School of Mining Engineering

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

THE IMPACT OF DIGITAL TECHNOLOGY IN SOUTH AFRICAN COAL MINING: A FINANCIAL PERFORMANCE ANALYSIS OF ANGLO AMERICAN, BHP BILLITON AND GLENCORE

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A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

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DECLARATION

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To my late grandmother Misola Ngobeni and my late mother Elsie Ngobeni whose presence would have meant so much for me to celebrate my successes with them. May their lovely Souls Rest in Peace.

ABSTRACT

Digital technology, typically, refers to electronic tools, resources, devices and systems that store, generate and process information rapidly. Digital technology and innovation are among the initiatives that can assist mining companies to realise productive, efficient, profitable and sustainable mines. As such, the mining industry is taking steps towards digital technology and innovations that have evolved in recent years. The objective of this report was to discuss the financial impact of digital technology of the selected South African thermal coal mining companies namely Anglo American Coal Division now operating as Thungela Resources, Glencore, and South32, previously spun out of BHP Billiton and now operating as Seriti Resources. Coal mines were selected for analysis, due to their importance with respect to energy generation in South Africa. Industry cost curves over the period 2013-2019 were constructed as part of the financial analyses to show the trend of the selected companies' unit costs. The research also used other financial analysis methods such as operating profit, profitability ratios, Economic Value Add and Du Pont analysis to analyse the performance of these companies.

There appeared to be no production and unit cost improvement directly linked with investment in digital technology, as breakdowns, commodity prices, depletion of reserves, selling of operations, mine closures, high contracting prices, inflations and other factors also affected these parameters. Results for Anglo Coal and South32 did not indicate consistent good or improved financial results in all the financial analysis methods post the investment years in digital technology, in contrast to Glencore's results which did. Glencore also invested more capital in digital technology as compared to Anglo Coal and South32. It is suggested that this may be one reason for its success. Consequently, it is recommended that companies looking to invest in digital technology follow the example of Glencore and invest as much capital as possible in this venture in order to maximise its potential.

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LIST OF ABBREVIATIONS

Abbreviation	Description
4IR	Fourth Industrial Revolution
Anglo Coal	In June 2021, Anglo American plc (a multinational, diversified mining company) completed the demerger of its thermal coal operations in South Africa to Thungela Resources Limited (Thungela). In this report, the company is referred to as "Anglo Coal".
CAS	Collision Avoidance System
EBITA	Earnings Before Interest, Taxes, and Amortization
EVA	Economic Value Add
GPS	Global Positioning System
Glencore	Glencore plc is a globally diversified natural resource company and is a major player in the coal production and marketing industry in South Africa. In this report, "Glencore" refers to the South African coal operations of this multinational company.
GHG	Green House Gases
GDP	Gross Domestic Product
JSE	Johannesburg Stock Exchange
Mt	Million Tonnes
PCDS	Pollution Control Dams
PWC	Price Waterhouse Coopers
PDS	Proximity Detection System
SA	South Africa
South32	In May 2021, South32 (a globally diversified mining and metals company) transferred their 100% shareholding in SA Energy Coal Holdings (Pty) Ltd to Seriti Resources Holdings (Pty) Ltd. South32 was, itself, spun out of BHP Billiton in May 2015. However, in this report, this company is referred to as "South32".
ZAR	South African Rands
TMMs	Trackless Mobile Machines
US$	United States Dollars
WACC	Weighted Average Cost of Capital

1 INTRODUCTION

1.1 Chapter Overview

This chapter describes the overview of coal mining in South Africa (SA), the role of coal in SA's economy, the performance of SA's coal sector and overview of digital technology in mining. This chapter also outlines the scope of the research. It further explains the aims and the importance of this research. The chapter is concluded by explaining the report structure.

1.2 Research Background

1.2.1 Overview of coal mining in South Africa

Coal was first discovered in Mpumalanga, KwaZulu-Natal, and Eastern Provinces of South Africa. Its discovery was first documented between 1838 and 1859 (Jeffrey, et al., 2015). The discovery of gold and diamond in 1886 and 1870, respectively increased the demand for coal due to the amount of electricity required on the operating mines. Mpumalanga is currently the major coal province in South Africa. The majority of South Africa's coal is mined from open-cast mines (53%) and underground bord-and-pillar operations (40%), while stoping (4%) and longwall mining (3%) make up the remainder (Jeffrey, et al., 2015).

South Africa has an estimated 30 billion tonnes of Coal Resources representing 3.5% of the world's Coal Resources (Statistics South Africa, 2019). The country produces 3.3% of global annual coal production. Figure 1-1 illustrates the location of coal mining operations in Mpumalanga and Limpopo.

South African coal mines are dominant in Mpumalanga, with 83% of the country's coal mining operations are from there and the remaining percentages mined in KwaZulu-Natal, Free State and Limpopo (Chamber of Mines of South Africa, 2018). The major coal mining companies in Mpumalanga are Thungela Resources (formerly named Anglo American), Glencore, Seriti Resources (formerly named South32, which was spun out of BHP Billiton), Sasol, Exxaro amongst others, creating over 170 000 jobs (Chamber of Mines of South Africa, 2018).

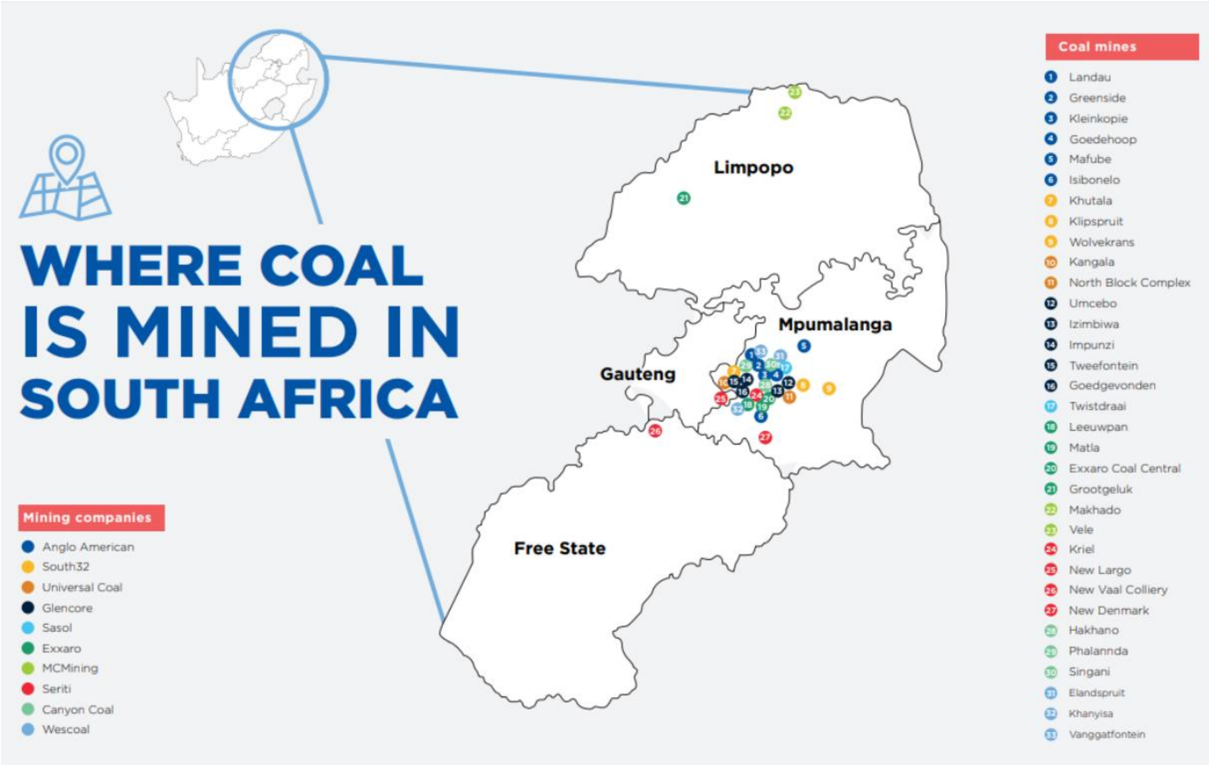

Figure 1-1: Locations of coal mining operations in Mpumalanga and Limpopo (Chamber of Mines of South Africa, 2018)

1.2.2 Role of coal in South African economy

South Africa's main source of energy is thermal coal, providing 77% of the country's energy (Statistics South Africa, 2015). Eskom produces 95% of the country's electricity by burning the coal at their 16 power stations (Statistics South Africa, 2015). The other coal which is not sent to Eskom is exported or sold on the domestic market. Figure 1-2 demonstrates the economic contribution of different commodities in South Africa.

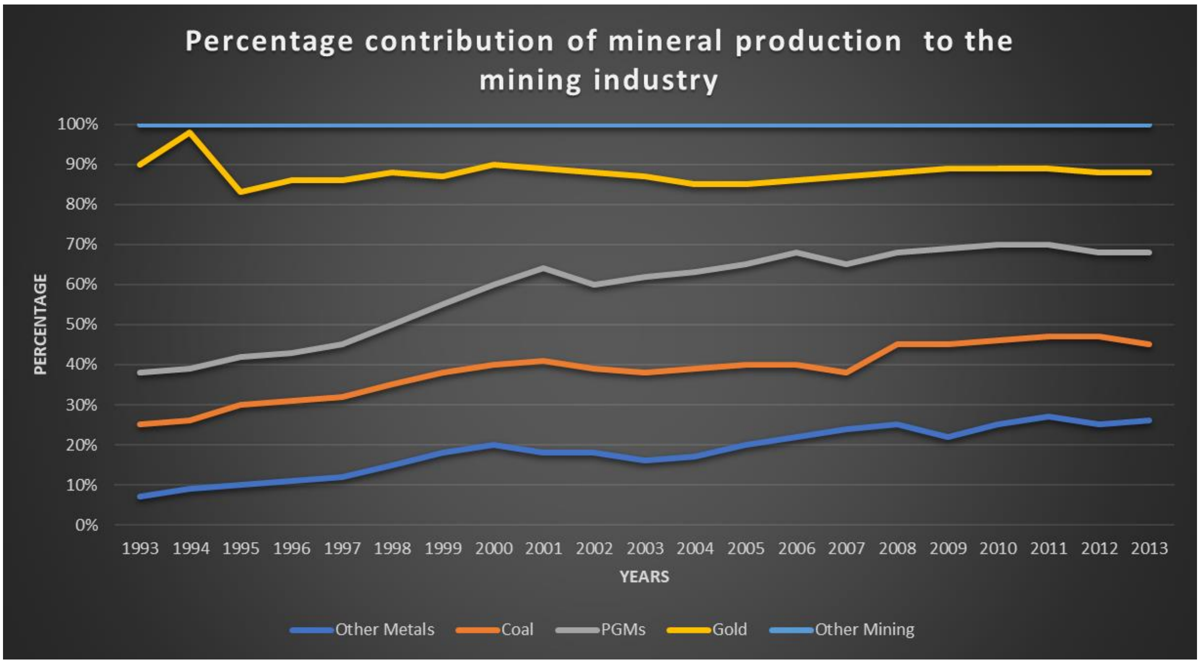

Figure 1-2: Percentage contribution of mineral production in South African's economy (Statistics South Africa, 2015)

The coal mining industry's contribution to South Africa's GDP was 21% and 45% in 1993 and 2013, respectively (Statistics South Africa, 2015). This shows a significant improvement, due primarily to increase in sales of coal between 1993 and 2013.

In 2020, coal was the largest source of revenue for mining companies by a wide margin. Revenues from coal production are ten times larger than those from minerals used in clean energy technology, maintaining its importance and supporting the relevance for this research. However, accelerating clean energy transitions are set to change this picture radically due to effort to reach the goals of the Paris Agreement (climate stabilisation at "well below 2°C global temperature rise") (International Energy Agency, 2021). This will result in the revenue from energy transition minerals overtaking those from coal well before 2040 as demonstrated in Figure 1-3. However, coal still has more than some 15 years before it can be overtaken by renewal energy which additionally support its relevance for this research.

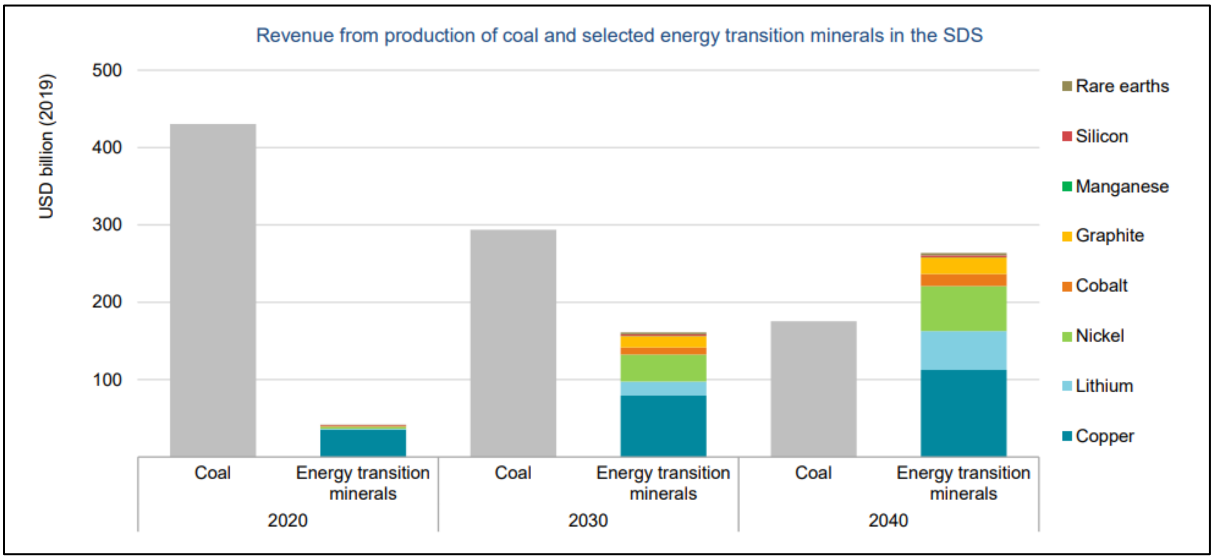

Figure 1-3: Revenue from production of coal and selected energy transition minerals (International Energy Agency, 2021)

1.2.3 Performance of South African coal sector

The coal price has been very volatile between 1970 and 2015. Figure 1-4 shows South African local and export coal prices between 1970 and 2015.

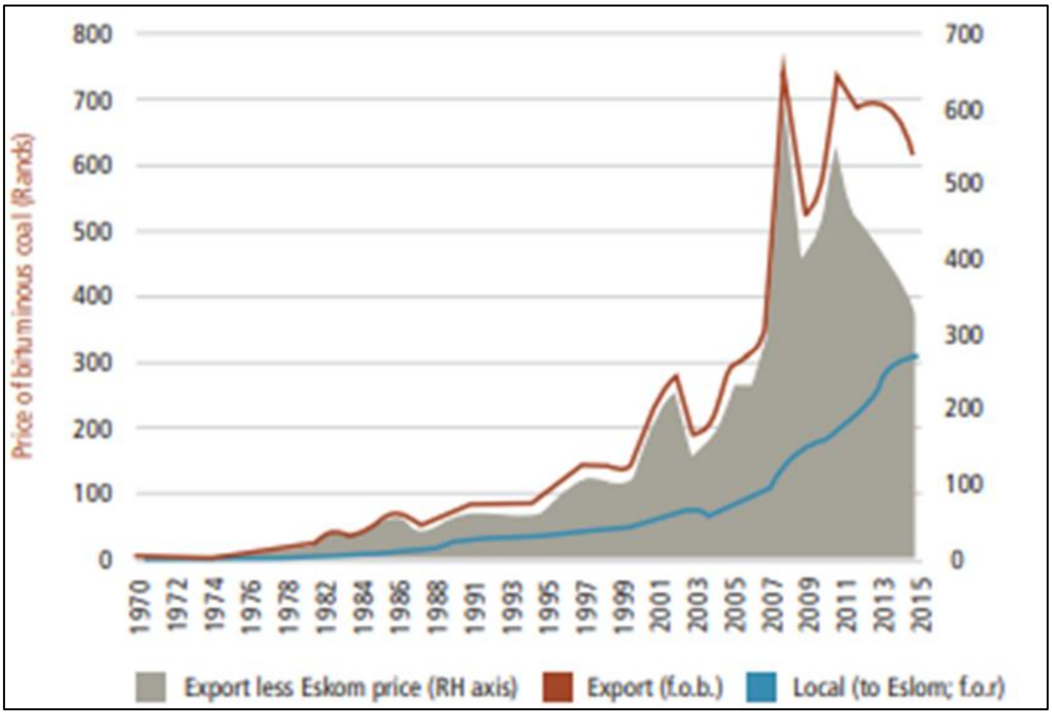

Figure 1-4: South African local and export coal prices between 1970 and 2015 (Chamber of Mines of South Africa, 2018)

The volatility of commodity prices has forced mining companies to identify stay-in-business financing options that include debt, equity, joint ventures, and royalty deals, (PWC, 2015). Further, most of the existing mines have matured and face multiple challenges such as longer haulage distances, low coal qualities and depleting Coal Reserves amongst others (Trench & Sykes, 2014). These challenges emphasise the need for coal mining companies to deploy digital technology as one potential solution to combat lower profitability.

According to Statistics South Africa (2019), coal mining operations' production has reduced by 0.2 % in 2018 compared to 2017 due to decreasing coal qualities and reduced Coal Reserves. Figure 1-5 shows the production of different commodities from 2015 to 2018.

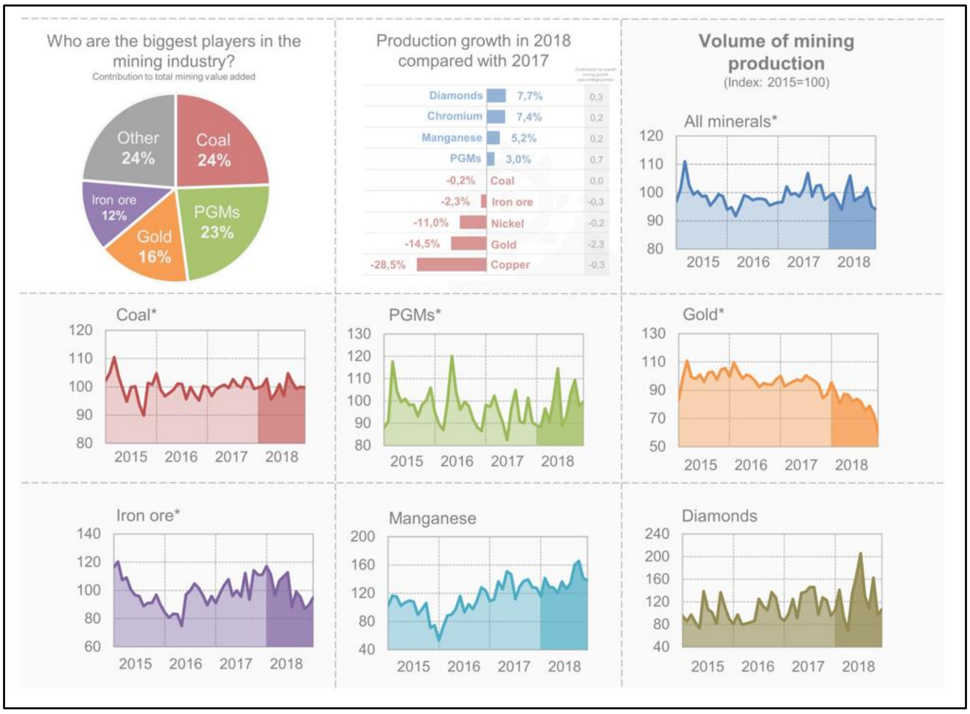

Figure 1-5: South African production of different commodities (Statistics South Africa, 2019)

The reduction of Coal Reserves and the decline in coal qualities have caused mining companies to be forced to mine at longer haulage distances to access good-quality coal. This results in increased mining costs, reduced profitability, and reduced productivity (Trench & Sykes, 2014). Due to these factors among others, mining companies face a continuous business risk, thus the need for digital technology to continuously improve the business and alleviate these challenges.

1.2.4 Overview of digital technology in mining

Digital technology refers to electronic tools, resources, devices and systems that store, generate and process information rapidly. It can also be regarded as technology that represents texts in a digital format. In the mining industry the implementation of technology has been developed in the past 40 years and is ongoing (Thomas, 2019). This technology forces change and the nature in which mining activities interact with the environment, employees, communities, customers, government, and every stakeholder at every step of the mining value chain (Thomas, 2019).

On a revenue comparison, the mining industry spends about 80% less on technology and innovation compared to the oil and petroleum industry. This makes the oil and petroleum industry a leader in digital technology investment and it is something that the mining industry should emulate (Jacobs & Webber-Youngman, 2017). Looking at the magnitude of the mining challenges, it is inevitable that the mining industry may need to spend more financial capital on innovation and technology.

Lack of funding is another key factor limiting investment in innovation for coal projects. There is a relative decline in coal demand driven by cost of coal production, emissions targets, and risk considerations. According to Mey, et al. (2019), banks and financiers have become more reluctant to invest in coal mining because of the risk of stranded assets and/ or climate liability. Therefore, there is a need for investment learnings to be noted in coal mining companies that invested in technology, for financiers to gain more confidence.

The mining industry needs to take more steps towards digital technology and innovations that have evolved in recent years. Digital technology and innovation are among the initiatives that can assist mining companies to realise productive, efficient, profitable and sustainable mines (Charlie, 2020). Learnings can be taken from mining companies that have already embarked on the digital technology transformation. Anglo Coal (currently operating as Thungela Resources), Glencore, South32 (originally spun out of BHP Billiton and currently operating as Seriti Resources), are examples of SA coal mining companies that invested in digital technology.

1.3 Scope of the Research

This research evaluates the financial performance of three coal mining companies that invested in digital technology, namely Glencore, Anglo American Coal Division (Thungela), and BHP Billiton (South32 SA Energy Coal Holdings (Pty) Ltd (South32)).

