

**Gordon Institute  
of Business Science**  
University of Pretoria

Mining production optimisation in South Africa

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A research project submitted to the Gordon Institute of Business Science,  
University of Pretoria in partial fulfilment of the requirements for the degree of  
Master of Business Administration

## ABSTRACT

South Africa has arguably the largest reserves of mineral resources in world. This resource abundance is clearly not being utilised, as South African mining production has fallen year on year, while other resource rich countries increased production during the current sustained commodity cycle which is driven by large emerging economies.

This study, exploratory in nature, attempted to determine whether the production techniques used by South African mining companies are efficient enough to allow South Africa to compete in an increasingly globalised sector. The study also attempted to determine what and how other factors affect the production output in the South African mining sector. The information was gathered by means of an online questionnaire, both qualitative and quantitative in design that was completed by 31 respondents at management level, currently engaged in mining production

The factors affecting production were found to be both non-technical, such as legislation and labour related and technical factors within the production cycle. Operating in a price taker global market, South African mining techniques certainly need an overhaul in comparison to international mining operations. Stakeholders within the sector need to recognise that a symbiotic relationship is needed to drive production in the sector instead of the current seemingly parasitic relationship.



## **KEYWORDS**

South Africa

Mining

Productivity

Economic growth

Mineral resources

## DECLARATION

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

Name: Dinasen Palavar

Signature:

Date:

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## **ACRONYMS AND ABBREVIATIONS**

PGM – Platinum Group Metals

GDP – Gross Domestic Product

GNP – Gross National Product



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## CHAPTER 1: INTRODUCTION TO THE RESEARCH PROBLEM

### 1.1 Introduction and background to the research problem

The rise of the South African economy has been inextricably linked to the discovery of vast mineral resources and subsequent exploitation of those mineral resources. The resulting mining industry allowed South Africa to make the transition into a modern industrial state at a much more rapid rate than the contemporary European economies (Harrison and Zack, 2012).

This dependence on mining as the economic backbone of the country is reflected in the sector's heady contribution to gross domestic product which peaked in 1970 at a 21% contribution and continues to contribute up to 8.35% of gross domestic product as recently as 2013. This contribution to gross domestic product, while impressive, has been on a downward trend in recent years and has led to a decrease in investment by mining companies in South Africa (Baxter, 2016).

While this decline in the mining sector could be attributed to a downturn in the world economy or perhaps a depletion of mineral reserves, both of these reasons are patently untrue. Simply put, there are countries that have been producing at higher volumes than South Africa in recent years (British Geological Survey, 2016)

The figures extrapolated from the data provided in the survey show a drastically declining trend in South Africa's mineral production, with even platinum group metals (PGM) being affected despite South Africa having 96% of the global proven reserves of these metals. Platinum group metals are metals that are clustered together on the periodic table. These metals consisting of ruthenium, rhodium, palladium, osmium, iridium, and platinum display similar physical and chemical properties and are often found clustered together in the same deposit hence, platinum group (SA Government, 2016).

Despite South Africa having over 50 different minerals being mined (Sorenson , 2011), the South African chamber of mines ranked the following four minerals as having the biggest contribution to mining minerals exports in South Africa . Platinum group metals, iron ore, gold and coal are four double-digit contributors to South African mining export and almost making the contribution of other metals irrelevant (Baxter, 2014).

These four major contributors to the mineral export market have seemingly impressive production figures when viewed in isolation but when viewed against an economy like Australia which grew 81% in a decade , with mineral resources as one of the major drivers of that growth (Miankhel, Kalirajan and Thangavelu, 2014) the South African production volume lags behind, especially when the like of Bloomberg tout South Africa as having the largest mineral reserves in the world (Crowley and Janse van Vuuren , 2014)

A comparison, compiled from the British Royal Geological Survey released in 2016, of the four major minerals mined, reveals the South African mining industry displays trend of a distinct slowdown in production.

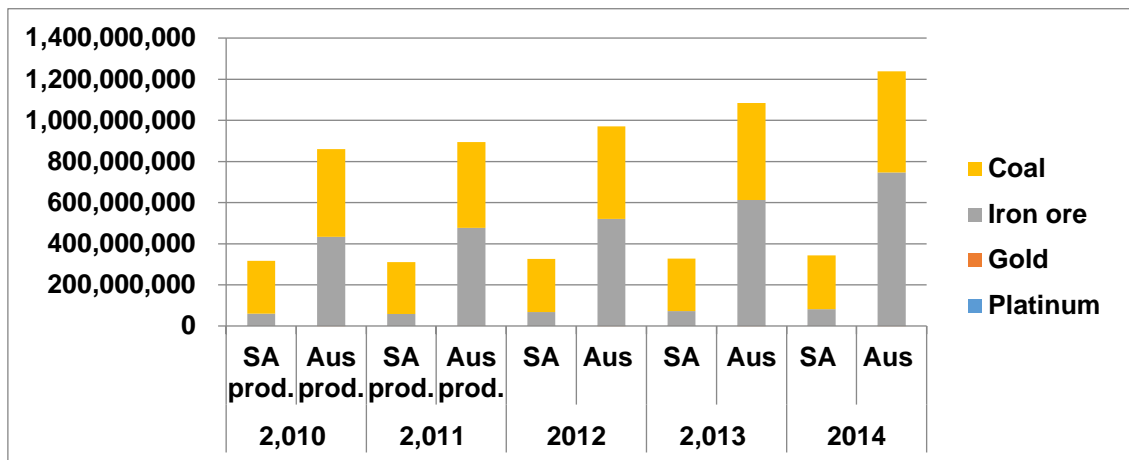
**Table 1: Comparison between South African and Australian Mining Production (2010 - 2014)**

	2,010		2,011		2012		2,013		2014	
	SA prod.	Aus prod.	SA prod.	Aus prod.	SA	Aus	SA	Aus	SA	Aus
Platinum	287,304	781	288,850	445	254,338	706	264,188	786	188,444	766
Gold	188,702	260,000	180,184	259,052	154,180	251,654	159,724	268,262	151,622	273,963
Iron ore	58,709,330	433,452,000	58,056,897	477,330,291	67,100,474	519,858,812	71,543,088	612,415,940	80,759,334	745,734,695
Coal	257,205,807	425,751,000	252,756,844	416,357,000	258,575,793	449,858,000	256,282,133	471,167,000	261,398,527	492,261,000

**Table 2: Year on year difference between South African and Australian Production (2011 - 2014)**

	2,011		2,012		2,013		2,014	
	yoy diff in SA prod.	yoy diff in aus prod	yoy diff in SA prod.	yoy diff in aus prod	yoy diff in SA prod.	yoy diff in aus prod	yoy diff in SA prod.	yoy diff in aus prod
Platinum	1,546	(336)	(34,512)	261	9,850	80	(75,744)	(20)
Gold	(8,518)	(948)	(334,364)	(7,398)	5,544	16,608	(8,102)	5,701
Iron ore	(652,433)	43,878,291	(125,157,371)	42,528,521	4,442,614	92,557,128	9,216,246	133,318,755
Coal	(4,448,963)	(9,394,000)	5,818,949	33,501,000	(2,293,660)	21,309,000	5,116,394	21,094,000

**Figure 1: Comparison between South African and Australian Mining Production (2010 – 2014)**



While it would be easy to blame this on the world economy at the time, the trend does not seem to have hurt other resource economies in the same fashion, which have shown increases in production year on year. What should be noted from the above production figures and their contribution to the export market is that South Africa has not made the attempt to diversify the risk prevalent in being over-reliant on a few commodities (Adibi and Atae-pour, 2015). With no investment into exploration and feasibility studies for new reserves, the reliance on legacy infrastructure and technology will further increase.

