented body of knowledge around adoption of technology in the mining industry in order to modernise the industry. The chapter concludes by making recommendations for mining executives, senior managers, the Mineral Council executives and future researchers to consider.

7.2 Consolidation of the findings of the study

7.2.1 Factors that influence effective adoption of technology solutions across the mining value chain of South Africa

These factors were defined in Chapter 2 as factors that are important for decision-making. It was important to classify these into internal and external factors, as guided by widely-accepted adoption models for information systems, such as diffusion of innovation by Rogers (1983) and the model of Iacovou et al. (1995). This classification should enable mining organisations to identify their locus of control. Figure 7-1 below shows a proposed model as developed by the researcher to represent the outcomes of the study. These factors have been identified by respondents during the interviews and were confirmed by literature as being necessary for effective adoption of technology innovation in the mining industry, limited to South Africa. The critical organisational factors were defined as those that are internal to the organisation and have to be considered during the innovation-decision-making process (Rogers, 1983), as described in Chapter 2 and 3. The external factors were defined as those factors outside the organisation that cause pressure on the organisation and should be considered during the innovation-decision-making process.

Figure 7-1: Factors that influence effective adoption of modernisation

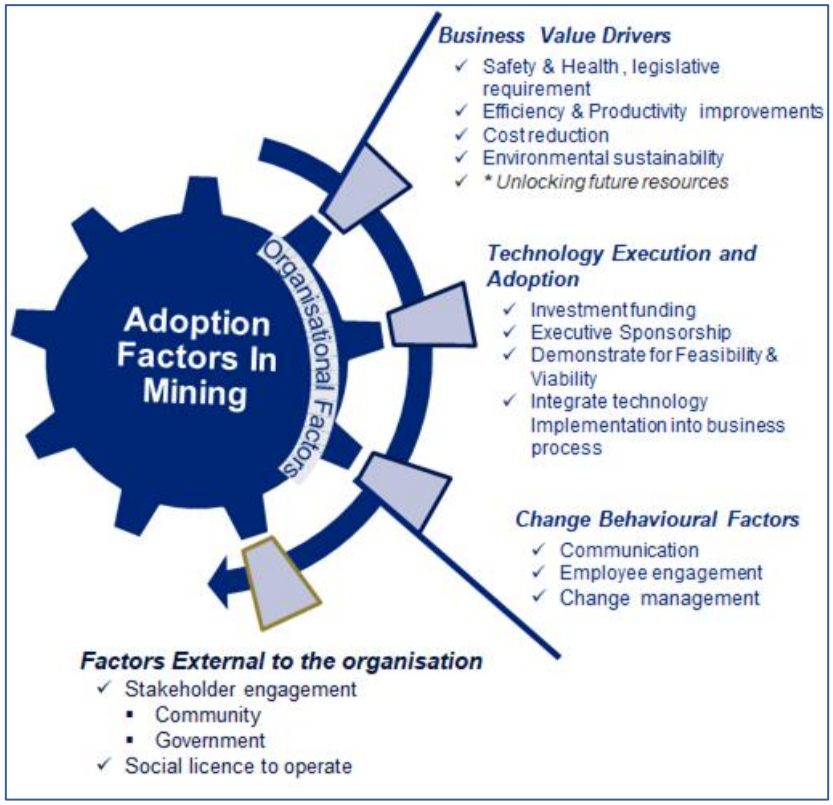


Figure 7-1 shows the business value drivers as being organisational factors that were identified as driving factors which influence mining organisations in South Africa to adopt technology solutions, in order to receive the perceived benefit that would contribute towards the organisations achieving their goals. Machine automation was highlighted as a key area of technology investment across the mining industry, as mining organisations require more outputs from the current production processes (Mavroudis & Pierburg, 2017). The motivation for mining companies to adopt technology solutions are the key five value drivers mentioned in Chapter 5 and 6, which are as follows: 1. Creating safer, healthier working environments in support of zero harm and complying with legislative requirements; 2. Improving efficiency and productivity to 3. drive down costs; 4. Implementing environmentally sustainable solutions; and 5. Unlocking future resources.