- Glencore plc is a globally diversified natural resource company and is a major player in the coal production and marketing industry in South Africa. In this report, "**Glencore**" refers to the South African coal operations of this multinational company.
- In June 2021, Anglo American plc (a multinational, diversified mining company) completed the demerger of its thermal coal operations in South Africa to Thungela Resources Limited (Thungela). In this report, the company is referred to as "**Anglo Coal**".
- In May 2021, South32 (a globally diversified mining and metals company) transferred their 100% shareholding in SA Energy Coal Holdings (Pty) Ltd to Seriti Resources Holdings (Pty) Ltd (Seriti). South32 was, itself, spun out of BHP Billiton in May 2015. However, in this report, this company is referred to as "**South32**".

It is expected that similar challenges and results will be identified in other commodities, however, this research focuses only on coal mines. Coal mines have been selected, due to their importance with respect to energy generation in South Africa.

1.4 Problem Statement

The coal mining sector has been faced with several challenges including volatile coal prices, environmental regulations on the emission of green house gases (GHG), reduced Coal Reserves and coal qualities (PWC, 2021). These factors have a major influence on productivity and profitability of the coal mines. The changes in market trends are increasingly limiting access to funding for coal projects (PWC, 2021). To combat these detrimental effects on profitability, some mining companies have invested in digital technology in recent years (post 2015).

The focus of this research is whether these companies have realised value from investment in digital technology. This question was investigated by analysing possible relationships between investment into digital technology and financial performance.

1.5 Research Significance

Mining companies such as Anglo Coal (Thungela), Glencore and South32 (Seriti) have invested in digital technology. However, the relationship between these investments and their financial performance has not been established. Filling this gap will have the following benefits:

- Mining investors can see and analyse the results of investing in digital technology.
- Mining companies that have not invested in digital technology can make better decisions on whether or not to invest in digital technology.
- Mining companies can decide not to invest in digital technology based on companies that invested on the technology but have not realised the predicted benefits of their investments.
- Workers and community that receive training in digital technology can be employable in other mines or use these skills beyond their operations' life of mine.
- Increase in production realised due to digital technology can increase profitability.
- Economic growth due to coal mines that invested in digital technology skilling communities, improved profit margins, and infrastructure development as part of the cooperate social development.

1.6 Research Aim and Objectives

The research aim was to analyse the impact of digital technology in South African coal mines. The specific objectives of this research project were to:

- Investigate the reasons why companies would deploy digital technology.
- Identify the digital technology and technology applications that were invested in by the selected mining companies.
- Develop and analyse industry cost curves for mining companies that have invested in digital technology to analyse production and cost performances.
- Investigate the financial performance trends of companies that invested in digital technology through operating profit trends, profitability financial ratios, Economic Value Add (EVA) and Du Pont analyses.

1.7 Report Structure

The report consists of five chapters. Chapter 1 introduces the research background, it provides the scope of research, problem statement, research significance, aims and objectives.

Chapter 2 defines the coal mining's local and global perspectives, examples of digital technology and the digital technology value chain. It further discusses the impact of digital technology, status of digital technology adaptation in mining, existing studies or case studies related to this research, drivers and barriers of digital technology and definitions of financial analysis methods.

Chapter 3 articulates research design, data collection, sample selection, reliability of data, steps or procedures followed in consolidating the data. It further discusses the data analysis, ethical issues and summarises the chapter.

Chapter 4 presents the digital technology investment by Anglo Coal, South32 and Glencore. It then analyses results of these companies. It analyses cost curves, operating profit trends, profitability ratios, EVA to invested capital analysis as well as a Du Pont analysis.

Chapter 5 summarises the findings and conclusion of this research project. It then outlines the recommendations for South African coal mines or companies intending to invest in digital technology. It also presents the limitations of the research and suggestions for further research.

2 LITERATURE REVIEW

2.1 Chapter Overview

This chapter discusses the coal mining's global and local outlook, examples of digital technology and digital technology value chain. It then details the impact, status of digital technology adaptation in mining, existing studies, drivers of digital technology and barriers to technology adoption. It further discusses brief literature of financial analysis techniques.

2.2 Coal Mining Outlook

2.2.1 Global

In 2019, the coal fired power generation started to decline due to weak coal generated electricity demand and low natural gas prices. The global coal consumption is estimated to have declined by 7% between 2018 and 2020 due to increased demand of generating electricity from renewables to reduce the global carbon emissions (International Energy Agency, 2020). Although the Russia and Ukraine war has recently increased coal demand in 2022, the urgency of coal transition to renewable energy remains unchanged (World Bank, 2022). However, coal will still be required globally for electricity use until at least 2030 to ensure a smooth transition to green or renewable energy sources (International Energy Agency, 2020). Coal is still relevant for at least the next 10 years globally and locally. Therefore, it is relevant to do this research.

2.2.2 Local

South Africa is currently a major emitter of greenhouse gases as a result of its generation of electricity using coal (Mkhize, 2021). According to Global Carbon Atlas South Africa is the 12th biggest carbon dioxide emitter in the world due to is vast scale of coal operations run by the country's state electrical power generation company Eskom (Mkhize, 2021). As a result, South Africa has now taken steps to invest in renewable sources of energy to reduce its GHG emissions. This will lead to lower coal demand, resulting in the retirement of power stations and closure of many coal mines by mid-2030s (Strambo, et al., 2019). South African coal will still be in demand for power generation until 2030 before the estimated full implementation of renewable energy sources of power.

2.3 Digital Technology

Digital technology refers to electronic tools, resources, devices and systems that store, generate and process information rapidly. It can also be regarded as technology that represents texts in a digital format (Thomas, 2019). Digital technology is the essential driving force for the Fourth Industrial Revolution (4IR). Nearly all the innovations and advances coming with the 4IR tide are made possible and enhanced through digital power (Schwab, 2016). Table 2-1 shows digital, physical and biological technology fields.

Technology drivers	Fields
Digital	The Internet of Things (IoT)
	Artificial intelligence and machine learning
	Big data and cloud computing
	Digital platform
Physical	Autonomous Cars
	3D printing
Biological	Genetic Engineering
	Neurotechnology

Table 2-1: Digital, Physical and Biological Technology Fields (Schwab, 2016)

Digital technology is mostly manifested on four characteristics, namely the Internet of Things, artificial intelligence and machine learning, cloud computing and big data, and digital platforms. This research focuses on digital technology and not biological and physical technology as shown in Table 2-1 above.

2.3.1 Digital mining technology

The digital technology in mining is challenging the past mining business models throughout the mining value chain. However, there is no adequate research that critically analyses financial performance of South African mining companies that have invested in digital technology.

Examples of digital technology in mining include smart blast designs, proximity detector systems, fragmentation improvements technology for the mine to mill concept, drones, remote operating systems, and others (Motion Metrics, 2019; Tauber, et al., 2018). According to Hermanus (2017) and Sganzerla, et al. (2015), the remote operating centres that have been utilised in the oil and gas industry, have also been adopted in the mining industry recently. The remote operations are reducing employees' exposure to safety hazards, as equipment are automated and only fewer people are required to run the operations remotely.

As the mining industry gets closer to the concept of 4IR which is the transformation of digital technology, an analogue to the application of 4IR in a mining context was conceptualized and it was called Mining 4.0 (Johanson, et al, 2019). Mining 4.0 was conceptualized as a mining operation where the miner is an expert who ensures that production runs smoothly and creates a model of how mining companies should operate (Bertayeva, et al., 2019; Johanson, et al., 2019). It may navigate its way to the future that works for all mining workers.

According to Johanson, et al. (2019), the mining industry is gradually getting closer to the vision of Mining 4.0 where more mining companies are looking at investing in digital technology which ensures that production runs smoothly. The Mining 4.0 miner is not confined to a control room. However, real-time process data and status of the mining equipment follow the miner as they move around the mine. The miner solves problems at source by engaging with other operators, suppliers, experts, and customers in multi-competent teams (Johanson, et al., 2019; Bertayeva, et al., 2019).

Production supervision by the miner can now be done through a digital twin far from the mine. In short, Mining 4.0 equips the miner with senses and memory extended through the digital technology (Bertayeva, et al., 2019; Johanson, et al., 2019). This technology supports human skills and increases situational awareness through technological sensors embedded on the clothes of the miner. This is essential in difficult mine environments where heat and long shifts are challenges.

Romero et al. (2016) developed a typology called Operator 4.0 which is one of essential developments of digital technology. It has been built on eight stereotypes that can be seen as the centre of the new technology. Operator 4.0 integrates information from the digital world to the physical world. This includes for example, maintenance department receiving direct support system from the equipment manufacturers of the digital technology (Bertayeva, et al., 2019; Romero, et al., 2016; Johanson, et al., 2019). There are special glasses developed to send and receive live videos so that both the maintainers and the manufacturers can be able to see the problem and be solved through instructions given by the manufacturer to the maintainer.

Mining 4.0 also developed a virtual miner that uses virtual reality (VR) technology for the simulation and training of high-risk mining situations (Johanson, et al., 2019). Examples of the high-risk mining situations includes fire events and simulation of new equipment (how the new equipment will fit in the mining environment). It is then possible to place the control room or production room in a VR environment and make it independent of the location (Johanson, et al., 2019). Meaning the training of high-risk events can be conducted far from the location where the event is likely to take place.

Johanson, et al. (2019) noted that Mining 4.0 developed a healthy miner that uses wearing of sensors that helps to monitor employee’s health in the workplace as well as locating them through GPS. Mining 4.0 has also developed a smart miner which uses smartphone applications to report malfunctioning equipment easily and rapidly. The smart miner uses advanced personal assistants to interact with machines, databases, computers and information to rapidly transmit the information between different departments of the mine (Johanson, et al., 2019; Bertayeva, et al., 2019).

Automated machines have also been developed. In mining, there are semi-autonomous machines such as loaders. Figure 2-1 shows an example of an automated loading operation being monitored from a control room.

Figure 2-1: Control Room of an Automated Loading Operation (Marklund, 2017)

The operator first teaches the machine the mining pathways which it then follows automatically while the operator monitors the activity from the control room (Johanson, et al., 2019; Bertayeva, et al., 2019). In this instance the strenuous and repetitive activity of driving and loading to and from the muck pile is taken over by the machines.

2.4 Technology Across the Mining Value Chain

A recent study by Callahan & George (2020) identifies the impact of different digital technology along the mining value chain globally. Figure 2-2 shows the percentage investment of different digital technology for mining operations.

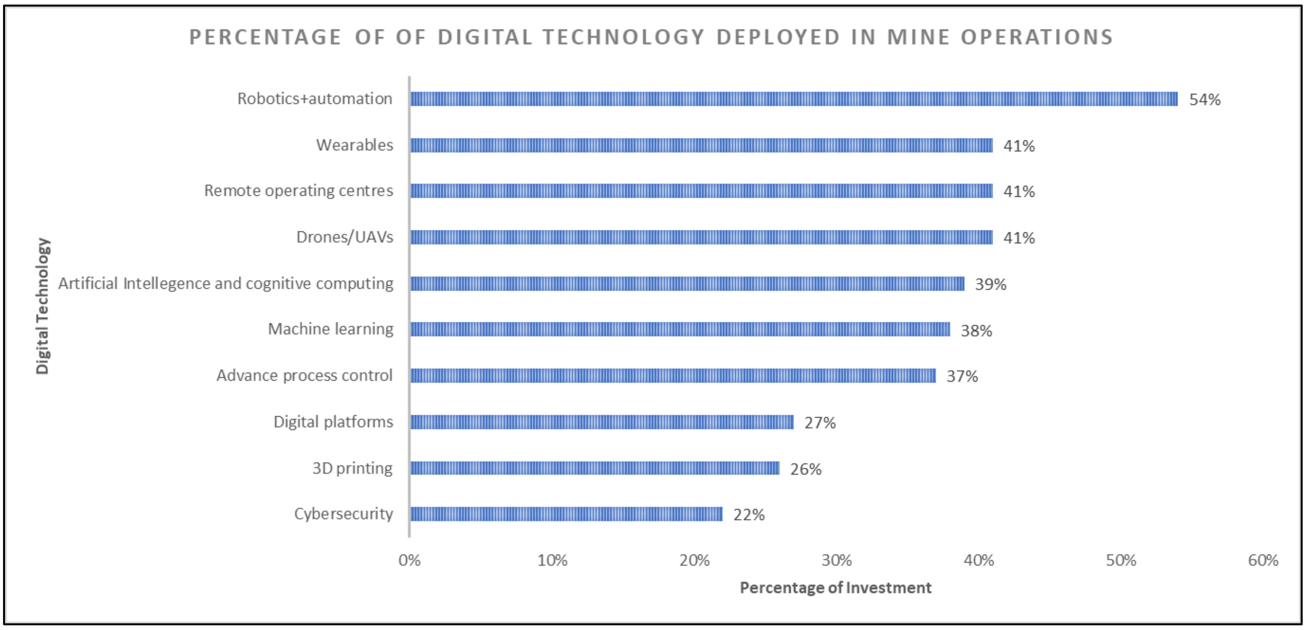

Figure 2-2: Digital technology investment of different stages of the mining value chain. (Adapted from Callahan & George, 2020)

From Figure 2-2, it can be seen that the most invested technology on the value chain is robotics and automation followed by drones, remote operating centres, and wearables. The least invested digital technology is cybersecurity.

According to a survey by World Economic Forum (2020), the pace of digital technology adaptation is expected to accelerate in mining. The findings indicate that adaptation of big data analytics, internet of things, connected devices-robots, automation and drones has been the high priority in the mining industry. A study by Barnewold & Lottermoser (2020) shows that key digital technology relevant for mining appears to be automation, internet of things, robotics, real-time data and big data. Of the companies surveyed 90% expressed the likelihood of adopting such technology by 2025 (Lazarenko & Tkalenko, 2021). Further, there has been a significant rise in interest for encryption, cloud computing, artificial intelligence, and cybersecurity (Lazarenko & Tkalenko, 2021).

What is important to mining operation is getting the correct information in the right timeframe to help take corrective actions and react fast to changing situations at the operations (Callahan & George, 2020; Ernst & Young, 2017a; Hermanus, 2017). This is achieved primarily through the four most prominent technologies identified in Figure 2-2 above namely; robotics/automation, drones, remote operating centres and the wearable technology (Callahan & George, 2020). These technology is also used relatively high in exploration, mine development and ore processing.

These four technologies together give a perspective that mining operations are developing rapidly in digital technology. Operational information through automated processes, digital platforms and drones are using the remote operating centres to make collaborative critical decisions with that information (Hermanus, 2017; Sganzerla, et al., 2015). Wearables are integrated with the overall system in order to share information with individual employee (Callahan & George, 2020).

The sales and marketing sectors do not appear to make significant use of digital technology. Better integration of digital technology across the value chain could be used to assist mining operations to understand market needs and conversely helps them make better sales. The market can also benefit from this technology by understanding which product specifications are in the pipeline and are available for the customers (Callahan & George, 2020).

Investment in cybersecurity is the lowest which is seen as a significant risk. As mines become more connected and increasingly digitised, mining companies will face network security threats (World Economic Forum, 2020; Ernst & Young, 2017b; Young & Rogers; 2019, Callahan & George, 2020). The mining industry's focus on cybersecurity is strong in marketing level but not on the mining operations. It is suggested that this may be the case since digital mining is still a new concept and awareness of cybersecurity risks on mining operations is still low. Mining companies are more concerned with security in their sales and marketing divisions than they are in their operations (Callahan & George, 2020). The mining industry like many other industries has initially focused on putting strong barriers around centralised technology like corporate servers in their marketing and sales department (World Economic Forum, 2020; Ernst & Young, 2017b; Young & Rogers; 2019, Callahan & George, 2020). However, mining operations are becoming more connected and sharing data with different partners. This means that they need to move past traditional approaches to secure data and invest in centralised security systems.

Awareness on cybersecurity is necessary since there have been significant hacking events on 22 mining companies since 2010 (Callahan & George, 2020; Klein & Walsh, 2017). The use of cybersecurity technology has been projected to keep growing. Twenty five percent of mining companies surveyed by Callahan & George (2020), indicated that they are piloting cybersecurity technology and 33% indicated that they are in progress of developing cybersecurity technology strategies.

2.5 Impact of Digital Technology in the Mining Industry

2.5.1 Positive impacts of digital technology

Digital technology does not only have an impact on the technology space of mining organizations and workplaces. It also impacts on knowledge transformation of employees. The digital technology requires mining companies to be learning organizations that have continuous learning workplaces and education (Tauber, et al., 2018).

Mining tasks have been traditionally seen as physically demanding and requiring strong workers (Tauber, et al., 2018). The new context of digital technology requires knowledge and skills that are more theoretical and abstract than physical. This opens more doors for women and other previously disadvantaged individuals in the mining industry especially in underground mines (Johanson, et al., 2019).

Digital technology related to automation, remote control and smart systems are designed to replace humans with machines in dangerous workplaces and routine behaviours (Ernst &

Young, 2017b; Hermanus, 2017; Deloitte, 2020). These assist operators to focus on creating, learning and valuing work tasks in a safe workplace.

For every investment, benefits are expected. On an operational level, mining analysts have cited digital technology as a catalyst to achieve better equipment performance by 47% improvement, operational cost savings by 42% and better decision making by 40% (Callahan & George, 2020). Mining analysts expect those benefits to continue but they may not be realised if they are other external factors that hinders the success of digital technology, such as low commodity price or inflation, for example.

According to Barnewold & Lottermoser (2020), digital technology is expected to have quantifiable reduction of operational costs by 15%–30%. This will be achieved by reducing labour costs and installing automated systems. This will be realised more in larger mines with a large workforce who will benefit from the reduced labour costs. For smaller mines, this effect would be reduced due to fewer pieces of equipment and a smaller workforce (Barnewold & Lottermoser, 2020).

2.5.2 Negative impacts of digital technology

Digital technology empowers employees with new skills but have an impact on job losses and unemployment, as it requires fewer people to operate a huge mining operation (Sganzerla, et al., 2015; Tauber, et al., 2018). This has the potential to cause conflicts between mining operations and employees.

Digital technology comes with a need for responsibility, teamwork and understanding of production flow from the workforce. This transition comes with negative impacts, whereby manual tasks that are now automated and are being controlled by the operators. These operators eventually work well with the new system and have the core understating of the technology (Johanson, et al., 2019). This also elevates a good question of how the operators' skills can be passed on to the smart mining programmer, because most equipment operators can tell if there is a maintenance problem or feel that the machine is not working efficiently while the programmer cannot tell (Johanson, et al., 2019).

The transformation as a result of digital technology has effects on workplace identities and cultures. Work tasks which were previously performed by solitary teams are now done by solitary employees equipped with different tools or equipment with digital assistance (Tauber, et al., 2018). Existing mining culture and structures are very hard to change and changing them may provoke employees' resistance. As an employee it can be hard to lose your work aspects and identity and aspects. New technology that threatens to disturb this, can result in a lag on digital technology implementation and formal organizational changes.

According to Barnewold & Lottermoser (2020), 37% of leading executives have insufficient knowledge and understanding of current digital technology available options and trends. This prevents them from knowing which digital technology is available to invest in and what could solve their operational problems. The lack of knowledge results in important digital technology principles not being fully understood by and communicated to potential users.

Another challenge is the increase in global information that flows rapidly. Private and confidential company's information is at risk of exposure due to cyber hacking (World Economic Forum, 2020; Ernst & Young, 2017a; Young & Rogers, 2019; Callahan & George, 2020). In today's digitised economy where threats to cybersecurity are continuously increasing, protecting data, infrastructure, customers, business partners, clients and third parties against a breach is one of the biggest challenges digitised companies face. On the other hand, if a company does not go through a digital transformation there is a risk it may get left behind, and if it does there is an inherent and increased risk of cybercrime.

2.6 Status of Digital Technology Adoption in Mining

A study by Accenture on undisclosed mining companies shows that information technology (IT)- operational technology (OT) integration is developing very well (Callahan & George, 2020). The integration of these groups under one governance is essential to getting the most out of the IT-OT union (Callahan & George, 2020; Klein & Walsh, 2017). For example, it enables practices of real-time monitoring of operations and the cloud-based service delivery of operational functions such as alarm management and production accounting (Callahan & George, 2020). It is also important for mining companies to focus on innovations that bring great efficiency and effectiveness on their operations.

Mining companies are looking to sophisticated analytics to help improve operations and make data-driven decisions (Sganzerla, et al., 2015). More than 31% of the mining companies said that they are making huge monetary investments in real-time data visualization and 58% said that they are still at strategy stage of implementing that technology (Callahan & George, 2020). Some 11% said that they are conducting research with machine learning analytics, cognancy computing and artificial intelligence (Callahan & George, 2020). Although research is being conducted, at this stage there is still a lack in implementing digital technology in the SA coal industry.

Statistics above indicate that mining companies are interested in leveraging digital technology and to take analytics to the next level. This next level involves moving to developing simulations, real-time and dynamic analysis. This also adds on tying in machine and artificial intelligence (Callahan & George, 2020; Lazarenko & Tkalenko, 2021). The ultimate goal is to use these tools to improve decision making on the fundamentals of mining and taking data-driven approaches to determine how best to process the data to achieve great value.

2.7 Existing Research in Digital Technology

Macfarlane (2001) investigated the advantages and disadvantages of introducing digital technology in South African mines. He also looked at the application of the appropriate technology, the level of work environment where the technology is introduced and the development of technological applications. This investigation was done by following the Wheel of Change model developed by Malherbe in 1993 (Macfarlane, 2001). The model ensures that aspects of an organization into which technology is implemented are in balance. Figure 2-3 illustrates the Wheel of Change aspects of organizations.