Some of the world’s biggest miners have all decreased their exposure within South Africa citing various reasons (Els,2016) , with Rio Tinto having divesting all but its shares in Richards Bay Minerals (Leon,2016) and BHP Billiton completely disinvesting via South 32 (Mathews,2015).

### 1.2 Mineral resource demand history

As determined by Vernier (2014) the four biggest contributors to resource mining in South Africa have all experienced huge demand surges. Gold has seen a 406% price increase over 13 years while production only rose 14%. Platinum has seen a comparatively more modest price increase over the same period of 205% while production has also only increased by 14%. Coal has seen a bit more



success with price increases of 135% and production increases of 70%. While iron ore, which has seen a whopping 889% increase in price has only upped production by 178% over the measured period. This led Vernier to conclude that the price and production of the above resources has increased globally right up to and including 2013. As can be seen by Figure 1, South Africa has clearly not followed the growth trajectory in the production of these resources that a similar resource dependent economy such as Australia has.

In spite of these minerals being perceived as rare and in short supply, recent exploration has shown that newly discovered reserves far exceed previous estimates. With the world population increasing, demand for these minerals has also increased, with new supply sources rising to meet this demand (Wellington and Mason, 2014).

### **1.3 Why is this relevant to South Africa?**

Within a resource dominated economy like South Africa, mineral production generates both domestic and international income. Mining industries also normally provide a stimulus on downstream industries such as transport and manufacturing, which grows the local economy as well as ensuring further revenues for government (Adibi and Atae-pour, 2015).

Roger Baxter, Chief Executive of the SA chamber of mines points out that mining has not grown at the same rate as the rest of the country's economy and considering the industry has a multiplier effect of up to 18% of GDP on the country's economy a decline in productivity does not just hamper the sector but the entire country (Sorenson, 2011).

Worldwide there is a changing view that economic growth is only effective when an enterprise is evaluated from three major points of view, and not just from a purely financial view. This economic, social and environmental view is collectively known as sustainable development and has subsequently become universally adopted, even though there exists no official or practical definition of what sustainable development is (Islam, Munasinghe & Clarke, 2003). Sorenson

(2011) surmises that mining in South Africa has become economically unsustainable while the social and environmental aspects have yet to become fully emergent.

#### **1.4 Research Aim**

The aim of this research is to determine some of the reasons for the mining sectors' failure to capture the benefits offered by a commodity boom cycle due to the inability to produce to demand. In a country with high unemployment (26.7%) and low economic growth (1.6%) (Stats SA, 2016), the opportunities afforded by the chance to boost employment, attract foreign exchange and foster growth cannot be ignored.

The struggle with labour and governmental policies has been documented and will form part of the theoretical discussion alongside the evaluation of current production techniques. This study will focus on the open cast/open pit sub/surface sector of mining as that is the method of mining most utilised worldwide [up to 85% of minerals are mining utilising this method (MIT,2016)], with very few mining operations still entertaining the idea of shaft or underground mining. The study will thus attempt to determine whether production techniques currently employed in South African open pit mines are allowing for optimum operating efficiency, as well as determine other factors that could affect productivity in the face of increased global competition. This will be purely from a mining perspective and will exclude processing of any commodities.

#### **1.5 Structure of this research study**

The research paper will be presented in seven chapters. A description of these chapters is provided below.

Chapter one will provide an overview of why this topic is not only currently relevant but also why there is a need to conduct research into the topic. Chapter two will provide an overview of the topic starting with why mining is of value to South Africa, followed by a production comparison with other resource

dominated economies of similar structure, following by the need to evolve to stay competitive in an innovative and globalised business environment, and concluding with possible country specific reasons excluding technique that are contributing to production drop off.

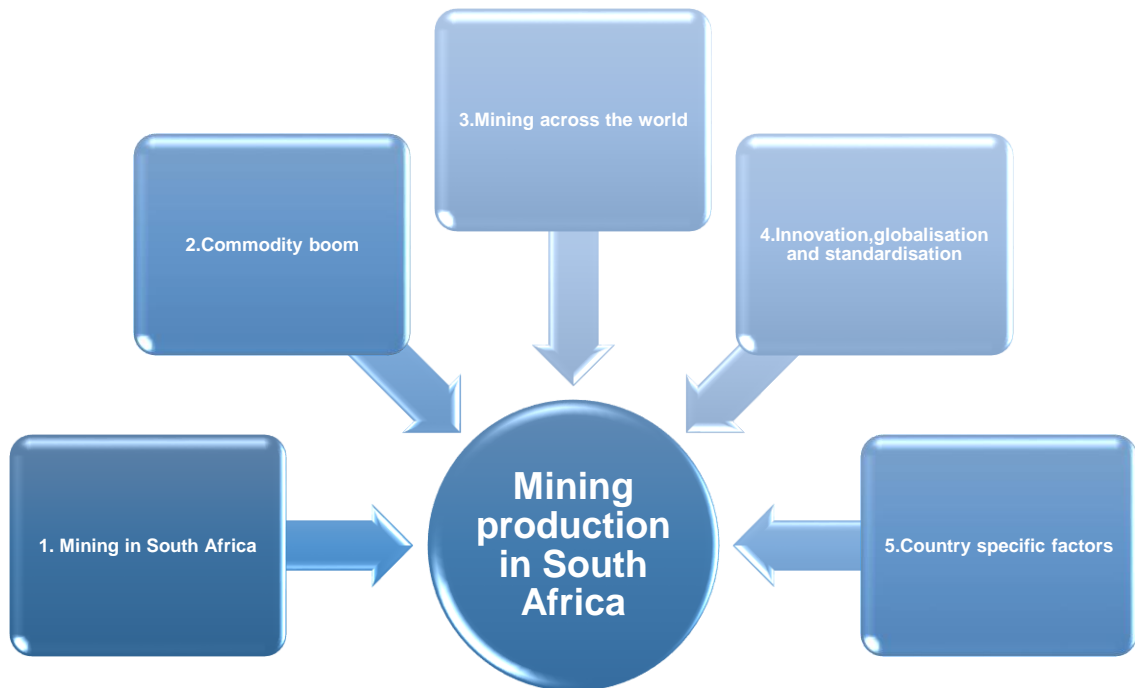
Chapter three provides the research questions that the study consists of. Chapter four clarifies the methodology used in this study. Chapter five is a presentation of the results and chapter six is a discussion of those results. Finally chapter seven provides a conclusion as well as suggestions for further research.