The mining value chain was described by Bryant (2015) as being a complex system that requires an integrated business solution that involves planning of solutions in advance. Thus, it is important for the technology team responsible for implementation to consider the key factors mentioned under technology execution and adoption. These key organisation factors include investment funding required to upgrade existing infrastructure, and the purchasing of hardware and any software licences required for successful implementation. In line with this, it is critical that executive sponsors be informed of the

plans to enable socialisation of the technology (Rogers, 1983) with the relevant decision-makers, particularly executive members. Sufficient time should be allocated to inform the various stakeholders and enable them to formulate the desired option regarding the technology solution. This process has been described by Rogers (1983) as the innovation-decision process.

The process of behaviour change is very important for establishing adoption of technology solutions, which ultimately translates to acceptance of a solution as deduced from well-known adoption literature, including Oliveira and Martins (2010) and others. Communication with employees was identified as a critical organisation factor, given that employees represent the end users of the technology solution. Employee engagement is important as part of the implementation process in order to provide adequate knowledge about what the technology is and how is it expected to be of benefit, including its pros and cons. Change management was also identified as a critical organisational factor to identify the populations affected and to classify them according to their desire to change as guided by Rogers (1983), and what they need to change in order to ensure acceptance. It is important to measure diffusion of the technology to ensure that a critical number of people have accepted the technology solutions for sustainability of the solution in the business.

The South African mining industry has been on the decline following the impact of additional pressures faced, including ongoing pressure from the government to increase their social commitment, which includes providing services for local communities that is generally part of government's responsibilities. This has resulted in new findings not discovered in the technology adoption literature, which are critical external factors to be considered for technology adoption in South Africa. These are: 1. Community and government stakeholder engagement, which organisations need to continuously manage; and 2. The social licence to operate, which includes involving the local mining communities in the modernisation roadmap to ensure a sustainable livelihood for the communities. These engagements are necessary to avoid the risk of any unrest by the communities, which could result in an unsafe situation and cause downtime for the mining operation.

7.2.2 Factors that enable the acceptance of technology solutions in the mining industry, limited to South Africa

The enabling factors were defined as those factors that make it possible for people to accept the technology solutions thereby supporting the adoption of modernisation. Table 7-1 details the enabling factors for technology acceptance.

Table 7-1: Factors that enables the acceptance of technology solutions in mining

Enabling factors	Details of the factors
Research and development	✓ Research and development was required to develop appropriate technology solutions through a process of testing, developing and demonstrating that a technology solution was fit for providing the solution
Funds dedicated for modernisation	✓ Most respondents agreed that capital funding was an essential part of modernisation and that funds that are dedicated for technology adoption enable the process of investigating for appropriate technologies to drive value for the business
IS infrastructure	✓ Some of the respondents highlighted the importance of having enabling information systems infrastructure necessary for equipment communication and successful utilisation of the technology solutions
Organisational culture	✓ Innovative culture that enables a collaborative environment where information is shared and where employees are encouraged to discuss their ideas
Business ethics	✓ Some of the respondents mentioned that mining companies were expected to demonstrate ethical conduct

7.2.3 Factors that inhibit the acceptance of technology solutions in the mining industry, limited to South Africa

The inhibiting factors are those that enhance the acceptance of technology in mining and are detailed in Table 7-2 below.