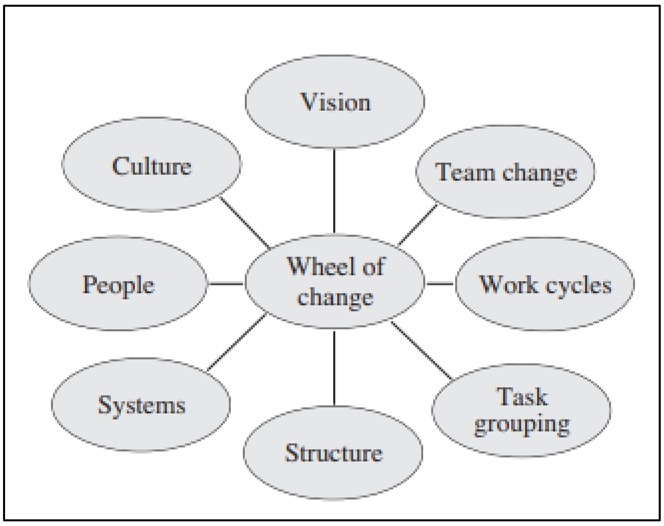

Figure 2-3: The Wheel of Change (Macfarlane, 2001)

The vision aspect looks at the need to implement the technology. The Mining Charter (2018) policy for South Africa supports the development and implementation of appropriate technology. Government undertakes and promotes research, technology transfer and implementation, because they believe that it will stimulate the optimal development of the country's resources in the longer term and ensure that the industry remains competitive (South African Government Gazette, 2018).

The team change aspect looks at the potential of digital technology to create jobs or take away jobs. Analysis done on a hypothetical mine (using realistic costs and grade-tonnage curves) showed that digital technology could increase production by 180 000 tonnes a month, for a life of mine of 20 years (Macfarlane, 2001). MacFarlane (2001) further suggested that this would have the effect of potentially creating some 5 700 new jobs while also benefiting existing employees by skilling them on the implemented technology. Based on these figures, it can be argued that technology is potentially more a job creator as opposed to a job destroyer.

The work cycles aspect looks at the way that work is carried out using the new digital technology implemented. This ensures that before technology is implemented at the mine, health and safety issues and ergonomic designs are considered from the start (Macfarlane, 2001). This avoids redesigns if technology is rejected by employees which can increase the initial capital costs. Ergonomic issues are extremely important, because if the new technology is user unfriendly, then operators of the technology will not be inclined to utilize it to its full capabilities.

The structure aspect looks at the influence of work cycles and task listings in a proper organizational structure. More complex technology like the move to continuous miner influenced an organization's structure. This meant that most conventional miners had to be moved to other tasks other than mining whilst others received training on the machine. The continuous miner had to meet required ergonomics standards and production capabilities. It is then essential that the structure conforms to the actual needs of the work cycles and task listings or groupings.

The systems aspect looks at new technology and methods. A systems engineering approach is embodied throughout the whole process of implementation. Specific systems are included to address, performance management systems for measuring the performance of the technology, against predetermined targets as well as for measuring the output of the work system (Macfarlane, 2001). These systems may include new safety technology, new emergency systems, appropriate financial accounting systems to ensure that the correct cost allocations are made etc.

The people aspect looks at the importance of people on the success of technology development, transfer and implementation (Macfarlane, 2001). This phase addresses the need for training and development. This is a critical component of whether the technology is appropriate, or competency and skill level are the main issues. An early imperative approach when implementing technology is to, assess the profile of the workforce required for the technology. Then after provide selection procedures and training which will allow the development of the required competencies identified during work cycles. Skills development should be a collaborative process, which must be done with full involvement of the equipment supplier, and organized labour.

The culture aspect gives the opportunity to check if everything has fallen into place. It is a review process to address results measured against planned outputs (Macfarlane, 2001). The process will normally highlight areas that need to be modified or revisited. It also indicates areas of small improvements need to be made, or major breakthroughs. This explains a fundamental component of the wheel of change, it is a continuous process which has no end. As the logical end of the sequence is reached, so the review process signifies the need to spin the wheel again, either entirely, or in selected parts.

An analysis done by the World Economic Forum (2020) to assess the accumulative value impact of digital technology in SA mining industry by the year 2025 indicates the following:

- An improvement in safety in the mining industry by avoiding 44 000 injuries and saving 1 000 lives. This is a decrease of 20% and 10% on injuries and fatalities, respectively.
- Carbon emissions are also estimated to reduce by 610 million tonnes from carbon emitting mining companies.
- The digital transformation in the mining industry will also add a value of 425 billion United States Dollars (US$) in the mining industry, society, customers and the environment.
- A major consequence of potential job losses of 330 000 employees equivalent to 5% of the South African mining industry, which mining companies will have to mitigate to avoid community unrest.

The World Economic Forum (2020) study does not include a financial analysis of companies that have invested in digital technology. It is a generic investigation of all mines in South Africa that have invested in digital technology, so that learnings can be implemented in other coal mines.

2.8 Drivers of Digital Technology

According to PWC (2021), drivers of the of digital technology through digital transformation or 4IR strategies are ranked using the top to bottom initiative approach. These are identified in Figure 2-4.

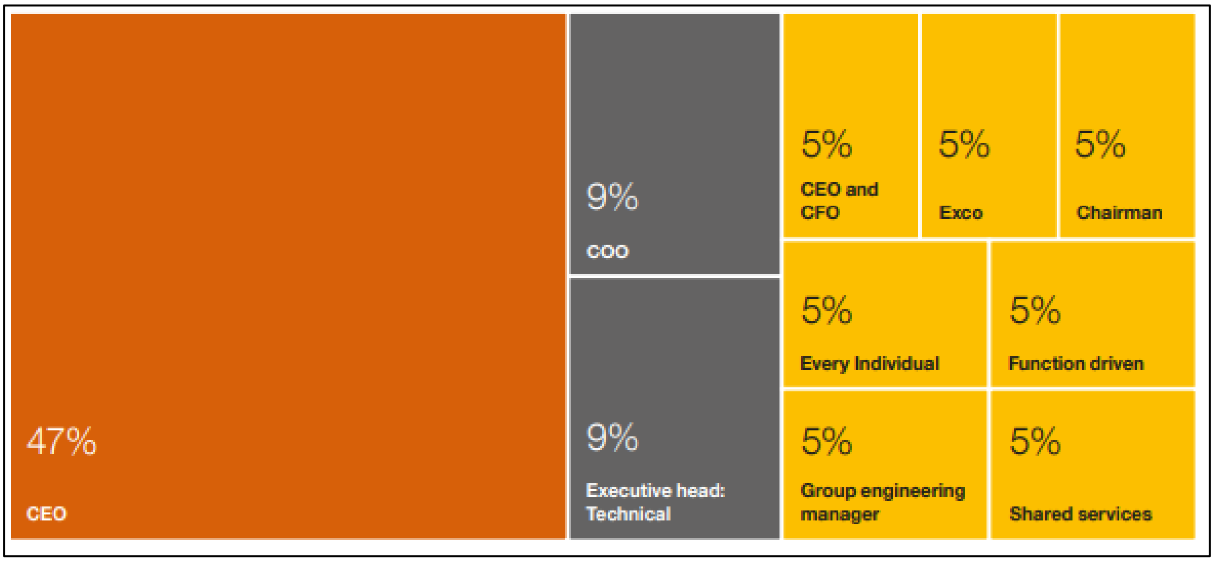

Figure 2-4: Drivers of 4IR (PWC, 2021)

Chief Executive Officers are the primary drivers of digital technology adaptation in the mining industry making 47% of the study done by PWC. The second influencial drivers are the Chief Operating Officers and Executive Head: Technical (PWC, 2021). As depicted by Figure 2.5, the top to bottom approach can provide the necessary impetus, since it involves an implementation process to operations' employees. Once this implementation is achieved, the operational benefits and support initiatives speed up the ownership and adaptation of the digital technology.

The road map to becoming a digital technology driver or champion is characterized by development of 4IR mining business ecosystem. This ecosystem is a link or network of internal and external suppliers, local communities, service providers, distributors, unionized and non-unionised labour, physical structure involved in identification, extraction, and processing of minerals (PWC, 2021).

For a mining company to become a digital technology champion, it must have successful digital solutions running in all these four drivers. Figure 2-5 demonstrates the levels of digital maturity.

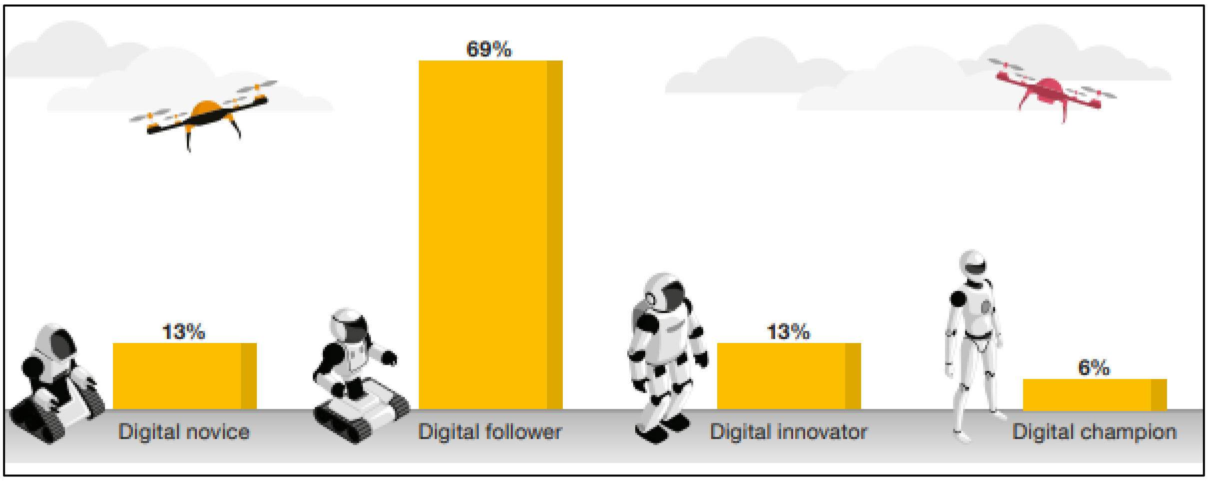

Figure 2-5: The levels of digital maturity (PWC, 2021)

A company typically passes through four levels of digital technology maturity to become a digital technology champion. The PWC (2021) study identifies these four distinct levels of digital maturity as:

- Digital novice — functional silos that are not yet connected.
- Digital follower — functionally connected practices.
- Digital innovator — cross-functionally connected practices.
- Digital champion — fully integrated health and safety, people, production, and cost ecosystem.

2.9 Barriers to Technology Adoption

It is also important to look at obstacles that hinder digital technology adoption. Figure 2-6 illustrates the barriers to implementing digital technology.

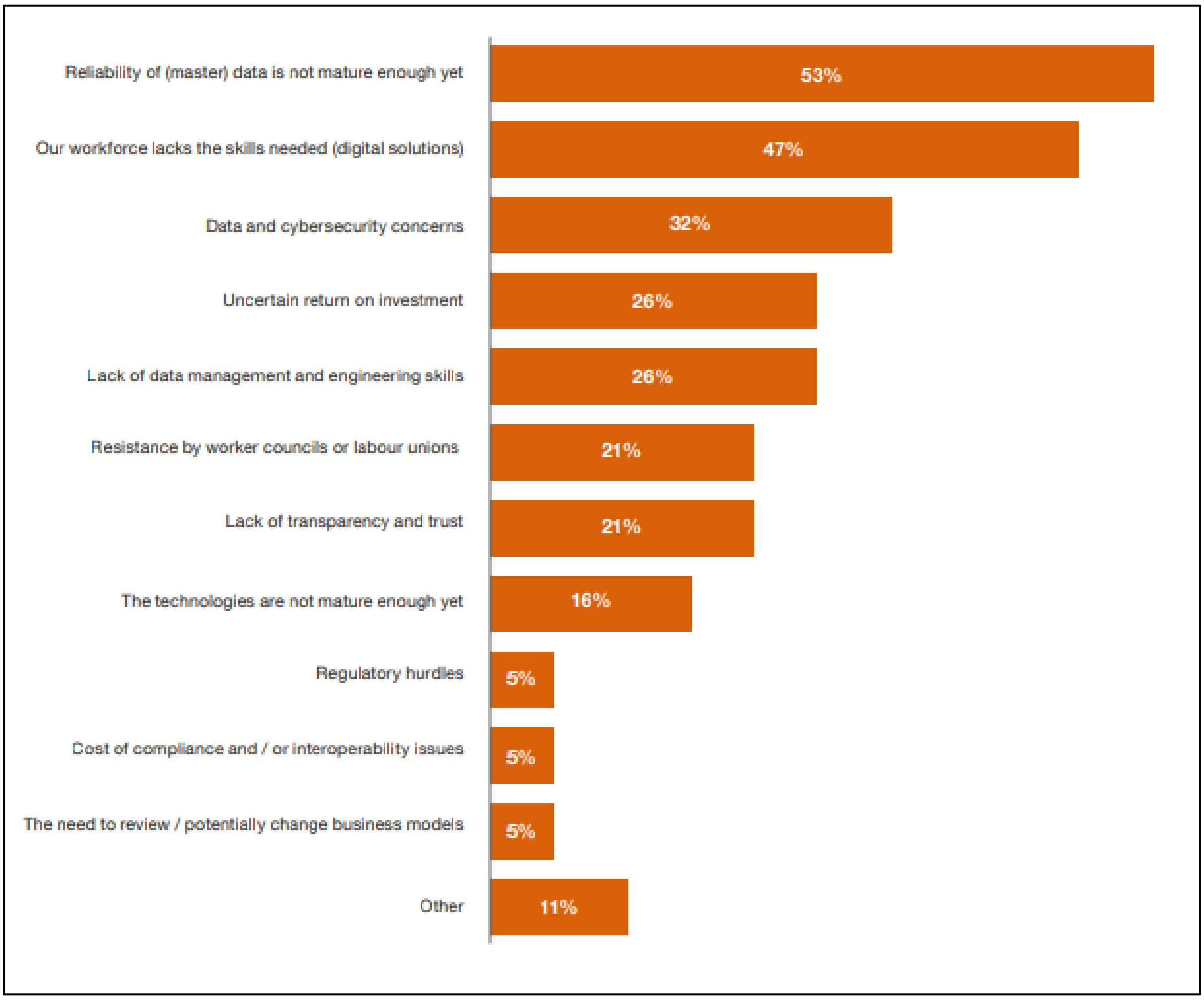

Figure 2-6: Barriers of implementing digital technology (PWC, 2021)

According to PWC (2021), 53% of respondents from their survey indicated that the largest barrier to implementing digital technology was that their data management practices were not mature enough. This same study highlighted that notion that the creation of a data management foundation is key for communication, visualisation and analytics as well as being able to have dependant key insights and make data-led decisions. It further noted that many South African mining companies are not yet at this stage to master their data and unlock this crucial potential.

The PWC (2021) study, also identified the second largest barrier as workforce lacking the skills to implement the digital technology. This challenge is driven by the type of workforce typically employed at most mining operations. The majority of this workforce has a low level of literacy, some are old and lack familiarity or knowledge of tools such as a personal computer. Innovation is required to address literacy, numeracy, and digital acumen in the mining workforce.

The third largest barrier of implementation, according to the study, is the concerns of cyber security. It is a real threat with convergence of IT and operation technology for transgressors to hack into a company's network and access dangerous machinery like automated dump trucks by stopping them and trapping miners underground or causing accidents in open pit mines.

The fourth barrier identified by the PWC study is the uncertainty on return of investment. Due to lack of public knowledge on companies that made big returns on digital technology implementations, investors are scared to invest their money with a fear of losing it. Most of the studies that exists out there only covers future estimates of returns on investment than the actual returns.

2.10 Financial Analysis

Nhleko & Neingo (2019) explain financial analysis as the procedure of selecting, evaluating, and interpreting financial information to support investment and financial decision-making. They further show that financial analysis tools and metrics are used to measure the trend in financial performance of a company comparative to its historical performance, its contemporaries and predict its possible future performance.

Several tools like cost curves, financial ratios and metrics like net present value, economic value add (EVA), amongst others can be used to analyse the financial performance of mining operations and companies (Nhleko & Neingo, 2019; Tholana, et al., 2013). However, this research project focused on cost curves, operating profit trends, profitability financial ratio, economic value add and Du Pont Analysis. The financial performance analysis was only performed on the parameters mentioned above, because the input data reported by these companies on their financial reports only supported calculations and analysis of these tools and metrics.

2.10.1 Production and industry cost curves

An industry cost curve is a tool to measure mining companies' or operations' unit cash margin by comparison of the unit operating cost to the commodity price (Trench & Sykes, 2014). Thus, cost curves are used to measure the production and financial performance of mining companies. Figure 2-7 shows an example of a typical industry cost curve.

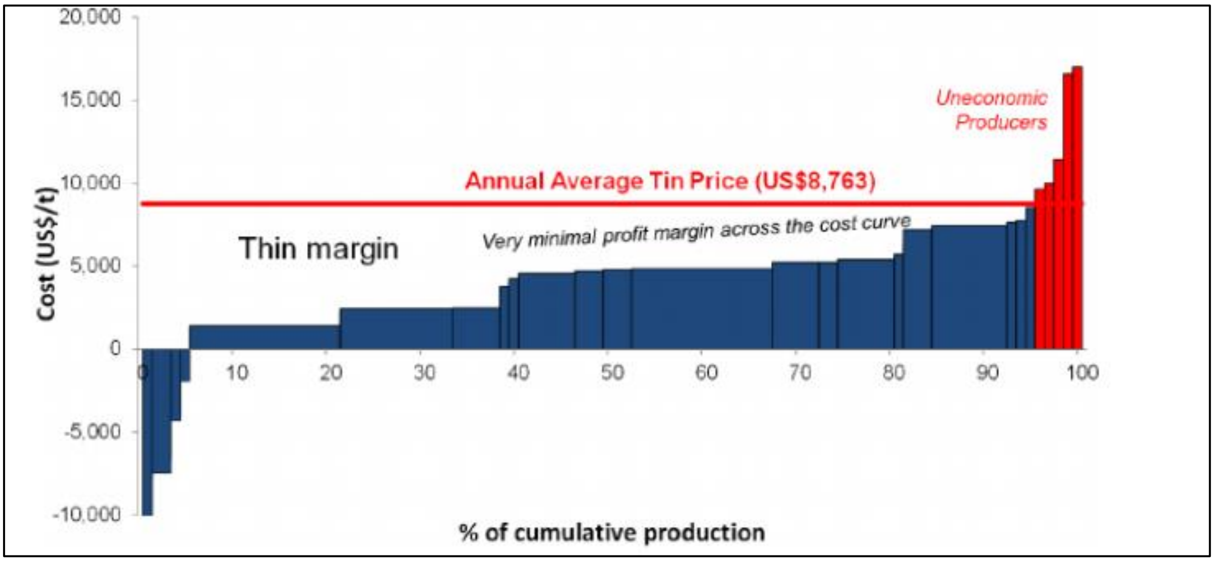

Figure 2-7: Example of an industry cost curve (Trench & Sykes, 2014)

The negative unit cost on production, indicates mines at development stage where investors are injecting capital. The positive unit costs below the red constant line show mining companies operating at low cost and above the red constant line at high cost. Using the unit cost and the commodity price, one can be able to measure the profitability of a mining company if certain volumes of the product mined is sold (Trench & Sykes, 2014; Tholana, *et al*., 2013).

2.10.2 Financial ratios

Nhleko & Neingo (2019) define a financial ratio as a relationship between two financial measures. According to Putri (2015), a financial ratio is a tool used to compare the items contained in the financial statements by dividing one number by another number. Table 2-2 indicates common financial ratios used in the mining sector and their standards.

Table 2-2: Common financial ratios used in the mining sector (Putri, 2015)

Ratio	Very Good	Good	Quite Good	Not Good
Liguidity Ratio				
1. Current Ratio	1.75-2	1.5-1.74	1.25-1.49	<1.25
2. Quick Ratio	1	0.75-0.99	0.5-0.74	<0.5
3. Cash Ratio	>0.1	0.07-0.09	0.04-0.06	<0.04
Solvability Ratio				
1. Debt to Asset Ratio	0-0.09	0.09-0.16	0.17-0.24	>0.25
2. Debt to Equity Ratio	0-0.39	0.40-0.69	0.7-0.99	>1
3. LTDteR	0-0.09	0.1-0.29	0.3-0.49	>0.5
4. LTDtAR	0-0.09	0.09-0.16	0.09-0.16	>0.25
5. Time Interest Earned	>6	>4	>2	<2
Profitabiliy Ratio				
1. Profit Margin	>0.3	0.21-0.29	0.14-0.2	0.07-0.13
2. Return On Asset	>0.15	0.07-0.14	0.01-0.06	<0.01
3. Return On Equity	>0.21	0.1-0.2	0.01-0.09	<0.02
Activity Ratio				
1. Fixed Assets Turnover	>1.1	0.6-0.9	0.2-0.5	<0.2
2 Average Collection Period	60 days	30 days-59 days	9 days-29 days	<9 days
3. Total Assets Turnover	>1.1	0.6-0.9	0.2-0.5	<0.2

According to Putri (2015), financial ratios are categorized under solvency, activity, market, liquidity, and profitability ratios. Normally, financial ratios describe the performance of a company and do not provide reasons for the occurrences. Therefore, they should be used in combination with other financial analysis tools that can consider the cause and effect. Only the profitability ratios were discussed in the report and only profit margin and asset turnover or return on asset were discussed since they are inputs to the Du Pont Analysis.

Putri (2015), states that profitability ratios specify the rate of return or cost (gain) associated to sales or assets. Profit margin is a ratio of EBITA over operating income while. Return on asset is a ratio of operating income over total assets. A very good profit margin is > 0.3 while 0.07 to 0.13 is not a good profit margin. A very good return on asset is > 0.15 while < 0.01 is not a good profit margin.

2.10.3 Economic value add (EVA)

As shown by Nhleko & Neingo (2019), EVA measures enduring wealth which is considered an appropriate measure of value in mineral resource management. The main objective of EVA is to quantify the cost of investing into a project and analyse whether the project generates enough value to be graded as decent investment. Figure 2-8 shows an example of input parameters used in EVA calculation.