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Introduction

The literature will be structured in a manner that will attempt to explain why mining is important to South Africa, why South Africa needs to improve production and what factors could be affecting production. The literature review can be modelled into the diagram below to detail the relevance of each section in relation to the research reason.

**Figure 2: Relational view of the literature review**



## 2.2 Mining and South Africa

South Africa owes much of its development and advancement to mining and mineral extraction. Commercially viable gold deposits were first discovered in the province of what is called Limpopo today in 1870 but it was not till the discovery of the Witwatersrand reef in 1886 that South Africa was put on the path to industrial development (Sorenson, 2011). This resource enabled the country under the leadership of Paul Kruger to rapidly move towards industrialisation from a predominantly agricultural based economy, which in turn led to the rapid development and urbanisation of cities such as Johannesburg (Muller, 2016)

This urbanisation was so rapid, that the population of the Witwatersrand increased thirty times over in a decade, due to the lure of gold to the prospector. This initial enthusiasm was quickly dampened by the realisation that the deposits were not of high quality and too capital intensive to extract. A combination of these factors led to the development of the MacArthur – Forrest process which allowed the gold to be economically mined. This was followed by the realisation that mining companies needed to combine their holdings in order to realise sustainability in the industry, brought about by economies of scale in owning and operating on larger claims (Muller, 2016).

Elbra (2013) explains how this consolidation of holdings shaped the future of South African mining and concentrated the industry in the hands of a few select companies until the end of apartheid and cemented South Africa's reliance on mining as an economic growth sector despite the country's increasing industrialisation in other sectors. Elbra (2013) goes on to further contend that South Africa has actually not benefitted as much as it should have, from having a mineral rich economy but this is not commonly realised due to the lack of research in this aspect in South Africa .

For many years mining was the backbone of the South African economy, in fact in 1970, it was recorded that it contributed up to 21% of the gross domestic product. This figure has progressively dropped year by year over the decades and as at 2013 mining contributed 8.6% towards the gross domestic product

(Chamber of Mines, 2014) .This trend continued in 2015 with a contribution of 7.7% to gross domestic product (Baxter, 2016).

The influence of mining in the South African economy reverberates to this day with the labour market still bearing the limitations and constraints put in place by a system designed to take advantage of the abundance of cheap manual labour that defined the mining industry in South Africa for many decades. These policies and practises which were initially designed to protect the interests of the white working class during the early part of the 20<sup>th</sup> century now serve to protect the interest of the African working class. Although archaic and cumbersome, these pro labour policies now effectively serve as barriers to the labour market for the unskilled and unemployed. The labour market protects these self-interest models with such zeal that proposed changes towards a more labour absorbing growth path are aggressively resisted (Seeking and Natrass, 2002).

According to Sorenson (2011), the current South African mining industry paints a bleak picture. There are currently over sixty minerals mined from approximately 1400 mines in South Africa. A large number of these mines are now derelict and abandoned due to lack of monitoring during the life cycle of the mining asset, which is illustrated in the recreated picture below courtesy of Roger Baxter (chief economist of the Chamber of Mines of South Africa) and will take considerable resources to rehabilitate successfully.

**Figure 3: The mining life cycle**



The brief historical background makes it clear that the mining industry in South Africa has and continues to play a massive role in the country's economy and that any disruption to the industry has ripple effects in other sectors and throughout the economy. Harrison and Zack (2016) give an explanation as to how Johannesburg, the city of gold has made the transition from a resource

based economy to a diversified and competitive agglomeration, but the industries that currently dominate the city are a product of a mining legacy .

The mining industry in South Africa currently has a multiplier effect on supporting industries, thus indirectly contributing almost 18% to the country's GDP. Linked industries include transport, professional services and electricity generation (Sorenson, 2011)

The impact mining has on the South African economy and the contribution towards GDP has been substantial. Whether by direct or indirect contribution, albeit on an ever decreasing scale, mining is an important player in the economy of a country with the largest proven mineral reserves in the world.

### **2.3 The rise in demand for commodities**

Commodity cycles are characterised by comparatively short periods of extreme demands, often as the result of a global event, characterised by long periods of steady, stagnant supply. During these periods of demands, the price of the commodity rises steeply, until supply catches up, driving the price back into the a new equilibrium (Cashin, McDermott and Scott, 2002)

There has been two previous periods in the recorded history of the world of extreme commodity demand, dubbed super cycles, interspersed with periods of long stagnation. The first of these so called super cycles began in the early twentieth century and was stimulated by demand from a rapidly industrialising United States of America. This cycle was prolonged and well sustained and led to a long period of economic growth in the United States. The second of these super cycles began during the middle of the twentieth century and was a result of the Second World War and was driven in two stages. The first immediate demand surge was caused by the need for European countries to rebuild their countries, industries and economies that were decimated during World War Two. This period of extreme demand was sustained by the emergence of Japan as an industrial power during the latter part of the cycle. (Erten and Ocampo, 2012)

Sustained industrialisation and urbanisation coupled with an ever increasing economic growth trajectory in China, leading to a massive and sustained spike in demand for commodities by that country, has prompted economists to call the current cycle a super cycle (Erten and Ocampo, 2012; Canuto, 2014). Even as the biggest producer of coal, internal Chinese production has not been enough to satisfy this demand forcing the country to look further afield. China has been particularly aggressive in forming trade agreements in Africa, where the need for capital investment is strongest in exchange for access to the plentiful mineral deposits (Li, 2007).

Perlich (2013) is at pains to point out that even though China was the greatest demand driver for Australia's mineral output, Japan and South Korea were also responsible for driving up demand with India recently also staking a small but extremely fast growing place in the Australian export market . This multi market demand spike has seen the Australian mining industry shield the country from the effects of the last financial depression. The effect of the Chinese demand is also felt very strongly in Africa where the likes of Zambia has seen a surge in production of copper, after decades of stagnation, to be used in items such as power transmission, electrical goods and motor vehicles (Negi, 2014).

The current commodity boom has led to the rise of the transnational mining company and the subsequent concerns over their ability to shape state policy in countries where they have significant operations and their aggressiveness in extracting resources, especially in territories occupied by indigenous people. This is especially prevalent in Latin America which in recent years has become the favoured mining investment destination over the likes of North America and Australia .This heavy handed approach has led to the rise of popular opposition to controversial mining projects (Gedicks, 2015).