Table 7-2: Factors that enable the acceptance of technology solutions in mining

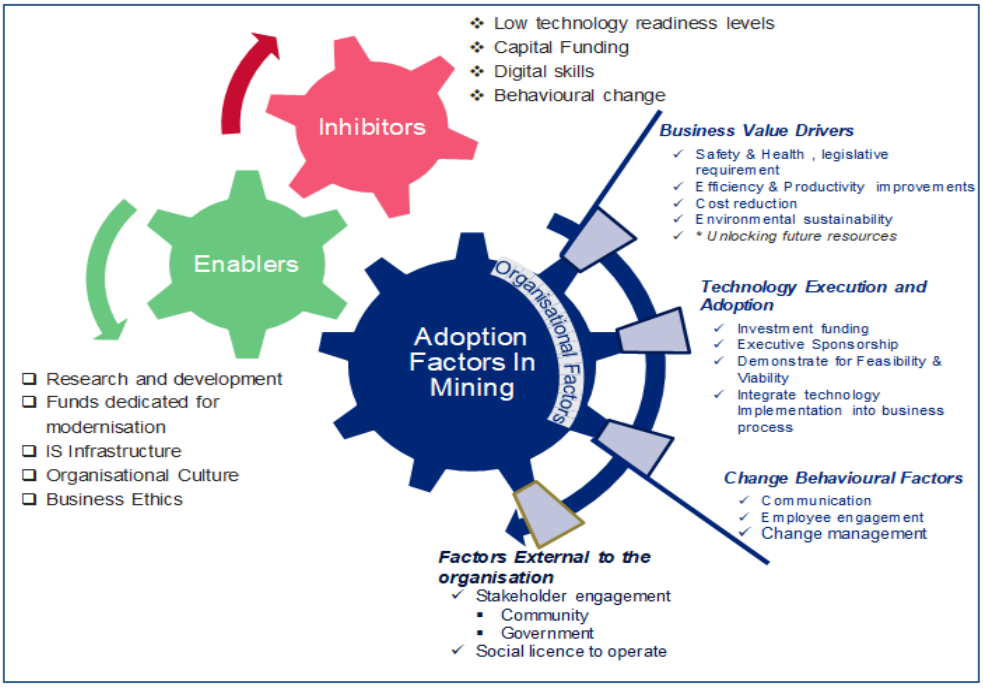
Inhibitors	Details of factors that prevent technology acceptance
Low technology readiness levels	▪ There was low impetus from mining companies to accept low readiness level technology, which was associated with high risk of introducing an unproven technology into an operational business value chain
Capital funding	▪ This pertains to the lack of funding, which was a definite inhibitor for introducing technology solutions in the mining environment

Digital skills	▪ The lack of required digital skills necessary for executing technology functions ▪ Relevant digital skills such as computer, engineering, chemical, analytics and coding as part of preparing for the fourth industrial revolution and the adoption of technology solutions
Behavioural change	▪ The individuals' mindsets and perceptions about the benefit that will be brought by the technology solutions. Technological change influences social and behavioural changes, and if the individuals' behaviour does not change there will be failure of acceptance

7.3 Recommended Conceptual Model for Adoption of Modernisation in the South African Mining Industry

The adoption of technological solutions for modernisation of the mining industry can be compared to the adoption of technology in information systems, as there are commonalities that can be drawn from both.

Figure 7-2: Proposed Modernisation Adoption Model for the Mining Industry of South Africa



7.4 Contributions and Implications of the Research Study

The contributions and implications of the study are outlined in this section with the theoretical contributions detailed in 7.4.1 and Business applications in 7.4.2.

7.4.1 Theoretical contribution

This research contributes to the framework for adoption of technology in the field of technology management. The research study was mainly built on the theory of diffusion of innovation by Rogers (1983) and on the model of Iacovou et al. (1995), which describes the characteristics that influence firms to adopt information technology innovations. The model that was concluded from the research is shown in Figure 7-2, which indicates the contribution of some of the unique factors such as community engagement and business ethics, which were not mentioned in the adoption models.

7.4.2 Practical business contribution

This study contributes to business applications through highlighting the factors that influence the process of modernisation for the South African mining industry. The factors explored will provide a guide to senior managers and executives of mining organisations on how to go about implementation technology solutions for their business. The research also provides a guide on the factors that contribute to gaining acceptance from employees and other stakeholders for modernisation in mining. The research concluded by outlining some of the enablers that support the effective adoption of technology solutions across the existing mining value chain. In addition, the study highlighted some of the inhibitors that mining executives and managers need to look out for as they adopt technologies in their efforts to modernise the mining value chain.

7.5 Limitations of the research study

The following points are highlighted as limitations for the study:

- The study only focused on understanding modernisation in South African mines and thus limited the data collection to South Africa. However, two of the participants from the industry expertise cluster have also had international working experience, specifically in Canada, South America and Australia.
- The data was gathered from a limited sample of participants from four commodity clusters, namely: Iron ore, Diamonds, Platinum and Coal. This is a limited sample as it only covers four of the eleven commodity minerals produced in South Africa,

as reported by the Facts and Figures 2017 Report (Minerals Council South Africa, 2018).

- The study did not cover the influence of the factors in Figure 7-2 on small mining companies and their understanding thereof, including plans for modernisation of their processes which are generally manual.
- This study did not explore the influence of modernisation on mining contractor businesses, which can be defined as being small- to medium-sized business that provide mining services to the mining companies.