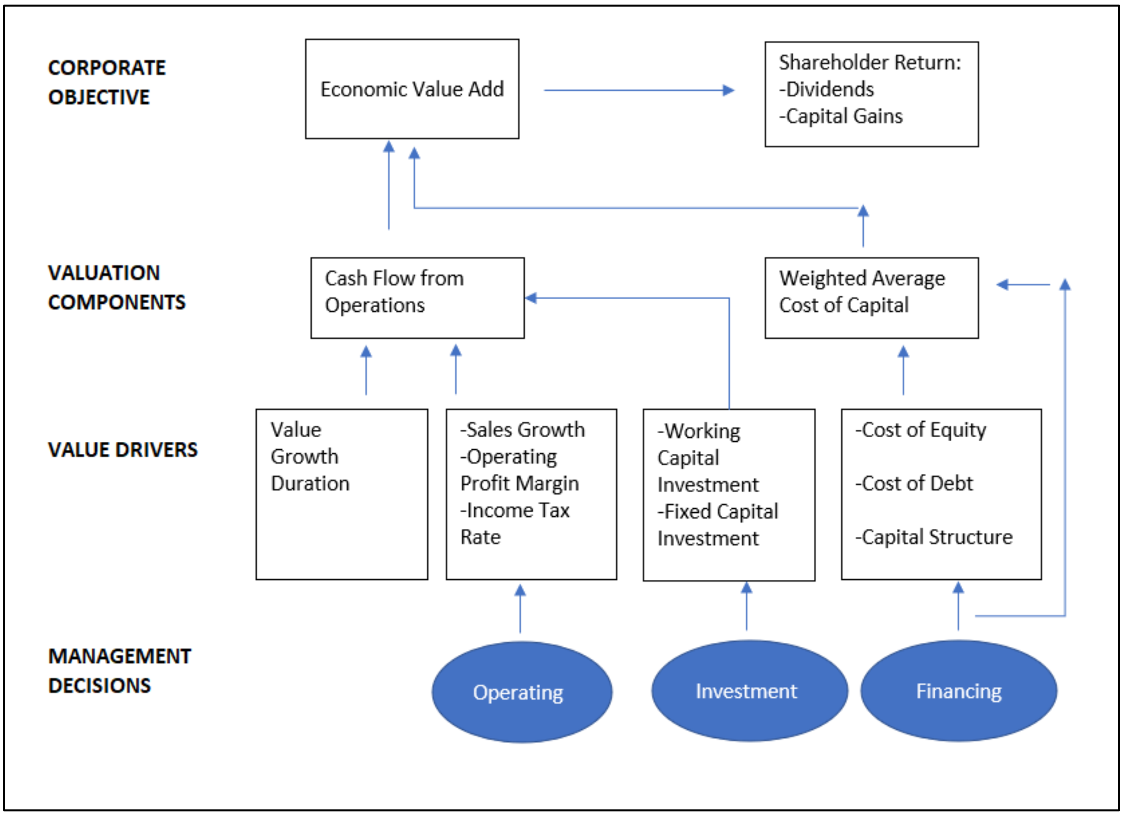

Figure 2-8: Flowchart of input parameters that result in EVA calculation (Nhleko & Neingo, 2019)

According to Nhleko & Neingo (2019), EVA is calculated as net operating profit after taxes less the cost of capital on capital invested. Profit is a normally reported traditional measure of value that does not account for cost of capital. Cost in capital is the monetary value calculated by multiplying invested capital with the cost of capital. The cost of capital can be cost of debt, cost of equity or weighted average cost of capital (WACC) depending on the capital form of the company. EVA increases with an increase in operating profit, decreasing capital invested and cost of capital. EVA decreases if the opposite happens.

2.10.4 Du Pont analysis

Du Pont analysis defines return on net operating assets into two ratios namely profit margin and asset turnover multiplier (Nhleko & Neingo, 2019). Du Pont analysis is deemed as a robust tool for strategic decision making to increase return on equity. Figure 2-9 illustrates the financial ratios required to calculate a return on equity of a company which is a Du Pont analysis.

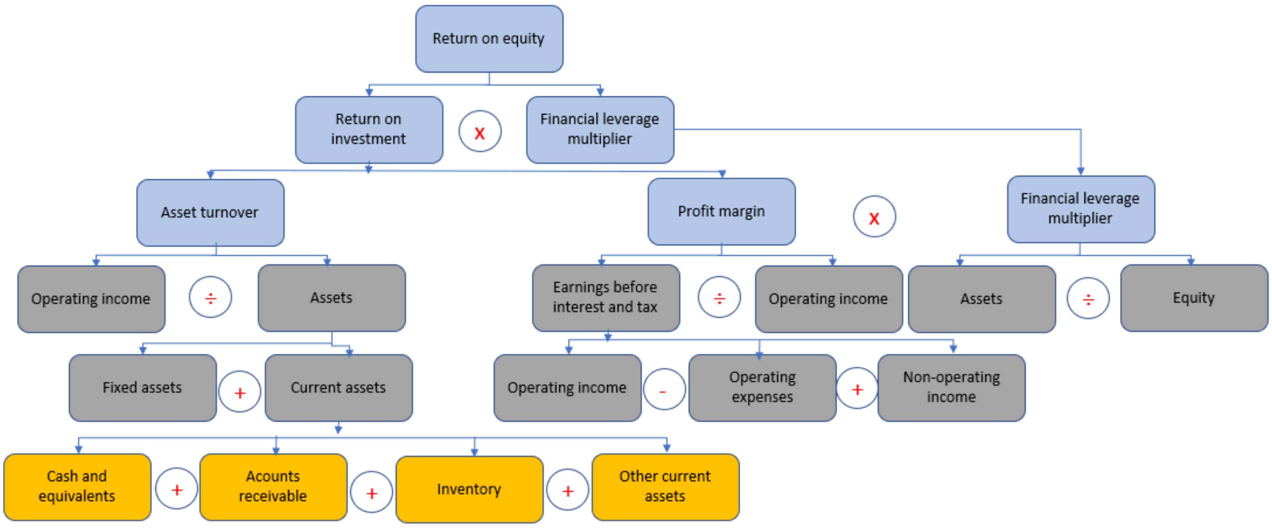

Figure 2-9: Flowchart of input parameters of Du Pont analysis (Nhleko & Neingo, 2019)

According to Nhleko & Neingo (2019), Du Pont analysis is referred as return on equity and is calculated using asset turnover, profit margin and financial leverage multiplier as shown in Figure 2-10 above. In mining terms, profit margin measures the profitability if revenues surpass the costs of mineral extraction and processing. Asset turnover measures the usage of revenue created from assets to generate value yielding returns.

2.11 Chapter Summary

Literature on digital technology in the mining industry was reviewed. It was noted that data analytics, internet of things, connected devices-robots, automation, wearables, remote operating centres and drones have been of high priority in the mining industry. Cybersecurity was the least popular digital technology in the mining industry. One of the positive impacts of digital technology was noted as reduction of labour costs through installing automated systems, while negative impacts include job losses and unemployment.

Chief Executive Officers are the primary drivers of digital technology adaptation in the mining industry. The largest barrier to implementing digital technology was noted as premature data management practices. The financial analysis tools and metrics namely cost curves, financial ratios EVA and Du Pont analysis were discussed. It was also noted during there is no literature that outlines financial performance of mining companies that invested in digital technology.

3 RESEARCH METHODOLOGY

3.1 Chapter Overview

This chapter describe the research methodology used in this study. This chapter of the report articulates research design, data collection, sample selection and data analysis. It further discusses ethical issues.

3.2 Research Design

This research was conducted using both qualitative and quantitative research methods. Table 3-1 compares the advantages and disadvantages of qualitative and quantitative research data type.

Table 3-1: The advantages and disadvantages of using qualitative research and quantitative research (Anpar Research, 2020)

Qualitative Research	**Quantitative Research**
Pros	Pros
Explores attitudes and behaviour in-depth	Larger sample size
Encourages discussion	Impartiality and accuracy
Flexibility	Faster and easier
	Data is anonymous
Cons	Cons
The sample size can be an issue	Limited by the set answers on a survey
Bias in the sample selection	Research is not carried out in their normal environment
Lack of privacy	Unable to follow-up any answers given
Whether you are using a skilled moderator or not	

According to English, et al. (2012), qualitative methods bring significant wide range of information discussion to the study, while quantitative methods provide essential data analysis and interpretation. The quantitative part discovers relationships between variables and the qualitative method helped with understanding the factors underlying the relationships. These assist in one method's findings to confirm the other.

3.3 Data Collection

Data was collected from the public domain, from audited financial statements and reports that are published online by the selected coal mining companies. The data collected from financial statements includes unit cost of production, production tonnages, coal prices, operating profits, total assets, EBITA, capital invested and cost of capital. Published reports and articles were used to analyse coal companies that have invested in digital technology to measure the financial impact of their technology. Literature from online published reports by the selected mining companies were used to further elaborate the analyses done on the financial statements.

3.4 Sample Selection

The research looked at Anglo Coal, South32 and Glencore financial statements to perform financial analysis since they were the only three coal mining companies that reported their investment in digital technology between 2013 to 2019. The years 2020, 2021 and 2022 were excluded from the research study due to the demerger of Anglo American to Thungela Resources in 2020 and South32 demerged to Seriti Resources in 2021/2022. The coal mining companies were selected due to the importance of coal as South African's source of energy (Deloitte, 2020).

It was assumed that the impact of demerging by these companies was minimal in this research data and analysis since the demerging took place outside the study period which is 2013 to 2019. South32's financial year runs from June to July, therefore it was normalised to the period January to December by assuming that their financial year runs from January to December, which does not have an impact on the duration of the study. This was done to make South32's financial period to be regarded the same as that of Glencore and Anglo Coal. This allowed the research to have data comparison of the same reporting period. The data gathered from these companies is considered to be reliable due to the regulatory compliance requirement of companies are listed on the Johannesburg Stock Exchange (JSE).

3.5 Data Analysis

Industry cost curves were constructed as part of the financial analysis as they show the trend of the selected companies' unit cost and production over the years. The cost curves were constructed using the concept of error bars in Microsoft Excel by inputting financial statements data of seven years, namely 2013 through to 2019. The selected companies invested in digital technology between 2015 and 2016. The seven-year period gave a clear picture of the impact of the digital technology pre- and post the technology investment.

On the selected mining companies and respective financial years, operating profit graphs were constructed with data from income statements. Bar and polynomial graphs were constructed from this financial parameter discussed above to identify operating profit trends between 2013 and 2019.

Profitability financial ratios of profit margin and return on asset of the selected companies were calculated from 2013 to 2019. These are shown in Appendix A. Only profit margin and asset turnover or return on asset were selected for the study since they are inputs to the Du Pont analysis which was analysed in this report to have a better comparison. Profit margin was calculated using Equation 1 (Nhleko & Neingo, 2019). Graphs were constructed in Microsoft Excel from profitability ratio calculation tables for them to be analysed, pre and post the investment in digital technology of the selected mines.

$$\text{Profit Margin} = \text{EBITA} / \text{Operating Income} \tag{1}$$

The return on asset was calculated using Equation 2 (Nhleko & Neingo, 2019):

$$\text{Return on Asset} = \text{Operating Income} / \text{Total Assets} \tag{2}$$

The economic value add (EVA) for these companies was calculated from 2013 to 2019 using Equation 3 (Nhleko & Neingo, 2019). The results are shown in Appendix B.

$$\text{EVA} = \text{Operating Profit After Interest Tax} - (\text{Invested Capital} \times \text{Cost of Capital}) \tag{3}$$

Operating profit, invested capital, and cost of capital were gathered from the income financial statements of these companies. The cost of capital used was the effective interest rate on invested capital that these companies had to pay back over a period of time (Hayes, 2022). Graphs were constructed in Microsoft Excel from the EVA calculation tables to analyse the relationship between EVA and invested capital, pre and post the investment in digital technology for the selected companies.

The return on equity representing Du Pont analysis of the selected companies was calculated from 2013 to 2019. The results are in Appendix C. Du Pont analysis was calculated from 2013 to 2019 using Equation 4 (Nhleko & Neingo, 2019). Graphs were constructed in Microsoft Excel for the Du Pont analysis calculation tables for them to be analysed, pre- and post the investment in digital technology of the selected mines.

$$\text{Du Pont Analysis or Return on Equity (\%)} = \text{Asset turnover} \times \text{Profit margin} \times \text{Financial leverage multiplier} \quad (4)$$

3.6 Ethical Issues

The research did not involve human participants and is categorised as no risk. However, as per requirement an ethical clearance certificate has been issued by the University of the Witwatersrand and is attached in Appendix D.

3.7 Chapter Summary

The research design was conducted using both qualitative and quantitative research methods. Data was collected from the public domain from audited financial statements and reports that were published online by the selected coal mining companies. The research investigated Anglo Coal, South32 and Glencore's financial statements to perform financial analysis since they were the only three coal mining companies that reported their investment in digital technology between 2013 to 2019. Data analysis was carried out by using industry cost curves, operating profitability, financial ratios, EVA and Du Pont analysis. The research did not involve human participants and is categorised as no risk.

4 RESULTS AND ANALYSIS

4.1 Chapter Overview

This chapter discusses the investment in digital technology by Anglo Coal, South32 and Glencore. It further presents the results and findings of this research project. Results are discussed by analysing industry cost curves, profitability trends, EVA relationship to capital invested and Du Pont analysis. Figure 4-1 identifies the locations of all operations mentioned in this section.

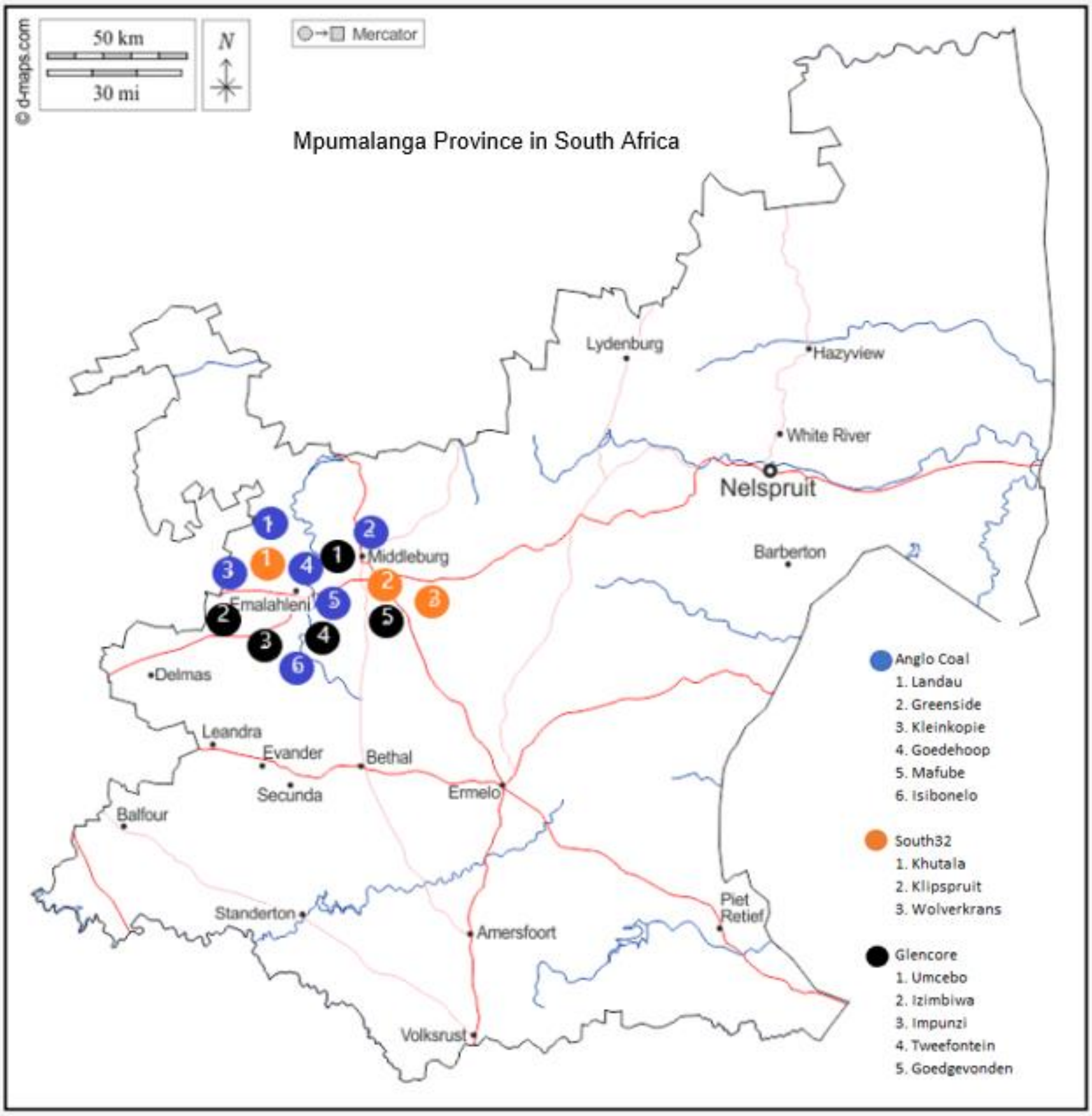

Figure 4-1: Anglo Coal, South32 and Glencore Coal Mines in South Africa. (Adapted from Chamber of Mines of South Africa, 2018)

4.2 Digital Technology Investment by Anglo Coal, South32 and Glencore

Anglo Coal implemented the investment in digital technology in 2016 (Anglo American, 2016). Anglo Coal invested in digital technology so that they can have more smarter, safer and sustainable mining operations. Anglo Coal invested almost constant amount of an average of US$150 million in digital technology per year in 2013 to 2019.

South32 implemented the investment in digital technology in 2016 (South32, 2016). South32 invested in digital technology as part of its strategy to have embedded systems, processes in its business model to achieve structural improvement of all its assets. South32 invested almost constant amount of an average of US$78 million in digital technology per year in 2013 to 2017. South32 started increasing their investments amounts in digital technology to US$164 million and US$213 million in 2018 and 2019, respectively.

Glencore implemented the investment in digital technology in 2015 (Glencore, 2015). Glencore invested in digital technology in order to have sustainable mining operations that extracts value across its mine value chain. Glencore invested an average of US$500 million in 2013 and 2014. In 2016 to 2019, Glencore maintained an average investment of US$192 in digital technology for continuous improvement and maintenance.

The common digital technology that Anglo Coal, South32 and Glencore implemented are cybersecurity, collision avoidance systems (CAS), fleet management systems (FMS), instrumentation sensors, advanced process control, fuel management and efficiency systems and drone technology which are discussed in the next subsections (Anglo American, 2016; South32, 2016; Glencore, 2015).

4.2.1 Cybersecurity

Due to increasing sophistication and number of cyber security losses or attacks, mining companies like Anglo Coal, South32 and Glencore have embarked on investing on technological systems to mitigate the risk of data or being hacked. The loss or theft of intellectual property can result to a company’s financial loses and damage to the company’s reputation (Kearney, 2018). This makes it vital for these three coal mining companies to ensure that their data or information is highly secured.

4.2.2 Collision avoidance system

Due to the number of Trackless Mobile Machines (TMMs) incidents at the mines, Anglo Coal, South32 and Glencore have invested on the collision avoidance system to improve on the safety of their employees and equipment. This digital technology has the following extra features; ramp assist and speed assist which prevents over speeding of mining equipment (Kearney, 2018). These companies reduced the risk of TMMs incidents as a priority to enable the elimination of TMMs related fatalities through the proximity detection system which automatically stops the machines before a potential collision. Collision avoidance system technology was then fitted in to loaders, haul trucks, light vehicles, mine buses, etc.

4.2.3 Fleet management system

Fleet management system is the system which is installed on mine equipment to monitor and optimise production (Kearney, 2018). This system is installed on mine trucks and loaders to take actions on production in real-time which ultimately increase production performance. Anglo Coal, South32 and Glencore have invested into this digital technology.

4.2.4 Instrumentation sensors

Anglo Coal, South32 and Glencore have implemented the instrumentation sensor systems to improve equipment availabilities. These systems are being used to accelerate a range of processes preventive maintenance and reduced downtimes. These systems are implemented in the company's maintenance models that detect failures before they occur and reduce unplanned breakdowns, thereby increasing the equipment's throughput (Kearney, 2018).

4.2.5 Advanced process control

Advance Process Control systems are functions to monitor efficiency at a processing plant (Kearney, 2018). Anglo Coal, South32 and Glencore have benefited by investing in this system because they can make optimal decision at their plants in real time and enhance mineral recovery, reduce water usage and electricity.

4.2.6 Fuel management and efficiency systems

Anglo Coal, South32 and Glencore have implemented the fuel management efficiency system to reduce fuel consumptions and save costs. This involves a range of efficiency and technology systems that look at fuel prices and volume discounts in real time (Kearney, 2018). Thus, results in better fuel management.

4.2.7 Drone technology

Drone technology is growing rapidly in the mining industry. Anglo Coal, South32 and Glencore have invested in implementing the technology to get accurate survey data measurements in a faster way. This technology ensures that measurements are done by drone flyover as compared to the traditional method of Global Positioning System (GPS) base which requires physical measurements (Kearney, 2018). This technology reduces delays which are incurred when measuring the mine faces, stockpiles, dumps, and other non-production related activities.

4.2.8 Production and cost analysis

Results of the cost curves constructed for South32, Glencore and Anglo Coal are discussed in this section. Figure 4-2 to Figure 4-8 shows industry cost curves for South32, Glencore and Anglo Coal mining companies from 2013 to 2019, respectively. The 2013 cost curve is discussed as a base year and 2014 and onwards years are analysed thereafter.