While previous commodity booms have been very short and driven by spurts of economic expansion and then depression, the current commodity boom has been on-going and sustained, even though a depression has occurred during the cycle. Radetzky (2013) attributes this to the dominant consumer countries in the emerging world (i.e. India and China) not being affected by the recession thus



not affecting the steady demand for resources. On the contrary, the Chinese presence in African commodities has increased to such an extent that there are now multiple Chinese owned and operated mines across the continent (Li, 2007). The above section provides clarification regarding a commodity boom and the resultant sustained demand, which South Africa is not taking advantage off.

## **2.4 Mining production in other mineral dominant economies**

In order to prove South Africa has a unique problem with their mining output an overview of similarly structured, developing world resource based economies is provided as well as showing that a transition from developing to developed world is possible, within a resource based economy.

The World Bank defines a developing country as a country as having low GNP per capita and/or their economic structure or government's position. GNP per capita is essentially the gross domestic product of a country excluding the outflows to foreign companies or person, so in effect the gross income of a country or economy (World Bank, 2016). South Africa, Chile, and Zambia used to fall into the category of developing countries, while Australia and Canada would have been classified as developed countries.

For reasons not fully explained the World Bank has decided to do away with referring to countries as developed or developing and instead with immediate effect categorise countries into the following:

- Low income economies
- Lower middle economies
- Upper middle economies
- High income economies

The above categories are based on calculations based on a formula provided by the World Bank but due to previous research using the terms of developing or third world countries that will remain the terms of reference within this document (World Bank, 2016).

Third world countries refer to countries that were not aligned to either North Atlantic Treaty Organisation (NATO) or the Soviet bloc during the period known as the Cold War. These countries which served as the proxy battle grounds for the main adversaries during the cold war were often underdeveloped areas of Latin America, Asia and Africa with strong colonial legacies (Litonjua, 2014).

Resource rich countries are often plagued by low growth rates and high inequality due to weak institutions, law and corruption. While this is often stereotyped as the norm, some resource rich countries have overcome this tendency with good institutions, trade openness and other mechanisms to overcome the stereotypical scenario (Van der Ploeg, 2011).

A characteristic of resource rich countries are boom-and-bust cycles which are caused by commodity price swings. If the commodity price happens to be set by the market, these price swings effect the flow of export income thereby making fiscal planning past the immediate future challenging (Alibi and Atatee-pour, 2015). Faradic, Islam and Moslehi (2015) have agreed to a large extent with the findings of Van der Ploeg and propose that the quality of institutions determines the productivity growth in resource rich economies. These high quality, forward looking institutions allow greater economic freedom that encourage more efficient utilisation of resources instead of allowing rent seeking behaviour to flourish .

One of these successful countries is Australia, which has a similarly resource dependent economy but the growth trajectory has been spectacular and sustained, to such an extent that Australia experiences a phenomenon known as the “two speed economy” whereby the growth in resource states is markedly greater than in non-resource states. While this resources has helped Australia stave off the effect of the current financial crisis and keep GDP performance stable, it has led to some criticism that the Australian economy is much too narrowly focused on mining (Perlich, 2013). While Australia’s current production status is ever increasing, Argent (2013) stated that an increase in production has had some negative effects for the Australian economy such as making imports cheaper and exports more expensive due to a robust currency.

Another resource rich country able to escape the stereotype of being unable to make the transition from developing to developed is Canada. Revenue from resources in that country has managed to be funnelled into streams that have contributed towards infrastructure implementation, welfare systems and economic growth (Elbra, 2013).

As a country touted as one of the last remaining examples of the “resource curse”, Zambia has also managed to increase their income from copper mining up to and including 2012. This “resource curse” theory put forward the notion that countries with high levels of natural resources often experience slower growth rates. The mechanics or limitations of the “resource curse” theory is not within the scope of this paper.

Copper mining in Zambia has been on the increase, due to demands from India and China, after a protracted two decade period of subdued activity. Even though the income from copper has risen dramatically in the last few decades and Zambia has achieved some semblance of a democracy, corruption and other rent seeking behaviours continue (Boos and Holm-Muller, 2015). Chile is an example of another resource rich country in the former third world or developing world that has managed to increase its mining contribution value add to GDP by 12%.

South Africa on the other hand did not increase its mining value add by any significant value in the same period, which just happened to be during the longest commodities boom the world has seen (Leon, 2012). Referring to the Asian countries, which as described by Perlich (2013) are the primary reason for the demand in mineral exports, Indonesia quadrupled their coal production in less than a decade. Even though an increasing proportion of this was subsequently consumed internally, the majority (70%) of it was exported to other Asian markets (Kim and Yoo, 2016).

The above examples all support the argument that at a time when other resource rich countries increased production on an exponential scale, albeit with

subsequent acknowledged and related problems, South African production has stagnated.

## **2.5 Implementing innovative new production techniques in a globalised industry**

Due to the previously mentioned protected and a fiercely defended labour structure, the South African mining sector has found it very difficult to adopt new innovative techniques that increase production, especially if these techniques even hint at direct labour reduction (Seeking and Natrass, 2002). Innovation is a driver of economic growth (Cetin, 2013), but within the South African context the unionised mining industry has so many protectionist measures in place that any attempt to change the current model of labour practises is met with extreme resistance, even though that model was designed for a different time and application (Seeking's and Natrass, 2002).

Innovation can be very broadly defined as introducing new products to the market, redesigning production processes or reconfiguring organisational practises. This process is continuous and the design, creation and implementation of new technologies cause higher economic growth rates. Innovations further enhance the efficiency of labour and the extent of the market (Cetin, 2013). To illustrate the effectiveness of innovation to the South African mining industry, the previously mentioned MacArthur-Forrest method of gold extraction is a most obvious example. This method of gold extraction allowed the Witwatersrand reef to go from a barely profitable operation to the world's most productive source of gold for many decades (Muller, 2016).

Mining companies are price takers i.e. the market sets the price and not the supplier (Baxter, 2016). This makes it very difficult for a price taker to pass on any added costs to the customer (Vernier, 2014). This situation is in total contrast to a price maker who sets the market price by controlling quantity (Jablanovic, 2013). An example of a price maker would be an energy storage facility. The facility which stores electricity during periods of low demand, low price subsequently releases the electricity during periods of high demand, high price

possibly affecting the market price (Shafiee, Zamani-Dekhordi, Zareipour and Knight, 2016)

Hana (2015) carried out research on the importance of innovation and knowledge in his home country of the Czech Republic and his findings were summarised into the following four statements, which shows the importance of innovation in a global market, namely:

1. Innovations are equally important for organisations of all sizes and across all economic sectors.
2. Competitive advantage is determined by innovation, which in turns drives economic success.
3. Innovations are a key driver of an organisation's quest to survive and grow in today's modern globalised business environment.
4. Knowledge is the element that drives innovation. Without knowledge, there is no cornerstone to base innovative measures on.