7.6 Implications for management and other relevant stakeholders

7.6.1 Recommendation for the Executives and Senior managers in mining organisations

It is recommended that mining executives and senior management conduct benchmarking outside their industry to identify technology innovation in other fields. The reason for this is that no mention was made of deliberate efforts to seek and investigate existing solutions that would be applicable in the mining environment. Mining companies can learn from other industries such as agriculture, manufacturing and healthcare regarding existing solutions and their formulated processes for how they go about investing and developing appropriate technology solutions and adopting them into existing business processes.

7.6.2 Recommendations for the Modernisation Executive at the Minerals Council of South Africa

The recommendation for the executive of modernisation at the Minerals Council is to accelerate the development of a South African mining technology roadmap and to establishing a resource platform to facilitate the development of digital skills required for adoption of modernisation in South Africa. This follows the need for current technical incumbents to gain the necessary digital skills required to accelerate the adoption of modernisation by mining companies, e.g. engineers who do not understand information systems architecture and standards including their applications. This initiative would support cost savings and the retention of employees in the industry following the current high cost of modernisation, as most OEM companies have established headquarters outside Africa, especially in Europe, Australia and North America. It is here where the research and development generally take place, with technical expertise also being situated in these areas. Thus, the cost of adopting these OEM technologies becomes high as hardware, software and knowhow is imported from these countries.

7.6.3 Recommendations for future MBA studies

The focus of this study was to explore the factors that influence technology adoption for effective modernisation of the mining industry, but with a shortcoming of ranking these factors. It is important to rank the factors according to impact, as this information could assist senior managers of mining organisations who are directly responsible for the rollout of technology projects. It is recommended that a quantitative study be conducted where researchers undertake to quantify these factors to refine and improve on the model in Figure 7-2.

There was a recommendation following unique data from the platinum commodity sector to understand the different social impacts, specifically for the platinum cluster in comparison to the other commodity clusters. Thus, the recommendation is made for future research studies to collect data from the other seven commodity clusters of the eleven in total in order to understand the merits of this finding.

For many minor mining companies and those with lower profit margins, the allocation of capital is mostly put on the backburner as companies are driving for savings more than improvements. Thus, the question remains as to whether modernisation is a reality for smaller mining companies, which mostly lack the required capital necessary to adopt technology solutions.

7.7 Conclusions

The study aimed to explore the factors that support or inhibit the acceptance of technology solutions for effective adoption of modernisation in the mining industry of South Africa. The research concluded from the data analysis conducted that academic technology adoption models developed by Iacovou et al. (1995) and Rogers (1983) are transferable as they can be applied in other industries including mining. The research also found that organisational factors such as the value drivers of companies have an influence on technology adoption, as companies are motivated by the desire to deliver according to their business goals in satisfying shareholders. In addition, the research discovered that the acceptance of technology is also influenced by resource availability and availability of enabling infrastructure, and that executive sponsorship plays a very important role in driving awareness for the business with regard to technology adoption. Other factors that influence technology adoption include the social licence to operate and business ethics, which mining companies are encouraged to take notice of in their process of adopting technology solutions for mining.

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APPENDIX A: ENDORSEMENT LETTER

MINERALS COUNCIL
SOUTH AFRICA

13 February 2019

Gordon Institute of Business Science
26 Melville Road
Illovo
Johannesburg
2196

Dear Sir/Madam

The Minerals Council continuously looks for ways to advance the position of and make improvements in the South African mining industry and participates in various initiatives and projects in areas relating to health, education, policy and regulations. The Minerals Council has concluded studies that show that the modernisation, specifically mechanisation or automation of mining operations, leads to improved safety and health, increase in efficiencies and productivity resulting in mining life extensions.

Bongi Ntsoelengoe, Manager Technology at Kumba Iron Ore has approached the Minerals Council to request for support for her research, that she is doing as part of her Masters In Business Administration (MBA) at GIBS. She aims to identify the factors that support and inhibit the effective adoption of automation technology and modernisation for open pit mining in South Africa. This topic forms part of People-Centred Modernisation focus areas that we as the Minerals Council are currently looking at. The outcomes of this research would add to the body of knowledge in determining the suitability of adoption models such as the Minerals Council's process and methodology for sustainable leading practice adoption in mining.