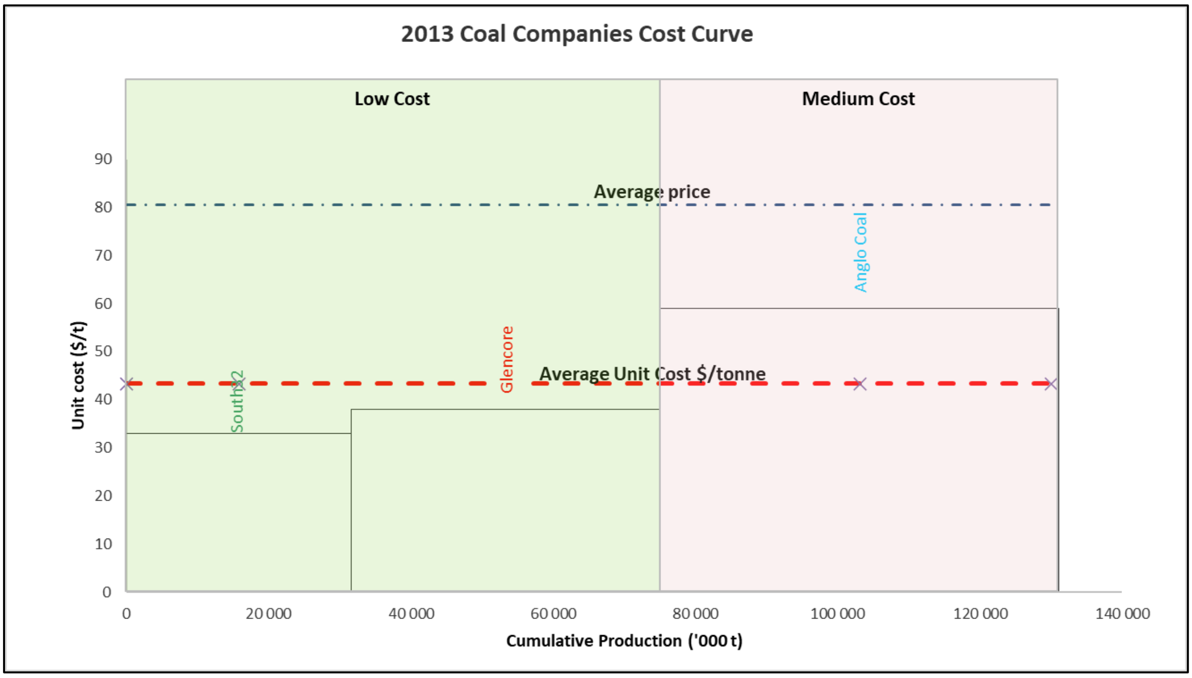

Figure 4-2: South32, Glencore and Anglo Coal 2013 Cost Curve (Anglo American, 2013; BHP Billiton, 2013; Glencore, 2013)

In 2013, South32 and Glencore were low-cost producing coal mining companies while Anglo Coal was a medium- cost producing mining company. There were no high-cost producing mining companies since all companies were operating at a unit cost below the average coal price of US$80 per tonne.

In 2013, South32 coal production came from four coal mines namely Khutala, Klipspruit, Middelburg and Wolverkrans. They produced total production of 31 million tonnes (Mt) of coal. The produced coal was sold to Eskom and export market. The unit cost of production was US$33 per tonne in 2013 (BHP Billiton, 2013).

In 2013, Glencore produced 44Mt of coal. The coal production was produced by the following mines: Impunzi, Tweefontein, Izimbiwa and Optimum Coal while South Witbank Coal was on care and maintenance. The produced coal was sold to Eskom and export market. The unit cost of production was US$38 per tonne in 2013 (Glencore, 2013).

In 2013, Anglo Coal produced 56Mt of coal. The coal was produced by the following mines: Goedehoop, Greenside, Isibonelo, Kleinkopje, Kriel, Landau, Mafube, New Denmark, New Vaal and Zibulo. The produced coal was sold to Eskom, Sasol and export market. The unit cost of production was US$59 per tonne in 2013 (Anglo American, 2013).

Anglo Coal produced more coal than Glencore and South32 due to having many mines than South32 and Glencore in 2013. Glencore had the lowest unit cost of production due to having fewer operations. Fewer operations can be optimized better, resulting in overall low-cost group operations.

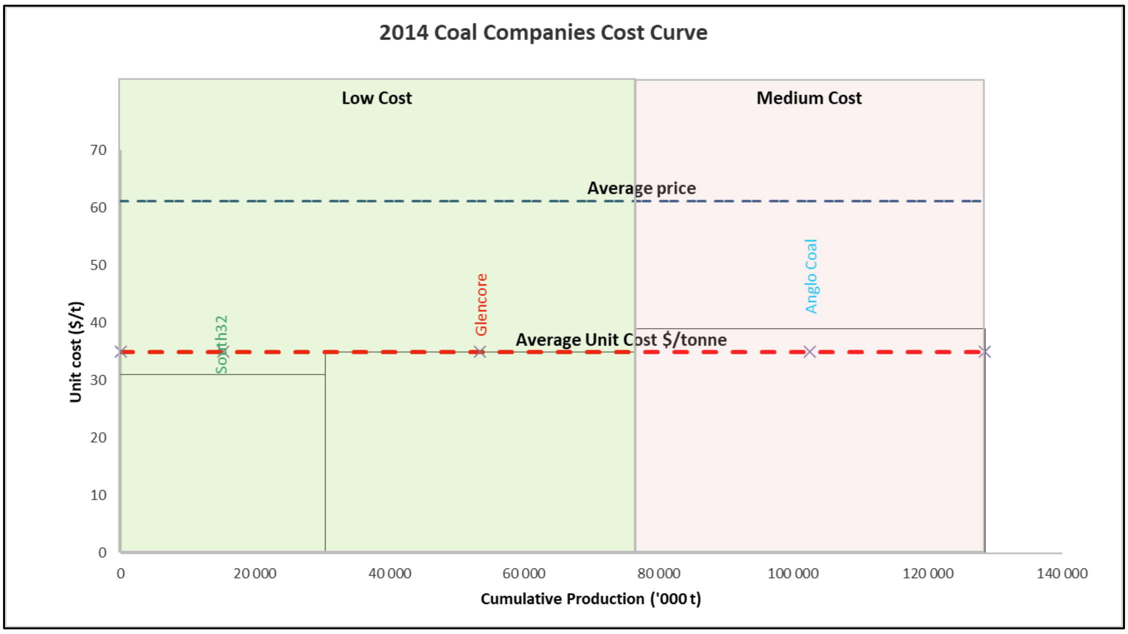

Figure 4-3: South32, Glencore and Anglo Coal 2014 Cost Curve (Anglo American, 2014; BHP Billiton, 2014; Glencore, 2014)

In 2014, South32 produced 30Mt of coal. The unit cost of production was US$37 per tonne in 2014. The reduction of coal production compared to 2013 was due to breakdowns at the Eskom utility and the Richard's Bay Coal export terminal. The increase in unit cost was due to a levied fine of US$94 455 which was issued to Khutala for non-compliance to the National Environmental Management Act (BHP Billiton, 2014).

In 2014, Glencore coal produced 46Mt of coal. The unit cost of production was US$35 per tonne in 2014. The increase in production was due to, early completion of the Tweefontein Optimisation Project, improved production at Tweefontein underground operations, the opening of the new Wonderfontein Open Cut Mine, and new Hlagisa Open Cut Mine (Kotze, 2015). The operating unit cost decreased by US$3 per tonne from 2013 to 2014 due to closing production of certain higher operating cost mines namely, Optimum Coal and South Witbank Coal (News24, 2015; Glencore, 2014).

In 2014, Anglo Coal produced 52Mt of coal. The unit cost of production was US$39 per tonne in 2014. The decrease in production was due to Eskom reducing off-take at New Vaal and planned production decreases at Kriel Mine to move to new mining areas (Anglo American, 2014). The production unit cost decreased due to improved maintenance, efficient contractor costs and lower overhead costs because of business restructuring (Anglo American, 2014).

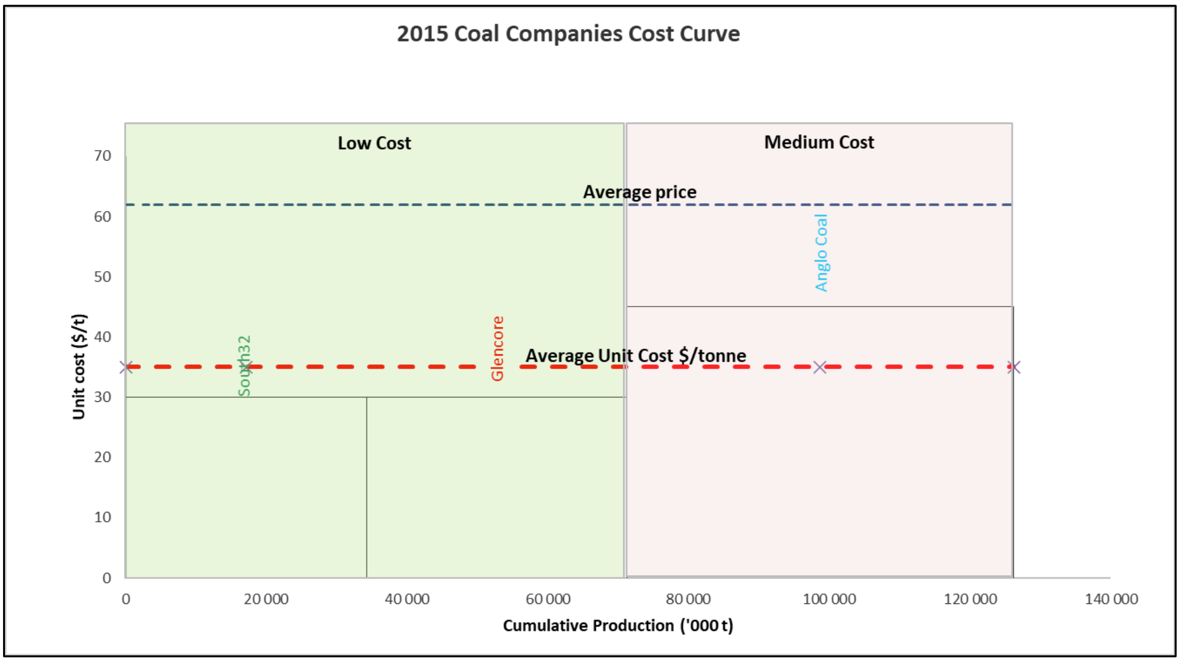

Figure 4-4: South32, Glencore and Anglo Coal 2015 Cost Curve (Anglo American, 2015; BHP Billiton, 2015; South32, 2015; Glencore, 2015)

In 2015, South32 produced 34Mt of coal. The unit cost of production was US$30 per tonne in 2015. In May 2015, South32 demerged from BHP in South African coal mines. The saleable production increased by 13% from 2014, this was due to optimisation of the mine planning (South32, 2015). The mining cost declined by 19% from 2014 due to weakening of the South African Rand (ZAR) to the US Dollar (from 10.85 to 12.78 ZAR/US$) and reduced stripping ratio by using optimizing mining planning tools. A weaker rand results in mining companies having cheaper mining costs because they gain buying power in South Africa. A stronger rand results in mining companies to have higher costs because they lose the buying power in South Africa (Stoddard & Antonioli, 2015). Insourcing of mining contractors and renegotiation of contracts on more favourable terms also reduced the mining unit cost (South32, 2015).

In 2015, Glencore produced 37Mt of coal. The unit cost of production was US$30 per tonne in 2015. The saleable coal product was 20% less than that of 2014 due to the deconsolidation and sale of Optimum Coal Mine. The operating unit cost also reduced by US$5 per tonne due to the deconsolidation of Optimum Coal Mine (Glencore, 2015).

In 2015, Anglo Coal produced 55Mt of coal. The unit cost of production was US$45 per tonne in 2015. The production improvement from 2014 to 2015 by 3Mt of coal was due to implementation of the Anglo-American Operating Model at Goedehoop and Zibulo (Anglo American, 2015). The Anglo-American Operating Model is an essential enabler for delivering production targets, and ultimately for reducing operating costs. It enables operational stability to deliver predictable outcomes, reduces variation to increase capability and efficiency. It further provides clarity, so that team members have a clear understanding of their work in order to facilitate consistent outcomes. This model focus on data-driven decision making, detailed planning, operating excellence and execution (Anglo American, 2015). Unit cost increased by US$6 per tonne due to costs incurred by the unplanned maintenance of a dragline at Isibonelo colliery.

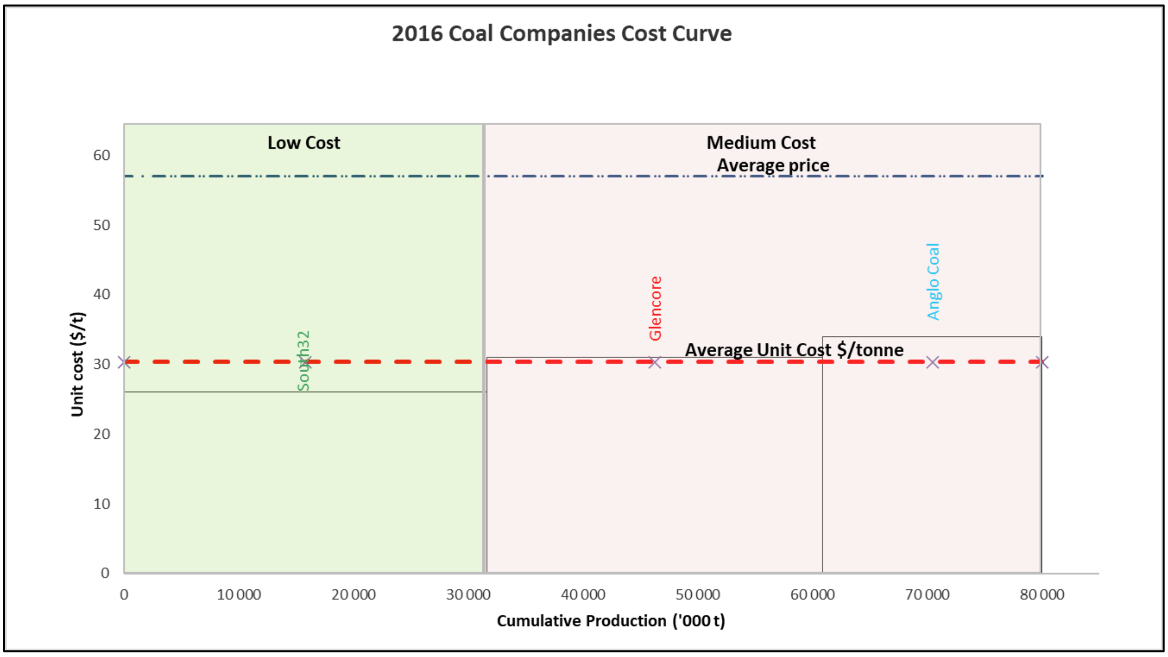

Figure 4-5: South32, Glencore and Anglo Coal 2016 Cost Curve (Anglo American, 2016; South32, 2016; Glencore, 2016)

In 2016, South32 produced 32Mt of coal. The unit cost of production was US$26 per tonne in 2016. The saleable coal product decreased by 2.6Mt from 2015 to 2016 due to planned closure of the Khutala Open Cast Mine and reduction of contractor activity at Wolverkrans Middleburg Complex to achieve value over volume (South32, 2016). The unit operating costs decreased by 13% from 2015 to 2016 due to stronger dollar and improved labour productivity. To achieve this, South32 reduced the number of employees by 14% (South32, 2016).

In 2016, Glencore produced 29Mt of coal. The unit cost of production was US$31 per tonne in 2016. The saleable coal product was reduced by 7.7Mt compared to 2015 due to the deconsolidation and sale of Optimum Coal Mine and closure of some scheduled mines (Glencore, 2016). The unit cost of production was in line with 2016 due to low coal prices which led Glencore to curtail production and preserve reserves until market conditions improved. In September 2015, Katanga and Mopani collieries production were announced to be suspended to implement the transformational upgrade projects that will significantly lower the production unit cost (Glencore, 2016).

In 2016, Anglo Coal produced 19Mt of coal. The unit cost of production was US$34 per tonne in 2016. The saleable coal product reduced by 65% from 2015 to 2016 due to the sale of the Eskom-tied domestic coal operations consisting of New Denmark, New Vaal and Kriel collieries and closing of four other collieries which were Eskom-tied operations (Anglo

American, 2016). Anglo Coal only started focusing on the export market. The unit cost of production reduced by 24% from 2015 to 2016 due to US dollar strengthening (from 12.78 to 14.70 rand per dollar) and business cost-saving initiatives (Anglo American, 2016).

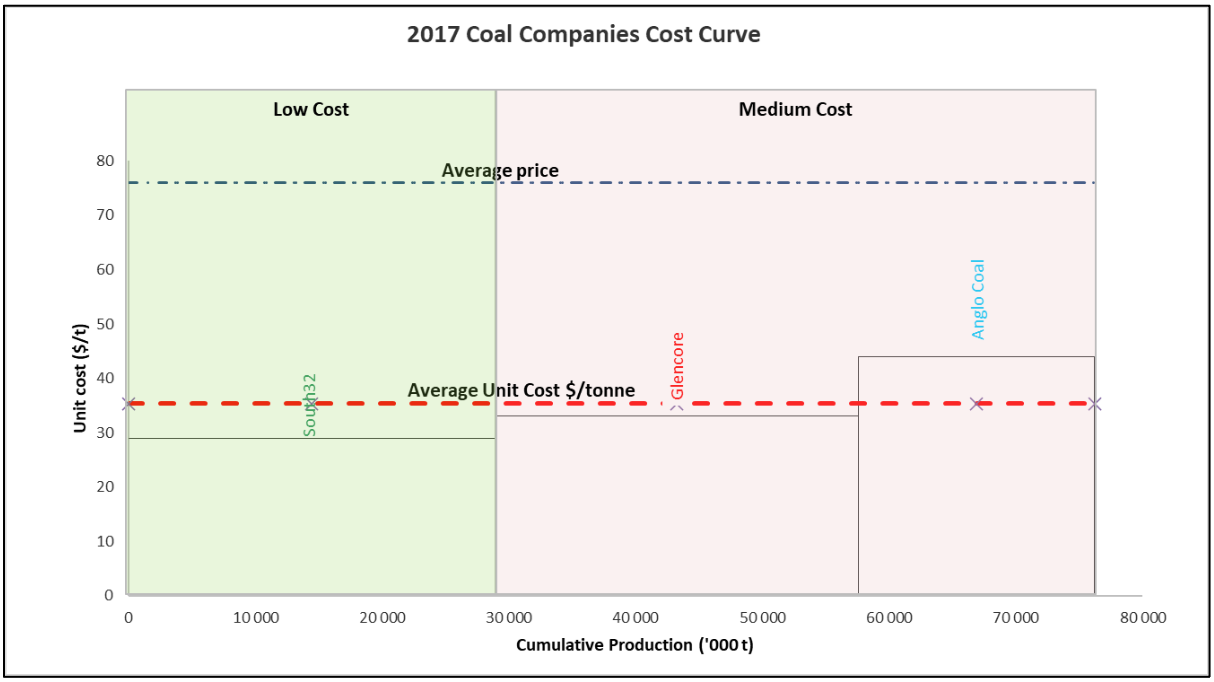

Figure 4-6: South32, Glencore and Anglo Coal 2017 Cost Curve (Anglo American, 2017; South32, 2017; Glencore, 2017)

In 2017, South32 produced 28.9Mt of coal. The unit cost of production was US$29 per tonne in 2017. The production of saleable coal product reduced by 2.8Mt in 2017 from 2016 due to challenging weather conditions and the depletion of the northern area at Wolverkrans Middelburg Complex (South32, 2017). The operation unit cost increased by 12% from 2016 to 2017 due the high fixed cost having been absorbed by the lower sales volumes in 2017 (South32, 2017).

In 2017, Glencore produced 29M of coal. The unit cost of production was US$33 per tonne in 2017. The production of saleable coal product was in line with 2016 coal production. The unit production cost increased by US$2 per tonne from 2016 to 2017 due to the implementation of the transformational upgrade projects (Glencore, 2017).

In 2017, Anglo Coal produced 18.6Mt of coal. The unit cost of production was US$44 per tonne in 2017. The coal saleable product reduced by 0.5Mt from 2016 to 2017 due to the sale of the New Largo thermal coal project. (Anglo American, 2017). The unit cost of production increased by 29% from 2016 to 2017 due to weakening of the US dollar against the Rand (from 14.70 to 13.31 ZAR/US$) and cost-inflation pressures (Anglo American, 2017).

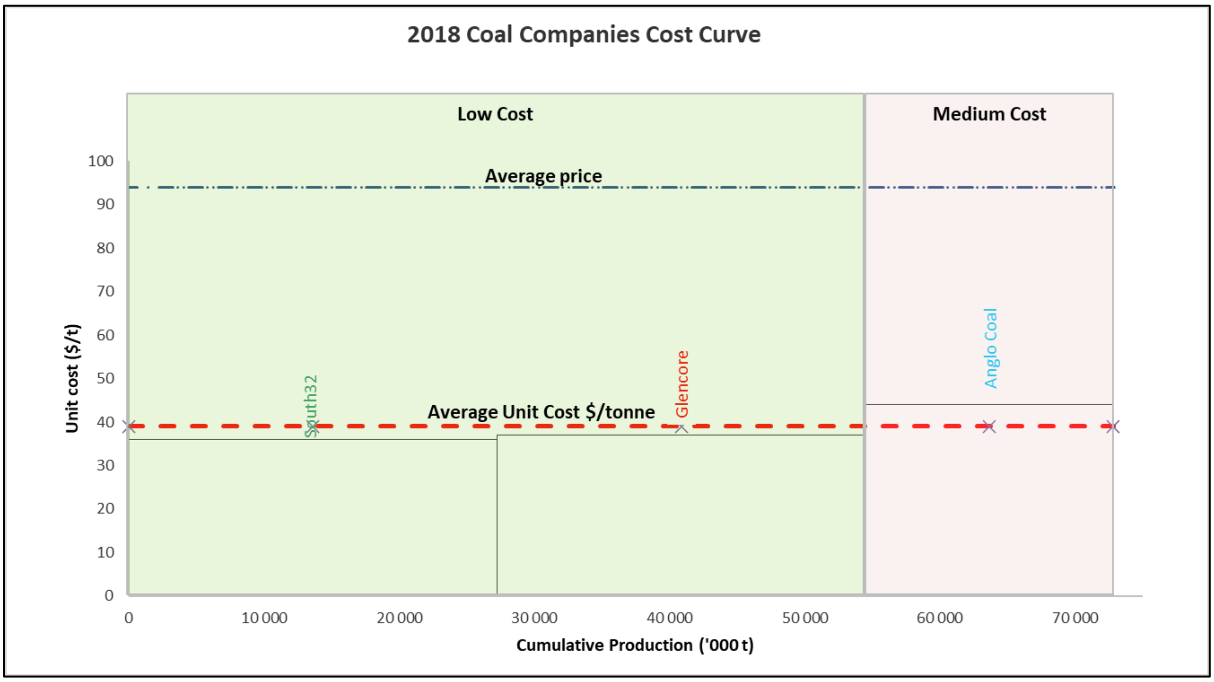

Figure 4-7: SOUTH 32, Glencore and Anglo-American Coal 2018 Cost Curve (Anglo American, 2018; South32, 2018; Glencore, 2018)

In 2018, South32 produced 27Mt of coal. The unit cost of production was US$36 per tonne in 2018. The saleable coal production reduced by 6% from 2017 to 2018 due to the domestic demand of coal remaining subdued and their product was reweighted towards the export market (South32, 2018). The unit operating cost increased by 24% from 2017 to 2018 due to inflation and favorable movement in exchange rates for South African Rand. The unit cost was further impacted by the additional logistics and washing due to increased proportion of higher margin export sales to maximize margins and returns (South32, 2018).