The application of innovation (past and present) in the mining sector and the subsequent benefits provide an example of how evolution is necessary to ensure sustainability. During the early days of the Australian gold rush, most of the miners who started the work only had experience operating in an environment with much more precipitation. This experience while completely efficient in its originating environment would prove to be arduous on the new environment in terms of water usage. The miners subsequently innovated a process that remained effective but still used water conservatively, due to the demands that the new environment placed on them. This process allowed the continued development of a new industry through adaptation to a changing environment (Lawrence and Davies, 2015).

In 2015, Chanturia, Kozlov, Mateeva and Lavrinenko went through the process of detailing how the Russian platinum industry, at the urging and support of the Presidium of the Russian Academy of Sciences, developed a new method of processing and extraction, due to the platinum being present in hard to extract ore. This method helped ensure the preservation and enhancement of the platinum mining industry in Russia.

For innovation to be a driver of economic growth, it is becoming increasingly important for government to take the lead in the innovation sphere. Governments should earmark funds for research and development as well as ensure that there are proper policies and procedures monitoring the usage and implementation of these funding policies to ensure a “whole of government approach”(Cetin, 2013).

Globalisation according to Miles Kahler in 2014 is the process of economic integration at the global level which is no longer limited to industrialised countries. Kahler further goes on to state that globalisation has removed the entrenched understanding of economic security, as globalisation now pits the effects of volatility by introducing new factors, against the spectre of the always tempting improved economic performance.

Khan and Bashar (2016) emphasize the impact that globalisation has had on developing and developed countries. While the impact is not standardised across countries, they do acknowledge that more and more countries are now embracing globalisation as a strategy for higher economic growth and development, and offer an opinion that companies will intensify and support any activities that offer a cost saving brought about via globalisation.

Globalisation generates new demands in the economic, political and cultural regions and organisations cannot ignore what is already an on-going process, whilst adopting a wait and see approach (Muscalu, 2014). Khan and Bashar (2016) state that the impact of globalisation is not fixed across all countries and that developing countries and developing countries often have completely different experiences of globalisation, so even though developed countries might experience might experience higher growth, developed countries are experiencing a brain drain of sorts, indicating a need for developing countries to carefully target the beneficiaries of outsourcing through globalisation.

Sprague (2015) warns that mining has become a more globally competitive industry and details in his paper how mining in the Caribbean basin has changed to reflect this evolution. Mining companies do not have a home nation as such

anymore but have become transnational operations, thus implementing globally competitive measures which have resulted in mixed results.

Global standardisation of processes is a common approach in industry to manage complexity. The benefits of managing this complexity result in cost saving, quality improvements and shorter time to market (Gepp, Steianman, Vollmar and Voigt, 2012). As Sprage (2015) points out imposing global standards within an industry does not always prove to be beneficial. Rhee, Park and Yoo (2015) further determined that a too high or too low degree of standardisation should be avoided and that standardisation is not always good or bad. Rhee et al. have suggested that their findings indicate that a moderate degree of standardisation and classification provide the necessary framework to encourage innovation. Even though implementing globally competitive measures might have mixed results, the above section has detailed the importance of innovation in a global market.

## **2.6 Country specific non-production related factors that affect the mining sector**

The literature up to this point has leaned towards a taper in production due to an inefficient technique but there are other various well documented non-production factors that plague the mining industry, amongst them institutional factors which, have been the subject of research reports in previous years and economic transition

Hodgson (2006) defines institutions as a system of established and prevalent social rules that structure social interactions. Hodgson further goes on to identify language, money, law and firms (and other organisations) as institutions of sorts and their impact on the market as institutional economics. Najee (2014) goes on to explain that behaviours within an organisation that have been legitimised are referred to as institutionalised behaviour.

Institutionalisation of behaviours within an organisation is an important cognitive step by management, as it immensely influences the change management

process. This process of institutionalisation is implemented either through a structured approach process or through natural, spontaneous evolution of routines and organisational structure.

A characteristic of institutions is that while they provide stability via an established framework on behavioural protocol, it is this very same institutionalisation that does not allow for fast changes. Due to the slow reaction of institution the action they do eventually take are sub-optimal. While it is understood that institutions are unable to make fluid and dynamic changes depending on changing needs and insights it's also now understood that institutions are able to change and adapt albeit at much slower pace than life changes (Lustick, 2011).

Venier (2014) determined that there were a number of institutional impediments to influencing mining investment in South Africa. The main factors affecting investment by mining companies in South Africa during this century include uncertainty, infrastructure and labour. These factors and their subsequent causality have eroded the trust between industry, government and labour leading to a holdup/stagnation of sorts within the South African mining sector (Vernier, 2014).

In 2012, Peter Leon, identified the following factors as impediments to the mining industry in South Africa which share some common themes with Vernier's findings:

- A flawed Black Economic Empowerment policy;
- The spectre of mine nationalisation;
- The emergence of a state owned company and
- A decline in South Africa's position in the Fraser Institute rankings of a country's attractiveness to investors.

In a detailed qualitative study undertaken in 2010, Rustum Norman engaged stakeholders within the mining industry in South Africa to determine the level of the technical skill shortage within the industry. Norman found that the skills



needed to effectively work the mining industry are in short supply, and that people nearing retirement age are encouraged to remain in order to pass on these skills and continue maintenance on current equipment. The reason being is that the current programmes and curriculums required for technical skills are not adequate and need to be redesigned. Norman also found that companies do not have effective training programmes in place due to financial and production demands, with the result that the newly appointed person never receives a protégé/mentor relationship in order to acquire the vital skills needed, and potential mentor is often poached across mining houses due to a lack of succession.

Due to their very nature, institutionalised behaviours are very difficult to modify over a short period (Lusick, 2011) but as discussed by Patora-Wysocka in 2014 the process of soliciting process change within an organisation to take advantage of rapidly changing market conditions is also an institutionalised behaviour and within an always evolving sector this process is accomplished by routine implementation. The mechanics and intricacies of institutional theory is not within the scope of this research but the above are some of the institutional issues, which could possibly have an effect on mining production in South Africa.

Another country specific problem was highlighted by Sorenson (2011) who contends that the South African mining sector continues to diminish in favour of secondary and tertiary industries which it has spawned. This process of economic transition is the shift away from primary resource dependence, due to the introduction of an alternative economic activity. Due to the boom and bust nature of the commodity cycle, alternative development paths should be forged to lessen the reliance on natural resources (Mitchell and O'Neill, 2016).