Yours sincerely

MINERALS COUNCIL
SOUTH AFRICA

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APPENDIX B: INVITATION INTERVIEW LETTER

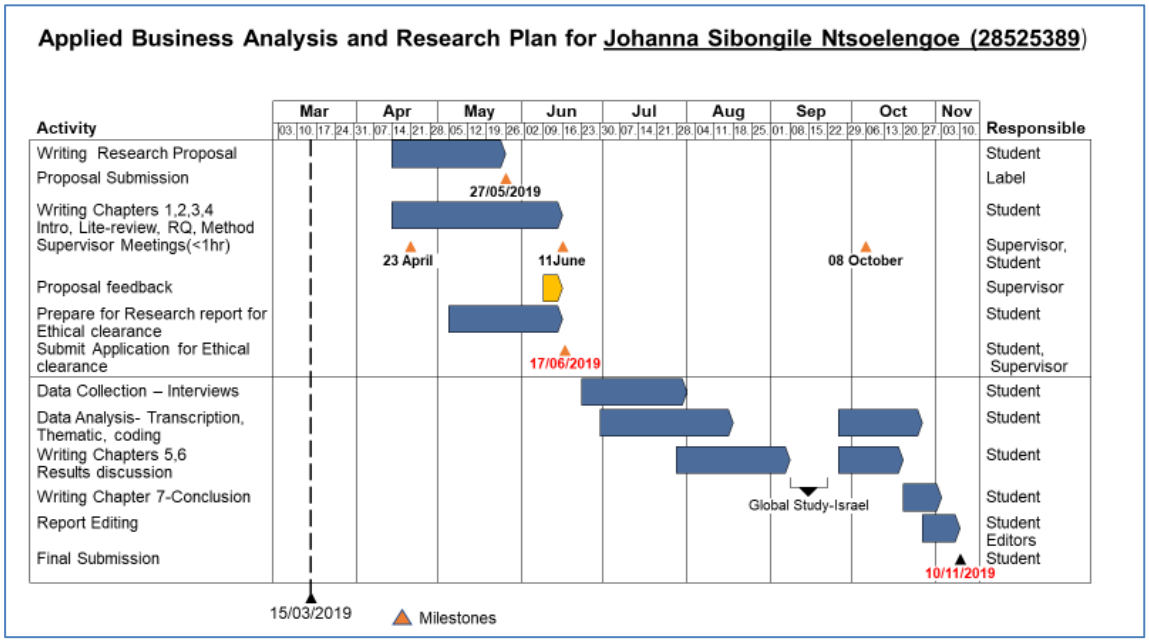
Date:

Dear Sir /Madam

As discussed telephonically, I am currently a second year MBA student, at the Gordon Institute of Business Science. I am currently busy with my research study titled: *Factors affecting the effective adoption of autonomation technology and modernisation in the South African mining industry.* I would like to conduct interviews in order to gather data in fulfilment of my studies. I have planned to collet this data during the planned period of 23rd June to the 31st July 2019 (see plan below).

Your participation is voluntary, and you can withdraw at any time without any penalty. All data will be reported without identifiers and if you have any concerns please contact my supervisor or myself

I would like to request that you consider my request and provide feedback on suitable dates, to conduct the interviews during this period.



Kind regards

Bongi Ntsoelengoe

MBA Candidate

APPENDIX C1: CONSENT FORM

The informed consent letter will be used in the case of an interview.

I am currently a student at the university of Pretoria's Gordon Institute of Business Science (GIBS) and completing my research in partial fulfilment of the MBA. I am conducting research on *Factors impacting the effective adoption of modernisation in the South African mining industry.*

The interview is expected to last about an hour and a half at most and will help in understand the influencing factors contributing to effective adoption of modernisation in the South African mining industry. Your participation is voluntary, and you can withdraw at any time without any penalty. All data will be reported without identifiers and if you have any concerns please contact my supervisor or myself. Our details are provided below;

Researcher Name: Johanna Sibongile Ntsoelengoe

Email address: 28525389@mygibs.co.za

Mobile number: 083 251 3502

Research Supervisor: Mr Hugh Myers

Email address: Myresh@gibs.co.za

Mobile number: 083 302 3802

Signature of Participant: ……

Date: ……

Signature of Researcher: ……

Date: ……

APPENDIX C2: PROPOSED RESEARCH INTERVIEW GUIDE

The respondent's identity will be kept anonymous, and all data collected during the interviews will be reported anonymously.