In 2018, Glencore produced 27Mt of coal. The unit cost of production was US$37 per tonne in 2018. The saleable coal product reduced by 5% from 2017 to 2018 due to adjusting for the technical accounting deconsolidation of 2017 Wonderfontein production. Unit production cost increased by US$4 per tonne due to the weakening of the US dollar against the rand (from 13.31 to 13.25 rand per dollar) (Glencore, 2018).

In 2018, Anglo Coal produced 18.3Mt of coal. The unit cost of production was US$44 per tonne in 2018. The saleable coal production was in line with the 2017 production. The production unit cost was also in line with the previous year at US$44 per tonne as the cost savings and productivity improvements managed to offset the 8% inflation impact (Anglo American, 2018).

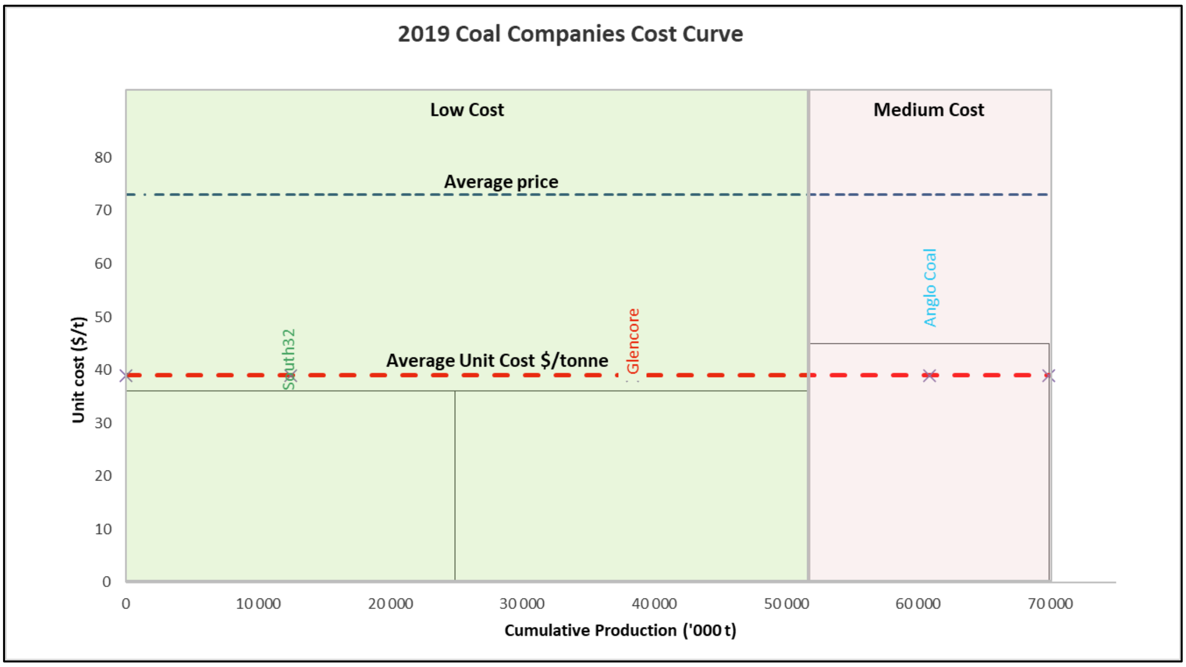

Figure 4-8: South32, Glencore and Anglo Coal 2019 Cost Curve (Anglo American, 2019; South32, 2019; Glencore, 2019)

In 2019, South32 produced 25Mt of coal. The unit cost of production was US$36 per tonne in 2019. The saleable coal product reduced by 8% from 2018 to 2019 due to an extended outage of the Klipspruit dragline following an incident in August 2018 (South32, 2019). The operating unit costs remained constant from 2018 to 2019 due to completed concurrent rehabilitation work and extra contractor capacity to recover the dragline availability at Klipspruit (South32, 2019).

In 2019, Glencore produced 26.9Mt of coal. The unit cost of production was US$36 per tonne in 2019. The production of 26.9MT saleable coal was broadly in line with 2018 production. The production unit cost reduced by US$1 per tonne which was in line with the 2018 unit cost (Glencore, 2019).

In 2019, Anglo Coal produced 18.1Mt of coal. The unit cost of production was US$45 per tonne in 2019. The saleable coal production reduced by 1% from 2018 to 2019 due to mine sections reaching their end of life at Goedehoop and Kwezela. There was a slight decrease in unit cost of production by US$1 per tonne from 2018 to 2019 which was in line with 2018 unit cost. This was due to cost savings, improved productivity and weakening of the rand against the US dollar (from 13.25 to 14.75 rand per dollar) offset the effects of lower production and inflation (Anglo American, 2019).

4.3 Impact of Digital Technology on Cost Performance

Anglo Coal implemented their investment of digital technology in 2016. This resulted in reduction of unit cost only in 2016 and rose again the year after. This was due to an increase in inflation, low production, and high exchange rates. The coal sealable production reduced post the investment due to the sale of the Eskom-tied domestic coal operations consisting of New Denmark, New Vaal and Kriel collieries and closing four other collieries which were Eskom-tied operations. Anglo Coal then started on focusing on exporting coal.

South32 implemented the investment of digital technology in 2016. This resulted in reduction of unit cost post the investment. The unit costs later increased again due to a combination of maintained fixed costs. The saleable coal production reduced post the investment due to closure of other mines because of depleted Coal Reserves.

Glencore implemented their investment of digital technology in 2015. This resulted in reduction of unit cost only in 2015 and increased again in 2017. This was due to upgrade projects and low productivity of other operations. The coal sealable production reduced post the investment due to sale of Optimum Coal Mine, suspended production at Katanga and Mopani Mines, and the technical accounting deconsolidation of 2017 Wonderfontein production.

In conclusion, there appears to have been no production and unit cost improvement directly linked with investment in digital technology. Other issues such as breakdowns, depletion of reserves, selling of operations, mine closures, high contracting prices, inflation and other factors also affected the production and unit cost.

4.4 Financial Analysis

4.4.1 Operating profit

Anglo Coal

Operating profit graphical trends of Anglo Coal, Glencore and South32 were analysed from 2013 to 2019. Figure 4-9 shows the operating profit of Anglo Coal trends between 2013 and 2019. The data used to draw the figure was taken from the 2013-2019 financial statements (Anglo American, 2013; Anglo American, 2014; Anglo American, 2015; Anglo American, 2016; Anglo American, 2017; Anglo American, 2018; Anglo American, 2019).

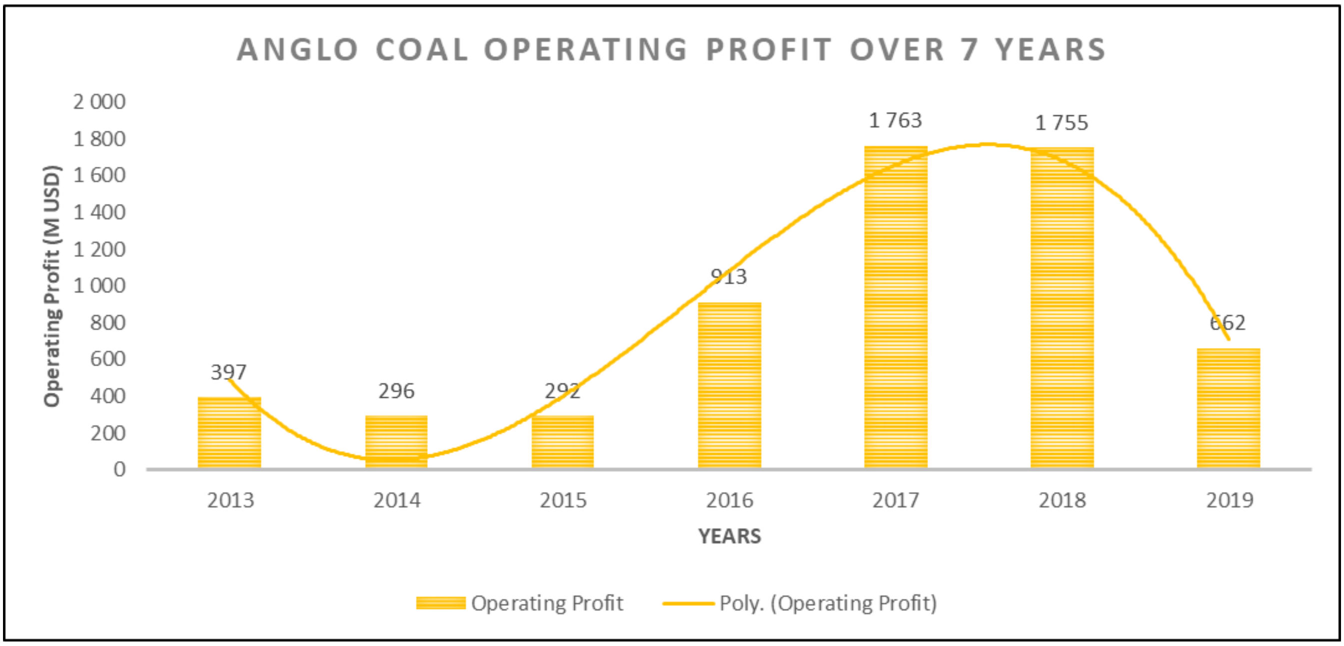

Figure 4-9: Anglo Coal 2013-2019 Operating Profit

The operating profit of Anglo Coal was relatively low between 2013 and 2015. The operating profit started increasing sharply in 2016 to 2018, showing an increase in operating profit trend post investment in digital technology. The sharp increase in 2016 operating profit was likely associated with the 42% decrease in unit cost of production (Anglo American, 2016). The sudden drop in operating profit in 2019 can be linked primarily to lower production of saleable coal due to their mine sections at Goedehoop and Kwezela reaching their end of lives and Anglo Coal incurring mine closure costs (Anglo American, 2019).

Glencore

Figure 4-10 indicates the operating profit of Glencore trends between 2013 and 2019. The data used to draw the figure was taken from the 2013-2019 financial statements (Glencore, 2013; Glencore, 2014; Glencore, 2015; Glencore, 2016; Glencore, 2017; Glencore, 2018; Glencore, 2019).

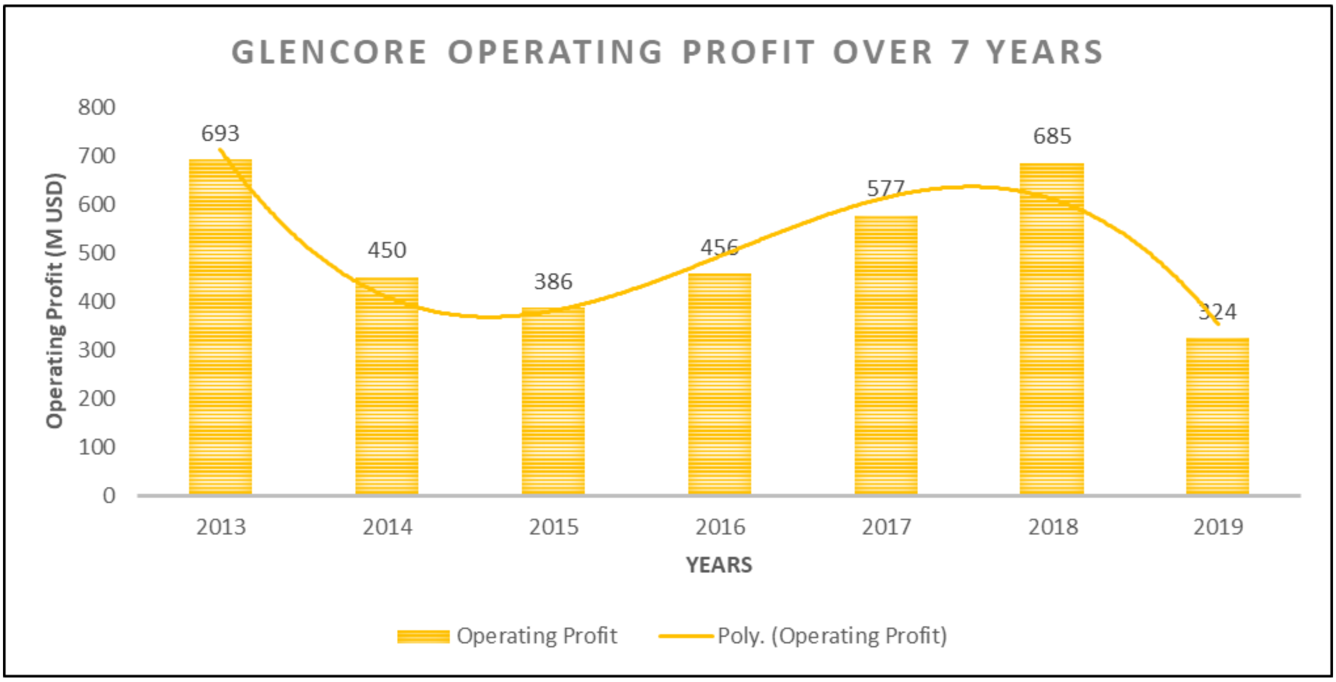

Figure 4-10: Glencore 2013-2019 Operating Profit

The operating profit of Glencore declined between 2013 and 2015 which was before the investment in digital technology. The operating profit started increasing in 2016 to 2018, showing an increase in operating profit trend post the investment year. The sudden drop in operating profit in 2019 was highly impacted by coal price reducing from US$104 in 2018 per tonne to US$73 per tonne in 2019 (Glencore, 2019).

South32

Figure 4-11 shows the operating profit of South32 trends between 2013 and 2019. The data used to draw the figure was taken from the 2013-2019 financial statements (BHP Billiton, 2013; BHP Billiton, 2014; BHP Billiton, 2015; South32, 2015; South32, 2016; South32, 2017; South32, 2018; South32, 2019).

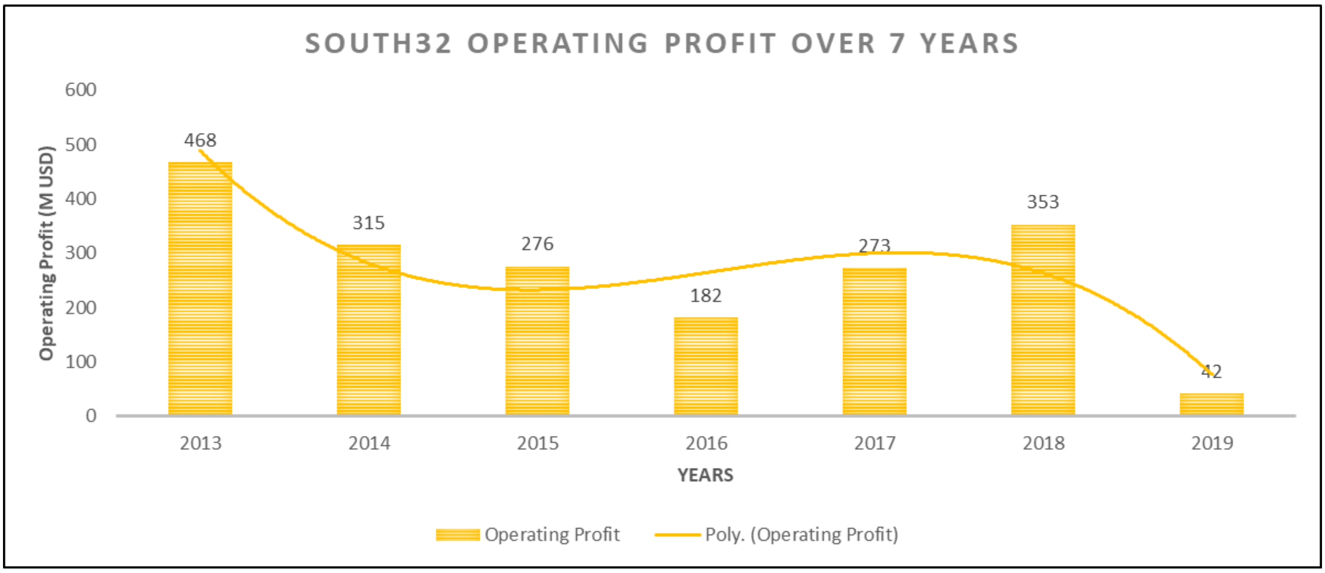

Figure 4-11: South32 2013-2019 Operating Profit

The operating profit of South32 declined between 2013 and 2016 which was before the investment in digital technology. The decrease in operating profit was associated with deconsolidation and sale of Optimum Coal Mine, and closure of some scheduled mines (South32, 2016). The operating profit started increasing in 2017 to 2018 after investing in digital technology on the remaining mines, showing an increase in operating profit trend post the investment year. The sudden drop in operating profit in 2019 was likely due to the extended outage of the Klipspruit dragline and depletion of the northern area at Wolverkrans Middelburg Complex leading to South32 incurring mine closure costs (South32, 2019).

4.4.2 Financial ratios

Anglo Coal

Figure 4-12 indicates Anglo Coal's profitability ratios. The data used to draw the figure was taken from the 2013-2019 financial statements (Anglo American, 2013; Anglo American, 2014; Anglo American, 2015; Anglo American, 2016; Anglo American, 2017; Anglo American, 2018; Anglo American, 2019). Profit margin for Anglo Coal has been above 0.3 since 2013 to 2018 but with a decreasing trend.

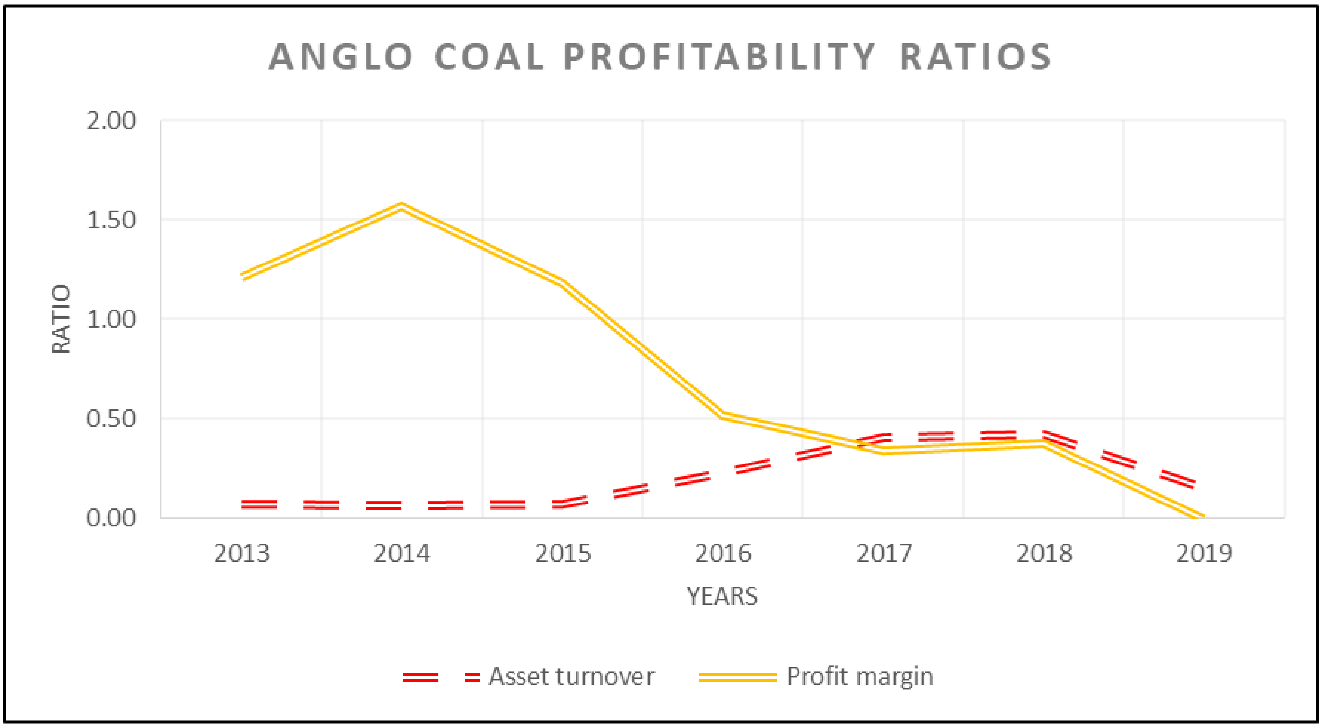

Figure 4-12: Anglo Coal 2013-2019 Profitability Ratios

Profit margins for Anglo Coal have been above 0.3 since 2013 to 2018 but with a decreasing trend. The decrease in profit margin was because of a sharp increase in operating profit while EBITA increased constantly. The 0.3 profit margin is classified as very good ratio as indicated in Table 2.1. In 2019, the profit margin dropped to -0.0076 which is not a good ratio. These show that Anglo Coal managed to have a very good profit margin pre and post the investment in digital technology. The sudden drop in profit margin in 2019 can primarily be linked to a significant drop in operating profit as a result of less production of saleable coal due to their mine sections at Goedehoop and Kwezela reaching end of lives and Anglo Coal incurring mine closure costs (Anglo American, 2019).