Li, Lo and Wang (2015) describe the importance of a resource economy planning for boom/bust cycles and the inevitable exhaustion of resource reserves. The intangible hurdles during the economic transition include legacy issues such as inherited administrative and fiscal policies as well as political interests. These challenges are more pronounced in transition economies compared to market economies, which are more evolved and developed. Using the city of Daqing in

China as an example, which is heavily dependent on oil, it has demonstrated the importance of initiating as broad a diversification strategy as possible as early as possible. This was tempered with the caution that severing ties completely with the mining industry is ill advised, as the initial reason for growth might provide divergent streams of income via vertical and horizontal integration.

Due to the non-renewable nature of commodities, planning and implementation of an economic transition helps prevent job losses and ghost town scenarios created by population migration. Mitchell and O'Neill (2015) have determined that new public and private sector employment help fill the gap in employment opportunities, which is helpful in stopping the flow of population migration out of the resource depleted area.

Even though mining has a less dominant role in the South African economy it still is the second largest provider of jobs to South Africa's unskilled and semi-skilled labour pool. Sorenson, 2011 goes on to suggest that while the economy will survive without mining, industries that depend on mining for survival should start to serve and explore other sectors.

## **2.7 Literature Summary**

The literature above provides the rationale for this study. South Africa used to be a world leader in the production of minerals for many decades. With mining providing the back bone to the economy in terms of contribution to GDP and employment provision, the benefit of taking advantage of this resource dominated economic structure could not be disputed.

For a country with arguably the world's highest proven mineral reserves, this position has not been taken full advantage off and the mining industry in South Africa has slowly declined while other countries with mineral based economies have increased production, year on year. The South African mining industry has been blockaded by protectionist measures and the subsequent strict enforcement of these measures has not allowed for the implementation of new ideas or processes.

The South African mining industry has also been affected by other non-production technique related factors such as institutional factors, lack of skills retention and migration away from the industry. This study aims to determine at a very exploratory level, the impact, if any, these factors have on affecting the productivity output in the mining sector.

## CHAPTER 3: RESEARCH QUESTIONS

From the introduction and literature review it is clear that South Africa's mining production is declining and that there are multitudes of factors that have an impact. These research questions will attempt to explore to what degree these factors have an impact on production volume. Research question were deemed to be more appropriate than either a hypothesis or a propositions as this research will enquiring more in a general direction instead of a specific area.

### 3.1 Research question 1

**Are South African mining techniques optimised for competing in global market?**

The purpose of this question is to explore miner's determination of current mining production technique. This will be done utilising both qualitative and quantitative methods. The introduction and sections 2.2 and 2.4 have shown that South African mining production has declined in recent decades while other resource rich countries have increased production exponentially.

### 3.2 Research question 2

**What other factors affect South African mining production and how do these factors affect the industry?**

The purpose of this question is to explore which factors need to be explored and explained in order for South Africa to become a competitive participant in the resources market. This includes production technique, country specific and global factors. This will be done using qualitative and quantitative methods. The introduction and section 2.2 and 2.4 in the literature review indicate that other factors could possibly have an influence on mining production in South Africa.

## CHAPTER 4: METHODOLOGY AND RESEARCH DESIGN

### 4.1 Introduction

This chapter explains the methodology employed in the research design, structure, data collection and data analysis.

### 4.2 The Research Design

Zikmund, Babin, Carr and Griffin (2009) state that the role of business research is to explain business phenomena via the application of scientific methods. Zikmund et.al go on to further explain the difference between applied business research (generally firm specific) and basic business research often called pure research (not firm specific, generally expanding on existing knowledge).

Regardless of the reason for the business research, both paths follow the same scientific method, which involves testing hypotheses derived from previous knowledge and observations. The knowledge gleaned from this research allows efficient management decisions to be implemented.

Taking the reason for business research into consideration, and the reason for this research as stated in Chapter 1, an exploratory approach to the research design was used. Saunders and Lewis (2012) state that exploratory studies are used when the researcher does not clearly understand a topic (or does not have sufficient knowledge of the topic). This type of study allows for tentative answers which will need more detailed research in the future. These statements are echoed by Zikmund et al. (2009) who concur that exploratory research is not intended to provide conclusive evidence. Exploratory research is often used to guide and refine subsequent more detailed studies in order to clarify ambiguous situations.

This research approach is relevant as there is a great amount of information from many sources surrounding the South African mining industry and the impact it has on the country, which is acknowledged, whilst the citizens are bombarded with news of falling productivity, a declining sector, uncertainty brought about by

new regulations and a militant labour force. The researcher will attempt to provide clarification on whether these factors have had an impact on the sector.

As this study, was largely exploratory, a mixed methods design was decided upon. A comparatively new method of research, absolute definitions of what is mixed methods study have not been determined. Johnson, Onwuegbuzie and Turner (2007) define mixed methods research as an intellectual and practical synthesis based on qualitative and quantitative research methods. The authors further opine that mixed methods offer a divergent approach to generating questions and providing answers. Mixed method studies have often been the subject of purists' scorn due to the very nature of the duality of the structure. Johnson and Onwuegbuzie (2004) provide a framework of the differing branches of mixed methods research. Mixed model approach is the process of mixing qualitative and quantitative methods within or across the stages of the research process versus the mixed method approach which involves the inclusion of a qualitative and quantitative phase in an overall research study. Due to time constraints this study has been tailored to the mixed method approach.

Further reasoning for using a mixed methods study is provided by Ivankova, Creswell and Stick (2006) who claim that neither quantitative nor qualitative methods by themselves, are able to fully capture the trends and details of a situation. These two methods, far from being completely incompatible in fact complement each other and allow for a more detailed analysis when used in tandem.

Even though Johnson and Onwuegbuzie (2004) list many weaknesses of using mixed methods amongst them:

- It is difficult for a single researcher to carry out;
- Methodological purists contend that there is only a qualitative or quantitative method;
- It is more time consuming;
- Details of mixed methods are not fully established by research methodologists.

These negatives are easily overridden by the much longer list of strengths that mixed methods provide. These include:

- Ability to add insights and understanding that only using a single method would not have brought about ;
- Can be used to provide stronger evidence for a conclusion;
- Ability to answer a broader and more complete range of research questions;
- Words, pictures and narrative can be added to gain a richer context.

Johnson, Onwuegbuzie and Turner (2007) have determined that even though mixed methods do utilise both qualitative and quantitative methods it is possible to further classify mixed methods research into three very broad categories. These categories are labelled qualitative dominant, equal status and quantitative dominant, depending on the weighting each method is accorded. This research study will be quantitative dominant. This triangulation of methods helps to provide a much more robust analysis overcoming the weakness of a single paradigm method.

#### **4.3 Research Population, Sample, Size and Ethical consideration**

The research population or universe is defined as a complete group of entities that share some common set of characteristics (Zikmund et al., 2009). The universe for this study was limited to management level employees, involved in production in open cast mining across South Africa. This population was chosen due to their close and unique perspective of being miners in a rapidly changing environment.