- Research Question (RQ): Identify the key organisational factors that support or inhibit the acceptance of technology solutions for effective adoption modernisation in the mining industry of South Africa.

Table 6-7-3: Interview guide questions aimed at answering the primary research question

Alignment with Literature, Influencing Factors	**Interview Questions**
Investment funding -required to drive automation technology including putting infrastructure in place	• To what extent does the capital requirements influence technology adoption in your organisation? • How is capital funding allocated, in your organisation?
Technology innovation solutions-development and availability of the appropriate technology solution	• What is the process of scanning, selecting and sourcing appropriate technology solutions? • What is the process of conducting research and development for your organisation? • To what extend does the technology readiness and availability of technology solution influence the acceptance, for your organisation?
Integrating technology innovation into strategic business planning and execution.	• What is process followed for adopting appropriate technology for your organisation? • What is the link between strategy, business planning and technology implementation for your organisation?
Executives support - managers and executives to understand the benefits of modern technology and innovation	• Is there an Executive sponsor, focusing on the adoption of technology in your organisation? • To what extent does communication between management and organisation's employees influence the adoption of technology?
Social, behaviour changes - Change management drive to create and influence social and behavioural changes	• To what extent does the organisation behaviour changes influence technology adoption in your organisation? • Are there specific skills required for acceptance of technology? • Are there specific behaviour changes required for acceptance of technology?

APPENDIX D: ETHICAL CLEARANCE LETTER

Gordon Institute of Business Science
University of Pretoria

01 July 2019

Ntsoelengoe Johanna Sibongile

Dear Sibongile

Please be advised that your application for Ethical Clearance has been approved.

You are therefore allowed to continue collecting your data.

Please note that approval is granted based on the methodology and research instruments provided in the application. If there is any deviation change or addition to the research method or tools, a supplementary application for approval must be obtained

We wish you everything of the best for the rest of the project.

Kind Regards

GIBS MBA Research Ethical Clearance Committee

APPENDIX E: CODE BOOK

	List of Codes
1	Adopting an ambition mindset
2	Adoption Process
3	Adoption Regulators
4	Affected people by decisions made
5	Affordability to apply technology
6	Assessing advantages and disadvantages
7	Assessment of business need
8	Availability of networking
9	Budget process for technology adoption
10	Budget towards research
11	Business development incubators
12	Business focused strategy
13	Business improvements
14	Business Panning in the mining industry
15	Capability profiling of institutions
16	Capital and associated human resources
17	Capital funding process
18	Centralisation of functional model
19	Challenges in Innovation
20	Challenges in the adoption of technology in the mining industry
21	Change in behaviour
22	Change management
23	Collaboration between government and companies
24	Collaboration of different technologies
25	Collaboration with OEM
26	Communication in technology adoption
27	Community engagement and thought leaders
28	Copper specific technology
29	Cost component in South African gold mines
30	Cost visibility of the adopted technology
31	Crisis with coal mining companies
32	Critical commercial opportunities
33	Critical terms of technology adoption
34	Critical thinking for problem solving
35	Data collection system
36	Departmental relationships
37	Depth of strategy
38	Developing a framework
39	Digitisation enabler
40	Efficiency and optimisation

	List of Codes
41	Establishing a test mine
42	Execution at technology readiness levels
43	Executive Support
44	Facilities that do verification
45	Factors Inhibiting Technology Implementation
46	Factors to consider
47	Feasibility Studies
48	Financial component of technology adoption
49	Formal process
50	Fully automated mines
51	Funding process of technology adoption
52	Future development possibility
53	Future projection
54	Future strategies
55	Green Mining and local community development
56	Ground level readiness
57	Group think and ideation sessions
58	Health and Safety
59	High Learning potential
60	Human development