Asset turnover was ranging from 0.05 to 0.07 between 2013 and 2015 which is a quite good ratio according to Table 2.1. It then increased to a range of 0.2 to 0.4 between 2016 and 2018 which is a very good ratio. An increase in asset turnover correlates with a gradual increase in Anglo Coal’s assets post digital technology investment, which resulted in increased operating profit. These shows that there was an increase in asset turnover post investment in digital technology for Anglo Coal. In 2019, it slightly dropped to 0.15 which is within the very good range of asset turnover.

Glencore

Figure 4-13 shows Glencore's profitability ratios. The data used to draw the figure was taken from the 2013-2019 financial statements (Glencore, 2013; Glencore, 2014; Glencore, 2015; Glencore, 2016; Glencore, 2017; Glencore, 2018; Glencore, 2019).

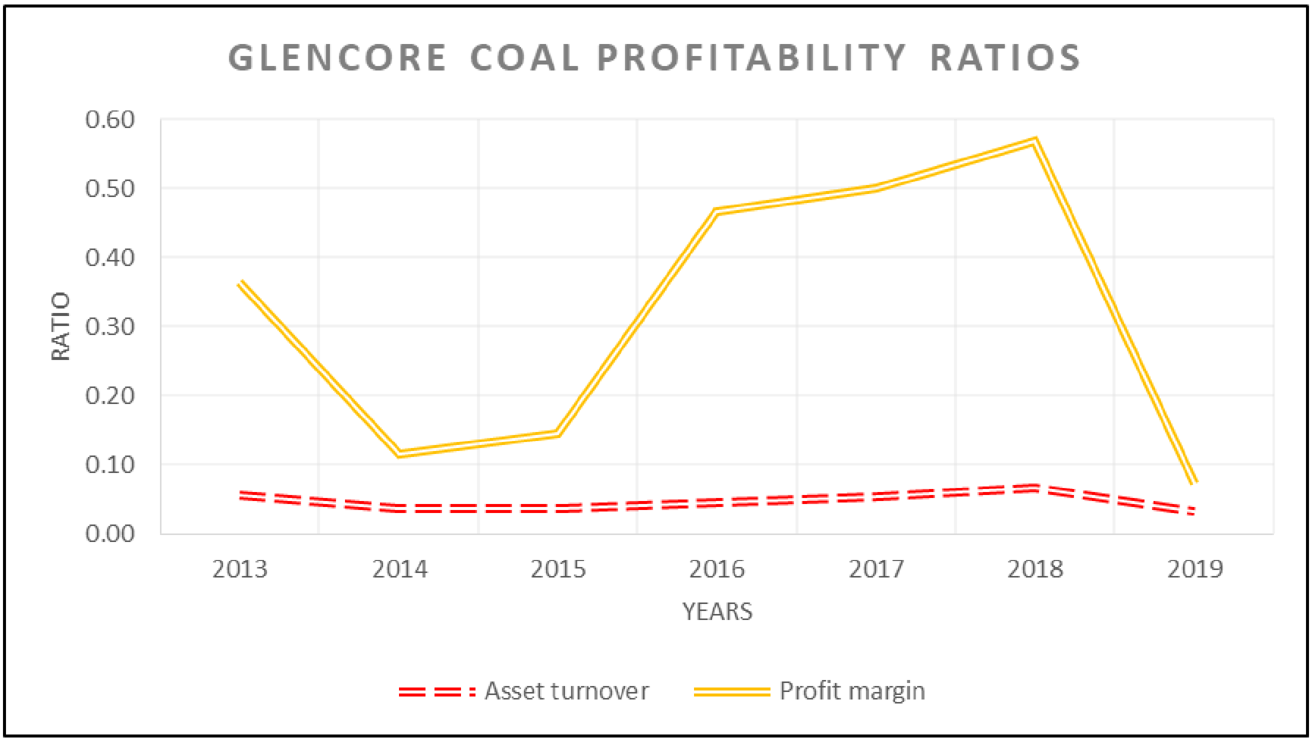

Figure 4-13: Glencore 2013-2019 Profitability Ratios

Profit margin for Glencore decreased from 0.38 to 0.14 between 2013 and 2015. The 0.14 profit margin is classified as quite good ratio as indicated in Table 2.1. In 2016 to 2018 it increased to a range between 0.46 to 0.55 which is way above 0.3 which is the very good ratio. The increase in profit margin was because of Glencore having increased EBITA post the investment in digital technology while operating profit increased gradually. These shows that Glencore managed to have a very good profit post the investment in digital technology, despite the dip in 2019. In 2019 it dropped to 0.07 which is not good ratio. The sudden drop in 2019's profit margin can be associated with the drop in operating profit in 2019 which was highly impacted by coal price reducing from US$104 in 2018 per tonne to US$73 per tonne in 2019 (Glencore, 2019).

Glencore's asset turnover decreased from 0.056 to 0.037 in 2013 to 2014. The asset turnover increased from 0.038 to 0.067 in 2015 to 2018 which indicates a quite good ratio according to Table 2.1. An increase in asset turnover was due to a gradual increase in Glencore's assets post digital technology investment, while the operating profit increased relatively high post the 2015 digital investment year (the formula that calculates profit margin is EBITA divide by operating profit, so an increase in operating profit and constant EBITA will decrease the profit margin over a period of time). These shows that there was an increase in asset turnover post the years of investing in digital technology for Glencore. In 2019, it slightly dropped to 0.033 which is within the quite good range of asset turnover. The 2019 asset turnover can again be associated with the drop in operating profit in 2019 which was highly impacted by coal price reducing from US$104 in 2018 per tonne to US$73 per tonne in 2019 (Glencore, 2019).

South32

Figure 4-14 indicates South32's profitability ratios. The data used to draw the figure was taken from the 2013-2019 financial statements (BHP Billiton, 2013; BHP Billiton, 2014; BHP Billiton, 2015; South32, 2015; South32, 2016; South32, 2017; South32, 2018; South32, 2019).

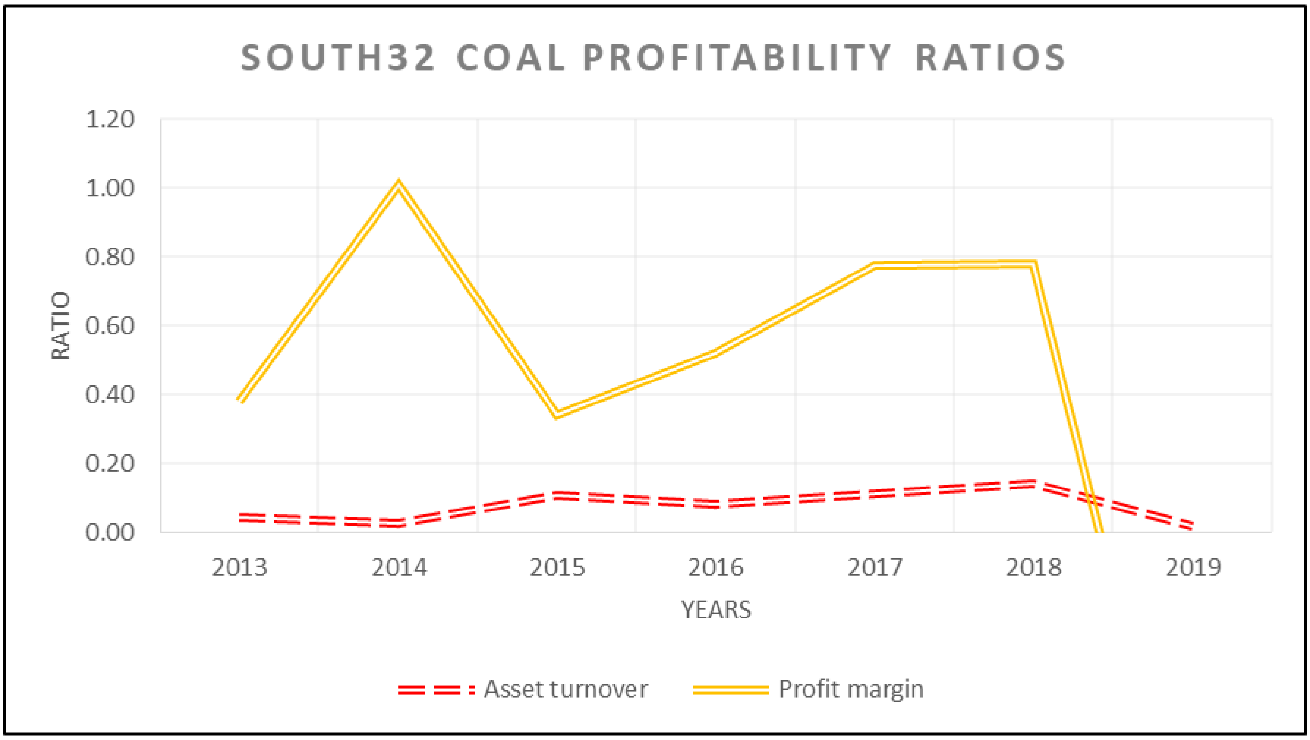

Figure 4-14: South32 2013-2019 Profitability Ratios

Profit margin for South32 in 2013 was 0.37, It increased to 1.00 in 2014 and then decreased to 0.34 in 2015. In 2015 to 2018 the profit margin increased to a range of 0.52 to 0.78. The profit margin of more than 0.3 is classified as very good ratio as indicated in Table 2.1. The increase in profit margin was because of South32 having increased EBITA post the investment in digital technology while operating profit increased gradually. These shows that South32 managed to have a very good profit post the investment in digital technology, despite in 2019. In 2019 the profit margin dropped to -1.0952 which is not good ratio according to Table 2.1. South32 (2019) attributed the sudden drop in 2019's profit margin to a huge drop in operating profit linked to the extended outage of the Klipspruit dragline and depletion of the northern area at Wolverkrans Middelburg Complex leading to South32 incurring mine closure costs.

South32's asset turnover decreased from 0.042 to 0.026 in 2013 to 2014. In 2015 the asset turnover was at 0.11. The asset turnover then increased from 0.082 to 0.14 in 2016 to 2018 which indicates a good ratio according to Table 2.1. An increase in asset turnover was due to a gradual increase in South32's assets post digital technology investment, while the operating profit increased relatively high post the 2016 digital investment year. These shows that there was an increase in asset turnover post the years of investing in digital technology for South32. In 2019, the asset turnover slightly dropped to 0.017 which is within the quite good range of asset turnover. The sudden drop in 2019's asset turnover can only be linked to huge drop in operating profit due to the extended outage of the Klipspruit dragline and depletion of the northern area at Wolverkrans Middelburg Complex leading to South32 incurring mine closure costs (South32, 2019).

4.4.3 Economic Value Add (EVA)

Anglo Coal

Figure 4-14 shows Anglo Coal EVA-Invested capital comparison. The data used to draw the figure was taken from the 2013-2019 financial statements (Anglo American, 2013; Anglo American, 2014; Anglo American, 2015; Anglo American, 2016; Anglo American, 2017; Anglo American, 2018; Anglo American, 2019).

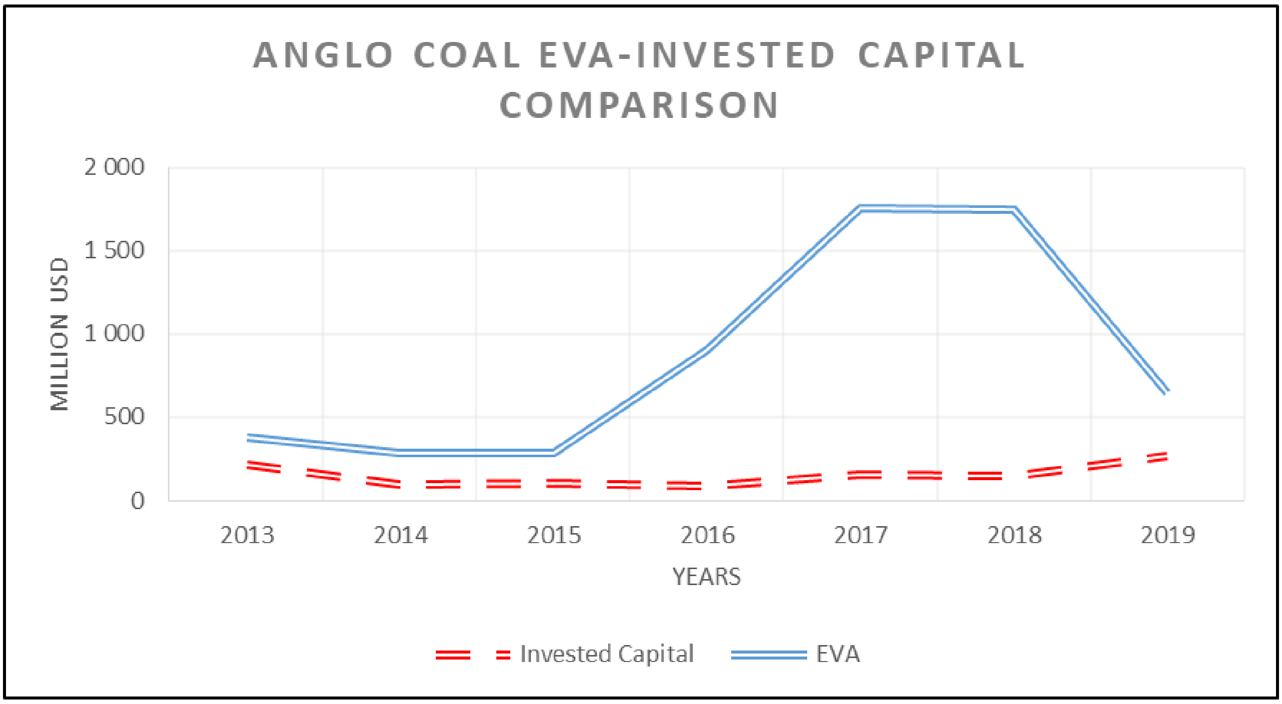

Figure 4-15: Anglo Coal 2013-2019 EVA-Invested Capital Comparison

Anglo Coal invested almost constant amount of an average of US$150 million in digital technology per year in 2013 to 2019. However, for digital technology value to be realised it needs to be implemented after a company invests in it. Anglo Coal declared their investment in digital technology in 2016. Anglo Coal continued to invest in digital technology beyond 2016 for continuous improvements and maintenance on their invested technology (Anglo American, 2016).

Anglo Coal had an average EVA of US$317 million between 2013 to 2015 which is before digital technology implemented. Anglo Coal's EVA then increased sharply to an average EVA of US$1262 million from 2016 to 2017. This shows that Anglo Coal had improved EVA after investing in digital technology. The sudden drop in EVA in 2019 was due to their mine sections at Goedehoop and Kwezela reaching end of life which reduced Anglo Coal's operating profit which is part of the EVA equation (Anglo American, 2019).

Glencore

Figure 4-16 indicates Glencore EVA-Invested capital comparison. The data used to draw the figure was taken from the 2013-2019 financial statements (Glencore, 2013; Glencore, 2014; Glencore, 2015; Glencore, 2016; Glencore, 2017; Glencore, 2018; Glencore, 2019).

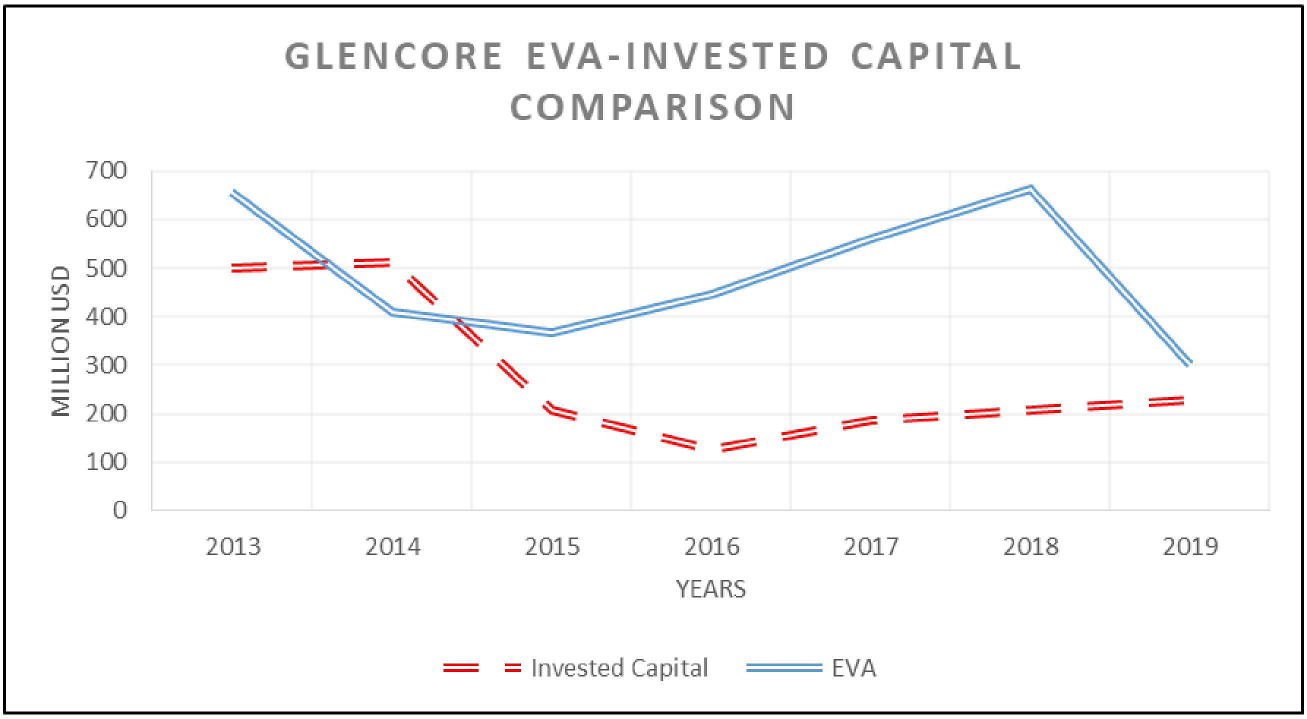

Figure 4-16: Glencore 2013-2019 EVA-Invested Capital Comparison

Glencore invested an average of US$500 million in 2013 and 2014. Glencore declared their investment and implementation in digital technology in the year 2015 (Glencore, 2015). In 2016 to 2019 Glencore maintained an average investment of US$192 in digital technology for continuous improvement and maintenance.

In 2013 to 2015, Glencore's EVA reduced sharply from US$656 million to US$367 million. That was expected due to initial high investment amounts for later high returns. The EVA then started increasing sharply from 2015 to as high as US$664 million in 2018. This shows that Glencore had improved EVA after investing in digital technology. The sudden drop in 2019's EVA by 55% can be associated with the drop in operating profit (which is part of EVA equation) in 2019 which was highly impacted by coal price reducing from US$104 in 2018 per tonne to US$73 per tonne in 2019 (Glencore, 2019).

South32

Figure 4-17 shows South32 EVA-Invested capital comparison. The data used to draw the figure was taken from the 2013-2019 financial statements (BHP Billiton, 2013; BHP Billiton, 2014; BHP Billiton, 2015; South32, 2015; South32, 2016; South32, 2017; South32, 2018; South32, 2019).

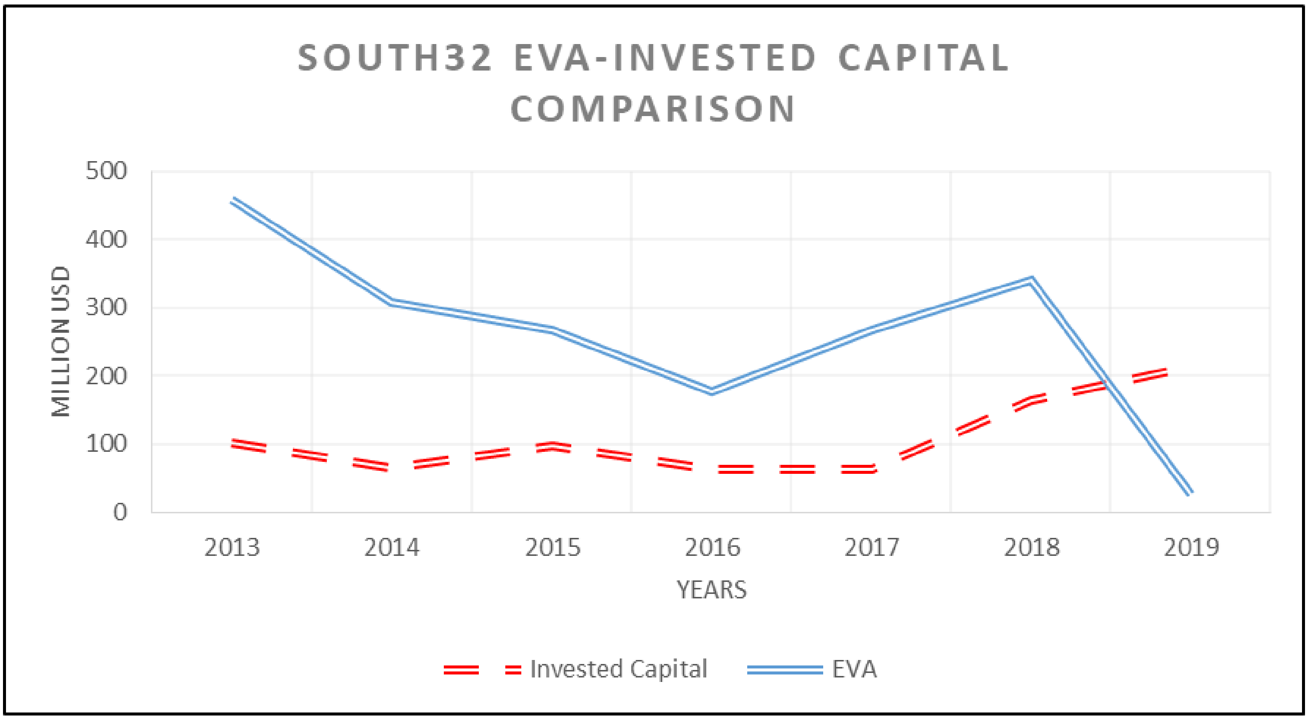

Figure 4-17: South32 2013-2019 EVA-Invested Capital Comparison

South32 invested almost constant amount of an average of US$78 million in digital technology per year in 2013 to 2017. South32 declared their investment and implementation in digital technology in 2016 (South32, 2016). South32 started increasing their investments amounts in digital technology to US$164 million and US$213 million in 2018 and 2019 respectively.