Due to the unavailability of a sampling frame (list of elements from which a sample may be drawn, Zikmund et al., 2009) the participants were chosen using non probability sampling. Non probability sampling can be split into five categories, namely:

- Quota sampling
- Purposive sampling
- Snowball sampling

- Convenience sampling
- Self-selection sampling

Purposive sampling, which involves the researchers initial judgement in choosing the respondent and snowball sampling which involved the use of initial sample members identifying others, were used by the researcher. Due to the mixed methods approach taken by this study the sample size was determined by both quantitative and qualitative constraints. Saunders and Lewis (2012) indicate that a sample size of at least 30 will be needed to enable accurate statistical tests. For qualitative analysis Marshall (1996) determined that an appropriate sample size is one that adequately answers the question. These differing requirements ensured that the minimum sample size was determined by the quantitative needs.

Taking into consideration the recent turmoil in the mining sector in South Africa and issues like budget cutbacks and on-going retrenchments, participating in this research, was an ethical dilemma for the respondents. An ethical dilemma refers to a situation in which one chooses from different ethical courses of actions, each with a different ethical implication. This decision is often guided by an individual's moral standards or the social or cultural acceptability of behaviour (Zikmund et al., 2009) with the above in mind, participants were assured of the confidentiality of the responses as well as the inability of the researcher to link responses back to particular respondents.

#### **4.4 Data collection, justification of data collection tool and unit of analysis**

The method of data collection was determined by the initial conversation with the sample group. Even though Saunders and Lewis (2012) indicate that for exploratory studies the preferred method of data collection is via interviews, the population sample had indicated an unwillingness to engage via interviews, instead favouring a questionnaire method, due to time constraints an interview would place on them.



Hunston and Oakey (2010) introduce the questionnaire as an instrument that has long been seen as a useful method to research people's views on a wide range of topics from products and services to political opinion, but as stated by Saunders and Lewis (2012) a questionnaire is only useful if collect the correct data from a large enough sample who understand the questions.

Designing a questionnaire meant implementing a framework as suggested by Boynton and Greenlaugh (2004). Their framework revolved around the researcher asking themselves the following questions:

- What information are you trying to collect?
- Is a questionnaire appropriate?
- Could you use an existing instrument?
- Is the questionnaire valid and reliable?
- How should you present your questions?
- Apart from questions what else should you include?
- What should the questionnaire look like?
- What approvals do you need before your start?

Utilising the above framework, a draft questionnaire was designed with input from the supervisor. Due to the constraints placed upon the researcher by the population group, this draft questionnaire required extensive thought and preparation.

The questionnaire structure in terms of questions asked was decided by realising that specific types of questions provide specific types of answers. Therefore this questionnaire was drafted using the guidelines below from Saunders and Lewis, 2012:

- Open ended questions to be used when response are not certain , a more detailed answer is needed or finding out what the burning issues in the respondents mind
- List questions are used to ensure that the respondent considers all possibilities

- Category questions are used when the researcher needs to ensure that the respondents answer will only fit one category such as yes or no
- Rankings are used when you want the respondents to place a list in rank order
- Ratings are used when you want a respondents opinion on matter
- Quantity questions are used when the researcher requires a specific number
- Matrix questions are used when the response for more than one question are selected from the same set of answers.

Once the draft questionnaire, was deemed ready a pilot study was done using a small group of people from within and outside of the sample group. A pilot study is a small scale study that collects data from respondents similar to those to be used in the full study (Zikmund et al., 2009). The purpose of a pilot study is to allow any problems that arise to be rectified before the actual research is undertaken (Saunders and Lewis, 2012). The draft questionnaire had some problems with ambiguity and clarity that needed to be resolved, resulting in the need for some questions to be reviewed. This reworked questionnaire (Appendix A), including an introductory note, consent statement and the assurance of anonymity (Appendix B), was then circulated amongst the targeted population till the required number of samples were obtained.

The questionnaire was designed in three very distinct stages. The first stage contained questions of a purely quantitative nature that would be required to provide a profile of the respondent. The requested information at this stage included questions on the number of years' experience in the industry, the proportion of time spent in the industry against the working life, the level of education of the respondent, and he level of seniority within the organisation.

The second section consists of questions that attempted to determine the opinion of the respondent on current mining production techniques in South Africa. The requested information based on the literature review included questions on the efficiency of South African mining techniques, the efficiency of international mining techniques and the ability to implement new techniques in South Africa.

The section ended with a single open ended question, answered in a short phrase, to determine which link in the production chain required the most urgent attention

The third and final section consisted of questions that attempted to gather data on other factors that affected production besides technique. This section included questions on education of the workforce, cost cutting and ended with a single open ended question , answered in short phrase to determine which country specific factors have the biggest impact on mining production .

The units of analysis were the experiences and perceptions provided by miners, currently employed within the industry. These units were analysed in determination of current production techniques, which areas in the current production technique need the most urgent attention (if any), and if there are any other factors affecting productivity

#### **4.5 Data Analysis**

Due to the mixed methods nature of the study, with a quantitative bias the data analysis followed suit, and allocated more resources towards the analysis of the quantitative data.

Saunders and Lewis (2012) prescribed the following steps for the analysis of data quantitatively, when using analysis software:

- Give each variable a name
- Work out a coding scheme for each variable
- Code each variable
- Set up a data matrix
- Enter your data into the analysis software

These steps allowed for the results of each random variable to be displayed. A random variable is any attribute of interest on which data is collected and analysed (Wegner, 2014)

These random variables can be classified into different types of data, which can be separated into two distinct categories, qualitative and quantitative. Qualitative data has further sub categories of nominal data which is categorically scaled with equal importance and ordinal data which is scaled but with an implied ranking. These are the weakest forms of data as the statistical tests that can be applied are very limited to descriptive statistics. Quantitative data on the other hand, provides a much stronger data set, thus allowing for more complex statistical tests to be performed. Quantitative data has sub categories of interval data which is normally associated with rating scales and ratio data which consists of real numbers and is normally regarded as the strongest data to perform statically tests with (Wegner, 2014).

Due to the structure of the data collection tool, the data provided was of almost exclusively qualitative data which limited the tests to descriptive statistics, specifically frequency tables and modal category. Even though the questionnaire contained some scale type question, further analysis of this was not possible due to non-profanity methods of sampling used. Wegner, 2014 states that purposive /judgement and snowball sampling, as used in this research, can only have valid statistical analysis via exploratory descriptive statistics.

Due to the inclusion of a scale type question a measure of validity was used to determine whether the instrument measures what it is supposed to measure, in order to determine reliability. It was decided to use the most widely used objective measure of reliability, Cronbach's alpha. While a score of 0.7 to 0.95 is seen as an acceptable value, lower alpha scores do not necessarily mean the instrument is not valid but rather poor correlation between items, or the test was of a low quality or length (Takavol, 2011).