	List of Codes
61	Hydrogen economy
62	Implementation success
63	Important gap from L4 to L8
64	Improve work environment
65	Incitement to invest in technology adoption
66	Increase in competitive advantage
67	Increase in productivity
68	Industrial effort
69	Industries dynamics
70	Influence of capital of technology adoption
71	Infographic model
72	Informal process
73	Information management
74	Information sessions
75	Inhibiting factor
76	Inhouse development
77	innovation and R&D promotion
78	Innovation and Strategy Integration
79	Innovation and technology
80	Innovative Mindset

Appendices

	List of Codes
81	integrated strategy
82	Invest in Research and Development
83	Investment development model
84	Investment funding
85	It is easier to adopt technology that already exist
86	Job automation
87	Lack of Creative Capacity
88	Lack of requirements for technology adoption
89	Learning experience
90	Limited Strategies
91	Logical approach
92	Macro-economic factors
93	Management support
94	Management training
95	Market relevant products
96	Measure companies against specifications
97	Mechanism to de risk Investments
98	Merging technology
99	Mindset change
100	Mining and Safety
101	Mining industry Capability and Capacity
102	Mining industry innovations
103	Misunderstandings between unions and management
104	Modernisation and Unions
105	Modernisation strategy
106	strategic level for technology
107	Necessity and Inventions
108	New technology implemented
109	Not fully understanding technology
110	Off shelf technology
111	Open door for partnerships
112	Open minded approach
113	Operations during technology implementation
114	Opportunities to adopt new tech
115	Optimisation of mines (1)
116	Organisation' financial ability
117	Organisation satisfaction
118	Organisational culture
119	Organisational Vitality
120	Original equipment manufacturer

	List of Codes
121	People's expectation and attitude
122	Personnel training
123	Pioneer work
124	Pipeline technology
125	Predictive Maintenance
126	Preparedness for the new technology
127	Problem solving
128	Problem solving requirement
129	Problem statement
130	Process around sourcing technology
131	Process followed in technology adoption
132	Process of Capital allocation
133	Processed technology development
134	Production Improvement
135	Productivity and efficiency
136	Productivity increasing factors
137	Productivity problem
138	Project analysis
139	Proven technology
140	Rapid Innovation
141	Rapid Innovation challenge
142	Readiness level
143	Reasonable delivery
144	Required skills sets for technology adoption
145	Requirement of a Clear focus for adoption
146	Resistance to change
147	Restricted funding
148	Return On Capital Employed
149	Risks associated with the adoption of new technology
150	Role of capital required
151	Role of sponsor is critical
152	Senior technology driver
153	Simulators for training personnel
154	Skilled personnel
155	Sourcing Appropriate Technology
156	Sourcing Technology
157	Sponsor engagement
158	Sponsor visibility
159	Spontaneous stimulation
160	stakeholders and employee ecosystem

	List of Codes
161	Standard databases
162	Strategy and Business planning integration
163	Strategy for the adoption of adoption
164	Strategy longevity

165	Support to idea development
166	Sustainability of project
167	Sustainability platforms and Visionary leadership
168	Sustainability strategies
169	Sustainability targets
170	Technical Support
171	Technology adoption
172	Technology adoption fear
173	Technology adoption needs and Challenges
174	Technology Availability
175	Technology behavioural changes
176	Technology Cutting
177	Technology enablers
178	Technology fail
179	Technology implementation
180	Technology Inclined
181	Technology Intercept
182	Technology investigation
183	Technology necessity
184	Technology Portfolio
185	Technology Readiness of the mines
186	Technology Sales man
187	Technology selection process
188	Terms of strategy
189	Testing Prior Implementation
190	The evolution of technology
191	The importance of leadership engagement
192	The monotony of the counsel and its role
193	The process of ergonomics
194	The process of research and development in technology adoption
195	The role of communication
196	The small top down approach
197	Theory to practicality
198	Third party verification initiatives
199	Time to Initiate plan
200	Transformation framework

	List of Codes
201	Transition acceptance and impact assesmnet
202	Uncharted technology teritory
203	Understanding adoption process
204	Understanding adoption requirements
205	Understanding business constraints
206	Understanding business perspective
207	Understanding of challenges and opportunities
208	Unions and technology adoption
209	University collaboration

210	Value chain reduce energy consumption
211	Value for the company
212	Vision Sharing in system's environment
213	Years before getting return on capital