South32's EVA reduced from US$459 in 2013 to US$177 million in 2017. South32's EVA started increasing post the 2016 investment year to as high as US$340 million in 2018. South32's EVA did not increase above the 2013 figure of US$459 million due to increasing investments amounts in 2018 and 2019. The sudden drop in 2019's EVA can only be linked to huge drop in operating profit (which is part of EVA equation) due to the extended outage of the Klipspruit dragline and depletion of the northern area at Wolverkrans Middelburg Complex leading to South32 incurring mine closure costs (South32, 2019).

4.4.4 Du Pont analysis

Anglo Coal

Figure 4-18 indicates Anglo Coal Du Pont analysis. The data used to draw the figure was taken from the 2013-2019 financial statements (Anglo American, 2013; Anglo American, 2014; Anglo American, 2015; Anglo American, 2016; Anglo American, 2017; Anglo American, 2018; Anglo American, 2019).

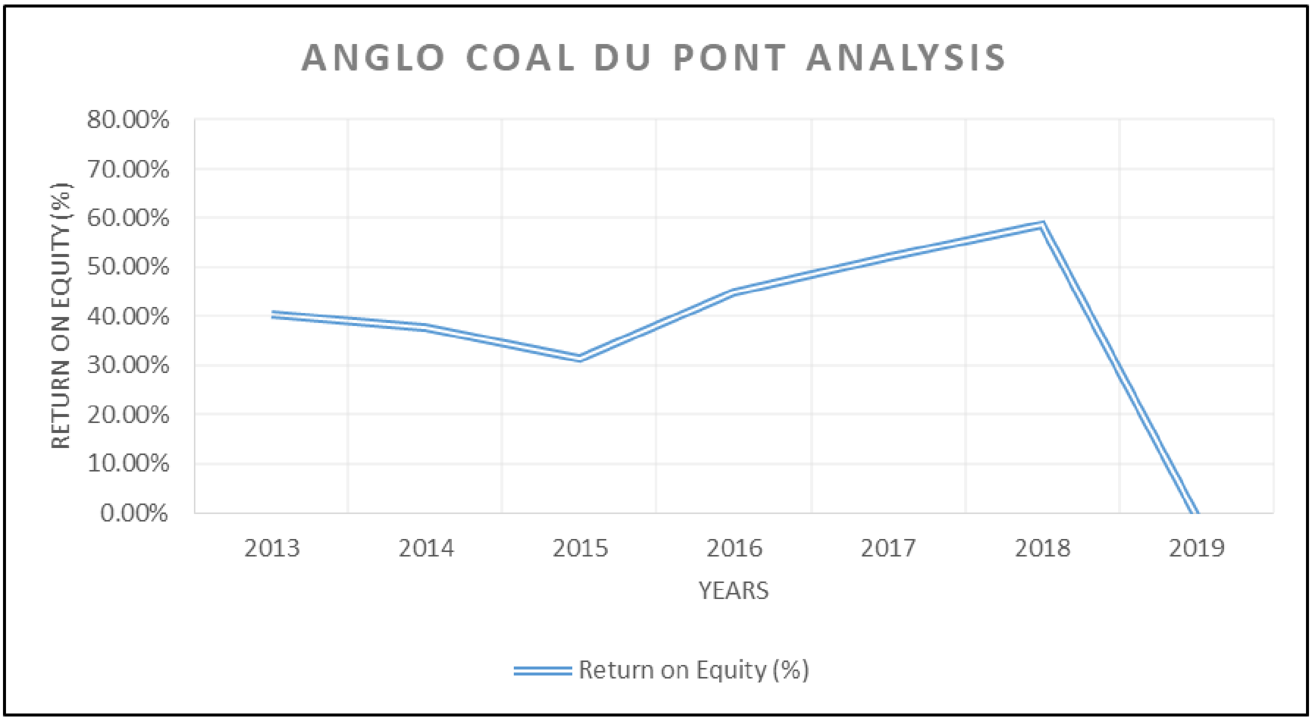

Figure 4-18: Anglo Coal 2013-2019 Du Pont Analysis

Anglo Coal’s return on equity decreased from 41% in 2013 to 31% in 2015. It increased sharply in 2016 and continued increasing to 59% in 2018. This shows that Anglo Coal had high return on equity post the year of investing in digital technology. The sudden drop in return on equity in 2019 was due to their mine sections at Goedehoop and Kwezela reaching end of life which reduced Anglo Coal’s operating profit which is part of the return on equity equation (Anglo American, 2019).

Glencore

Figure 4-19 shows Glencore Du Pont analysis. The data used to draw the figure was taken from the 2013-2019 financial statements (Glencore, 2013; Glencore, 2014; Glencore, 2015; Glencore, 2016; Glencore, 2017; Glencore, 2018; Glencore, 2019).

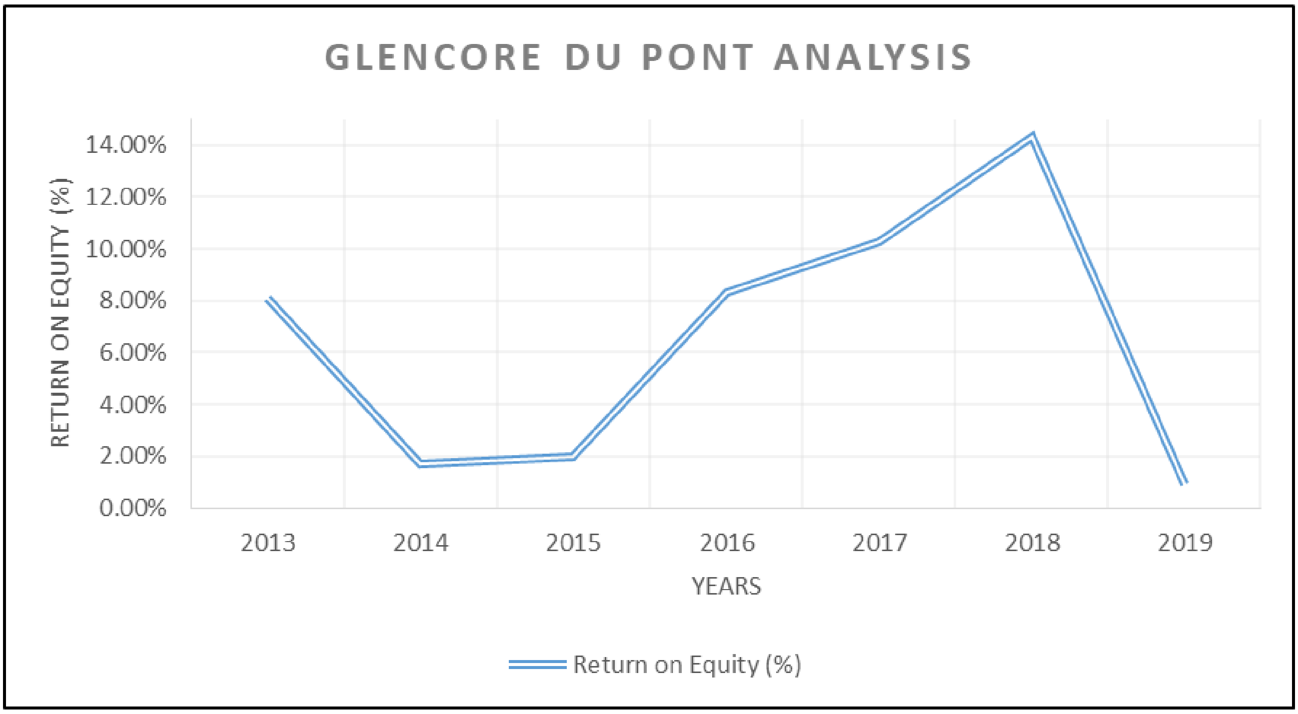

Figure 4-19: Glencore 2013-2019 Du Pont Analysis

Glencore's return on equity decreased from 8% to 2% between 2013 and 2015. Between 2015 and 2018 Glencore's return on investment started increasing sharply until it reached 14% in 2018. This shows that Glencore had relatively high return on equity post the year of investing in digital technology than pre-investment year. The sudden drop in 2019's return on equity can be associated with the drop in operating profit (which is part of return on equity equation) in 2019 which was highly impacted by coal price reducing from US$104 in 2018 per tonne to US$73 per tonne in 2019 (Glencore, 2019).

South32

Figure 4-20 indicates South32 Du Pont analysis. The data used to draw the figure was taken from the 2013-2019 financial statements (BHP Billiton, 2013; BHP Billiton, 2014; BHP Billiton, 2015; South32, 2015; South32, 2016; South32, 2017; South32, 2018; South32, 2019).

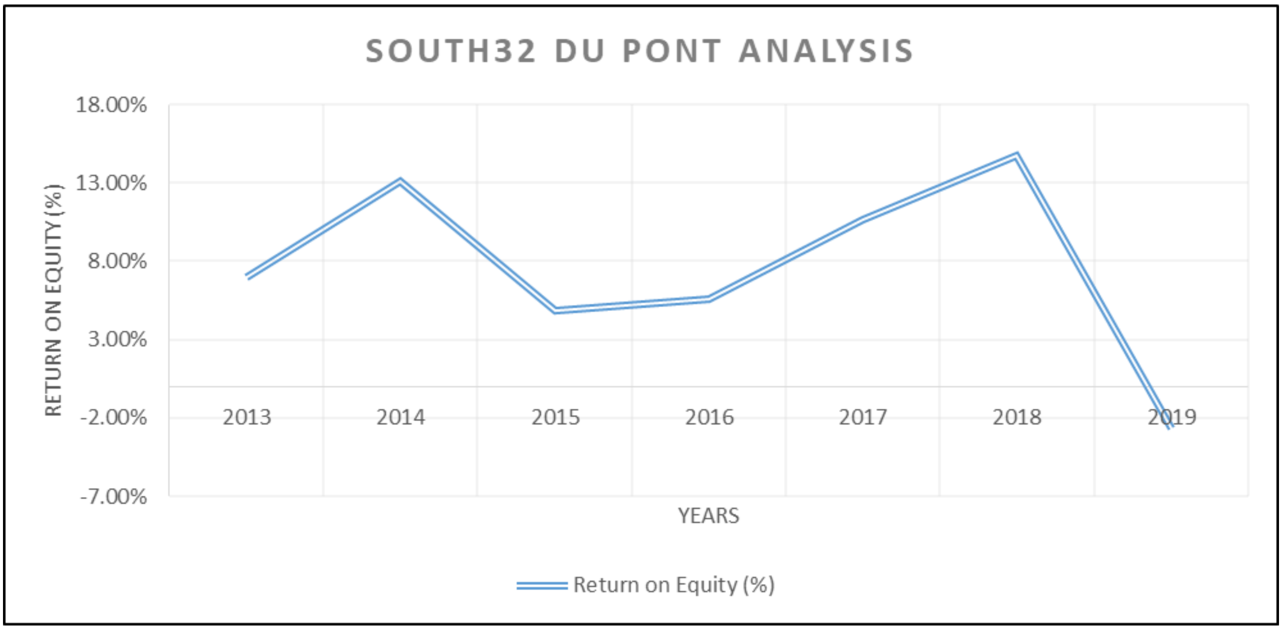

Figure 4-20 South32 2013-2019 Du Pont Analysis

South32's return on equity increased from 7% in 2013 to 13% in 2014. South32's return on equity then decreased to 5% in 2015. South32's return on equity started increasing in 2016 and it went to 15% in 2018. This shows that South32 had relatively high return on equity post the year of investing in digital technology than pre-investment year. The sudden drop in 2019's return on equity can only be linked to huge drop in operating profit (which is part of return on equity equation) due to the extended outage of the Klipspruit dragline and depletion of the northern area at Wolverkrans Middelburg Complex leading to South32 incurring mine closure costs (South32, 2019).

4.5 Impact of Digital Technology on Financial Analysis

The operating profit graphs in Section 4.4.1 shows that Glencore had high operating profit before and after the investment in digital technology. Anglo Coal had low operating profit before the investment in digital technology and high after the investment. South32 had high operating profit before the investment in digital technology than after the investment.

The profitability ratio analysis in Section 4.4.2 shows that Glencore and South32 had low profit margins before investment in digital technology and high after the investment. While Anglo Coal had high profit margin before the investment and low after the investment. Anglo Coal, Glencore and South32 had a low asset turnover before the investment in digital technology and high after the investment in digital technology. Before the investment in digital technology EVA and Du Pont analysis showed Anglo Coal, Glencore, and South32 had low EVA and return on equity. However, after the investment EVA and return on equity started increasing for all the selected companies.

Glencore is the only mining company that showed better financial performance on all four financial analysis methods studied in this report post investment in digital technology. This indicates that not all companies that invest in digital technology will have improved financial performance. Financial performance is not dependent only on the implementation of digital technology, but issues such as, but not confined to, mine closure, breakdowns, depletion of reserves, selling of operations, high contracting prices, and inflation will also impact on the bottom line.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter Overview

This chapter concludes the findings of this study. It then states the recommendations for South African coal mines intending to invest in digital technology. Limitations of the research findings and suggestions for further research are also discussed in this chapter.

5.2 Conclusions of the Research

The aim of the study was to analyse the financial impact of digital technology in South African coal mines namely Anglo Coal, Glencore and South32. The results from the analysis demonstrate that the investment in digital technology did not make all the selected coal mining companies to be more productive and profitable for the period under review. Out of the three selected companies only Glencore, showed better financial performance results on all four financial analysis methods studied in this report post years of investment in digital technology while Anglo and South32 managed to have improved results on some of the methods and relatively low or no impact of digital technology in some methods.

There appears to be no production and unit cost improvement directly linked with investment in digital technology as breakdowns, depletion of reserves, selling of operations, mine closures, high contracting prices, inflations and other factors affected these parameters. Therefore, not all companies that have invested in digital technology were productive and profitable post the years that have they invested in the digital technology than the years before investing in digital technology.

5.3 Recommendations

Results for Anglo Coal and South32 did not indicate consistent good or improved financial results in all the financial analysis methods post the investment years in digital technology, in contrast to Glencore's results which did. Glencore also invested more capital in digital technology as compared to Anglo Coal and South32. It is suggested that this may be one reason for its success. Consequently, it is recommended that companies looking to invest in digital technology follow the example of Glencore and invest as much capital as possible in this venture in order to maximise its potential.

5.4 Research limitations

In the publicly available literature, investment of mining companies in digital technology is described purely in general terms. The investment of coal companies was not specified. As a result, it was difficult to reconcile the research results which were focussed on coal companies only with the limited data available in the public domain.

A second limitation stems from the fact that financial details of investment in digital technology by the selected coal-mining companies are not published on their websites. Consequently, it was not possible to do direct comparisons between capital invested specifically for digital technology and financial returns for any of the selected companies.

5.5 Suggestions for Further Research

Mines that have been sold and/or closed should be removed from the study, to mitigate the impacts of mine closure and sales on the financial performances of these companies. This will allow the research to more closely correlate the financial performance of the digital technology.

Further research should focus on each digital technology in isolation to analyse the cost and benefit of each technology. This will assist in identifying financial value-adding technology and value-destroying technology so as to make comprehensive recommendations to investors and mining companies. Such research, however, will require in-depth access to technological and financial data from the selected mining companies.

A further suggestion is to investigate other commodity mines that have invested in digital technology and see whether similar trends can be identified. It is also thought that these operations (specifically gold and platinum mines) may have more information and data available in the public domain.

It is also suggested to link cost curves, operating profit, financial ratios, EVA and Du Pont analyses performances of companies that invested in digital technology. This will assist in developing a relationship between these financial metrics and tools.

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APPENDICES

Appendix A: Profitability financial ratios calculation formulas and tables

Formulas:

Profit Margin = EBITA / Operating Income

Return on Asset/ Asset turnover = Operating Income / Total Assets

Table 1a: Anglo American Coal financial ratios calculation

Anglo American Profitability Ratios		
Years	**Asset turnover**	**Profit Margin**
2013	0.070	1.2065
2014	0.056	1.5642
2015	0.070	1.1815
2016	0.228	0.5181
2017	0.405	0.3335
2018	0.420	0.3704
2019	0.148	- 0.0076

Table 2a: Glencore Coal financial ratios calculation

Glencore Coal Profitability Ratios		
Years	**Asset turnover**	**Profit Margin**
2013	0.056	0.3636
2014	0.037	0.1156
2015	0.038	0.1451
2016	0.046	0.4671
2017	0.053	0.5009
2018	0.067	0.5679
2019	0.033	0.0741

Table 3a: South 32 Coal financial ratios calculation

South 32 Coal Profitability Ratios		
Years	**Asset turnover**	**Profit Margin**
2013	0.042	0.3782
2014	0.026	1.0095
2015	0.107	0.3406
2016	0.082	0.5220
2017	0.111	0.7766
2018	0.140	0.7819
2019	0.017	- 1.0952

Appendix B: EVA calculation formula and tables

Formula:

EVA = Operating Profit After Interest Tax – (Invested Capital x Cost of Capital) Table 1b: Anglo Coal EVA calculation

Table 1b: Anglo Coal EVA Calculation

Anglo Coal EVA calculation (In Million USD)				
Years	Operating Profit	Invested Capital	Cost of Capital	EVA
2013	397	214	8.50%	379
2014	296	93	8.50%	288
2015	292	104	6.50%	285
2016	913	90	6.50%	907
2017	1763	152	7.00%	1 752
2018	1755	148	7.00%	1 745
2019	662	264	7.00%	644

Table 2b: Glencore EVA calculation

Glencore EVA calculation (In Million USD)				
Years	Operating Profit	Invested Capital	Cost of Capital	EVA
2013	693	499	7.50%	656
2014	450	511	8.00%	409
2015	386	209	9.00%	367
2016	456	126	9.00%	445
2017	577	188	9.50%	559
2018	685	207	10.25%	664
2019	324	229	10.05%	301

Table 3b: SOUTH 32 EVA calculation

South32 EVA calculation (In Million USD)				
Years	Operating Profit	Invested Capital	Cost of Capital	EVA
2013	468	101	8.60%	459
2014	315	65	9.20%	309
2015	276	98	8.00%	268
2016	182	63	8.50%	177
2017	273	64	8.00%	268
2018	353	164	8.00%	340
2019	42	213	7.50%	26

Appendix C: Du Pont analysis calculation formula and tables

formula:

Du Pont Analysis or Return on Equity (%) = Asset turnover x Profit margin x Financial leverage multiplier

Table 1c: Anglo Coal Du Pont analysis calculation

Anglo Coal Du Pont Analysis										
Years	Operating Income	Assets	Equity	**Asset turnover**	EBITA	Operating Income	**Profit Margin**	Return on Investment (%)	Financial Leverage	**Return on Equity (%)**
2013	397	5 693	1 182	0.070	479	397	1.2065	8%	4.82	41%
2014	296	5 281	1 225	0.056	463	296	1.5642	9%	4.31	38%
2015	292	4 159	1 096	0.070	345	292	1.1815	8%	3.79	31%
2016	913	4 012	1 055	0.228	473	913	0.5181	12%	3.80	45%
2017	1 763	4 355	1 127	0.405	588	1 763	0.3335	14%	3.86	52%
2018	1 755	4 176	1 109	0.420	650	1 755	0.3704	16%	3.77	59%
2019	662	4 479	1 050	0.148	-5	662	- 0.0076	0%	4.27	0%

Table 2c: Glencore Du Pont analysis calculation

Glencore Du Pont Analysis										
Years	Operating Income	Assets	Equity	**Asset turnover**	EBITA	Operating Income	**Profit Margin**	Return on Investment (%)	Financial Leverage	**Return on Equity (%)**
2013	693	12 395	3 114	0.056	252	693	0.3636	2%	3.98	8%
2014	450	12 176	3 011	0.037	52	450	0.1156	0%	4.04	2%
2015	386	10 279	2 781	0.038	56	386	0.1451	1%	3.70	2%
2016	456	9 968	2 561	0.046	213	456	0.4671	2%	3.89	8%
2017	577	10 847	2 815	0.053	289	577	0.5009	3%	3.85	10%
2018	685	10 294	2 714	0.067	389	685	0.5679	4%	3.79	14%
2019	324	9 926	2 613	0.033	24	324	0.0741	0%	3.80	1%

Table 3c: South32 Du Pont analysis calculation

South32 Du Pont Analysis										
Years	Operating Income	Assets	Equity	**Asset turnover**	EBITA	Operating Income	**Profit Margin**	Return on Investment (%)	Financial Leverage	**Return on Equity (%)**
2013	468	11 134	2 530	0.042	177	468	0.3782	2%	4.40	7%
2014	315	12 113	2 431	0.026	318	315	1.0095	3%	4.98	13%
2015	276	2 582	1 945	0.107	94	276	0.3406	4%	1.33	5%
2016	182	2 229	1 712	0.082	95	182	0.5220	4%	1.30	6%
2017	273	2 456	1 994	0.111	212	273	0.7766	9%	1.23	11%
2018	353	2 522	1 875	0.140	276	353	0.7819	11%	1.35	15%
2019	42	2 453	1 701	0.017	-46	42	- 1.0952	-2%	1.44	-3%

Appendix D: Ethical clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

SCHOOL OF MINING ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: EMINN/2020/07W**
PROJECT TITLE	Impact of digital technology in coal mining: A financial analysis of Anglo American, BHP Billiton and Glencore
INVESTIGATOR	Reply Maluleke
SCHOOL/DEPARTMENT OF INVESTIGATOR	School of Mining
DATE CONSIDERED	12 October 2020
DECISION OF THE COMMITTEE	Approved unconditionally
RISK LEVEL	NO RISK
EXPIRY DATE	12 October 2023

ISSUE DATE OF CERTIFICATE 08 February 2021 **CHAIRPERSON** ______________ (Mr H Thomas)

cc: Supervisor: Paskalia Neingo

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am are authorised to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

RMaluleke
Signature

Date 04 / 06 / 2021