The data analysis up to this point has described much of the quantitative analysis in great detail due to the quantitative dominate nature of the data collection tool.

Daft (1983) states that qualitative research is more concerned with the meaning rather than the measurement of phenomena. In order to provide meaning to the qualitative grouping the following procedure was followed. Due to the short

nature of the qualitative questions and the phrases rather than sentences that were received these phrases were analysed in much less detail than a rich full context interview might have been.

Using a method suggested by Miles, Huberman and Saldana (2014) the following steps were utilised in extracting information from the qualitative data. The text was scanned for recurring themes or patterns that seemed to jump out at the researcher. These themes or data were then clustered into groups that contained similar themes. These themes were then used to provide more detail to the statistical analysis.

Saunders and Lewis (2012) reinforce the above method with a slightly different framework. From the literature review, meaningful groupings or coding were developed and the responses were grouped into these categories depending on relevancy.

Using a deductive approach, which is testing a theory with the data, gathered the category grouping was decided upon. A deductive approach was used due to the literature providing the existing categories. Once the categories were decided upon the units of data were placed in category deemed most appropriate to what works. A unit of data is a predetermined piece of data such as line of a transcript, sentence of paragraph or response. (Saunders and Lewis, 2012)

Due to the very brief and terse nature of these units the data was grouped manually using an Excel spread sheet and the researcher's judgement of the categories was gleaned from the literature.

#### **4.6 Research limitations**

While exploratory research provides insights into a particular scenario, the insights are only as good as the researcher and this researcher acknowledges his complete inexperience and very basic knowledge of the art of research.

Time constraints meant the response rate for the online questionnaire was not high. This was due to the time needed to answer the respondents' individual queries regarding the confidentiality and discretion of the questionnaire. This was largely due to the fear of being seen as critical of an employer, during a period of pay cuts and retrenchments within the sector.

The questionnaire itself, in retrospect, was not as seamlessly designed as it could have been. Data analysis and conclusions could have been much more detailed, if the questionnaire was designed by an expert in the field of questionnaire design. This became clear during the data collection and analysis stages when the disadvantages of almost exclusively categorical type data and brief snippets of qualitative data became very apparent.

#### **4.7 Conclusion**

This chapter explains the methodology used the definition of the unit of analysis, the population, the sample size and sampling method, the research instrument, data collection and data analysis.

## CHAPTER 5: PRESENTATION AND ANALYSIS OF RESULTS

Chapter 2 presented the literature used to support the research; chapter 3 introduced the research questions and chapter 4 presented the method used to conduct this research. Chapter 5 provides a view and discussion of the results of the research. This chapter presents the results obtained by the data collection tool, which was an online questionnaire, as well as the reasoning behind the questions. The usage of the Typeform online platform to collect data was preferred to the likes of Survey Monkey and other established platforms as the newer format allowed for data to be collected and analysed in a much more efficient manner. The results are presented as numbered in the questionnaire.

### 5.1 Question 1: Mining industry tenure

**How many years have you been employed within the mining industry?**

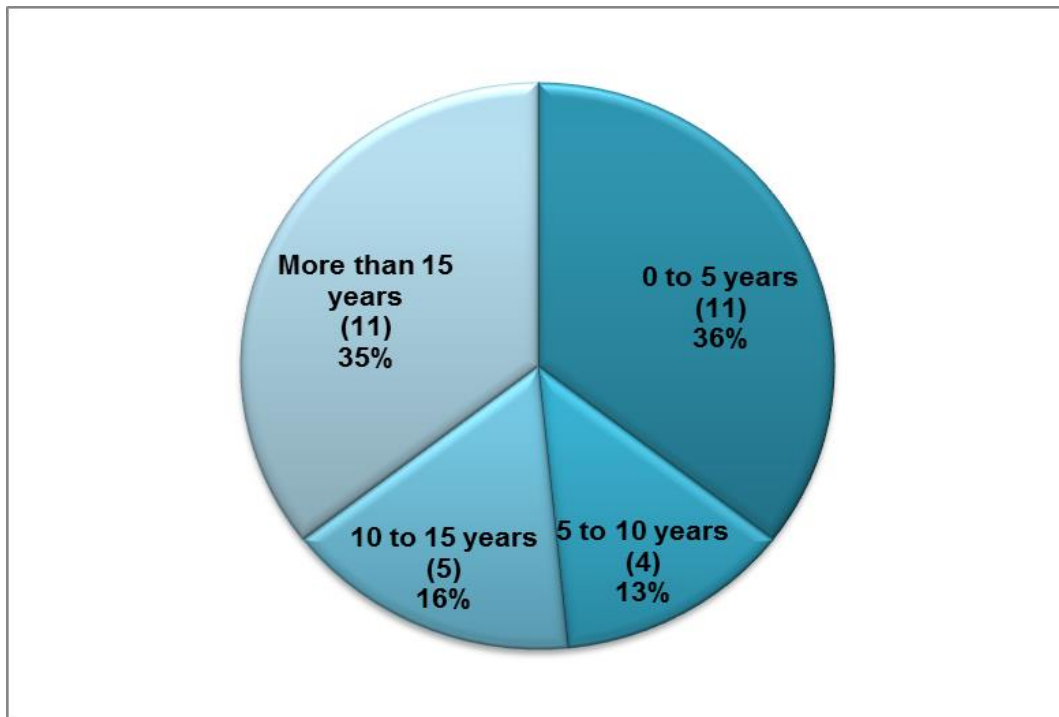
**Table 3: Mining industry tenure**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
<b>0 to 5 years</b>	11	35.5	35.5	35.5
<b>5 to 10 years</b>	4	12.9	12.9	100.0
<b>10 to 15 years</b>	5	16.1	16.1	51.6
<b>More than 15 years</b>	11	35.5	35.5	87.1
<b>Total</b>	31	100.0	100.0	

The first question was a multiple choice question that presented the participants with options indicating mining industry tenure. The purpose of this question was to assist in creating a profile of the sample of respondents. The creation of the profile of the sample of respondents aids in the analysis and discussion of the results. It provides a picture to draw conclusions from. As can be seen through Table 3 and Figure 4, this question generated a 100% response rate, meaning that all 31 of the participants responded to this question. The analysis shows that the majority of the respondents have either been working in the mining industry

for less than 5 years (36%) or they have been working in the mining industry for more than 15 years (35%). The mode occurred in the categories 0-5 years and 15+ years. From the sample of 31, 11 had 0-5 years' experience and a further 11 had 15+ years of experience.

**Figure 4: Mining industry tenure**



## 5.2 Question 2: Mining related qualification

Do you have a mining related qualification? If more than one, please choose the highest ranked option.

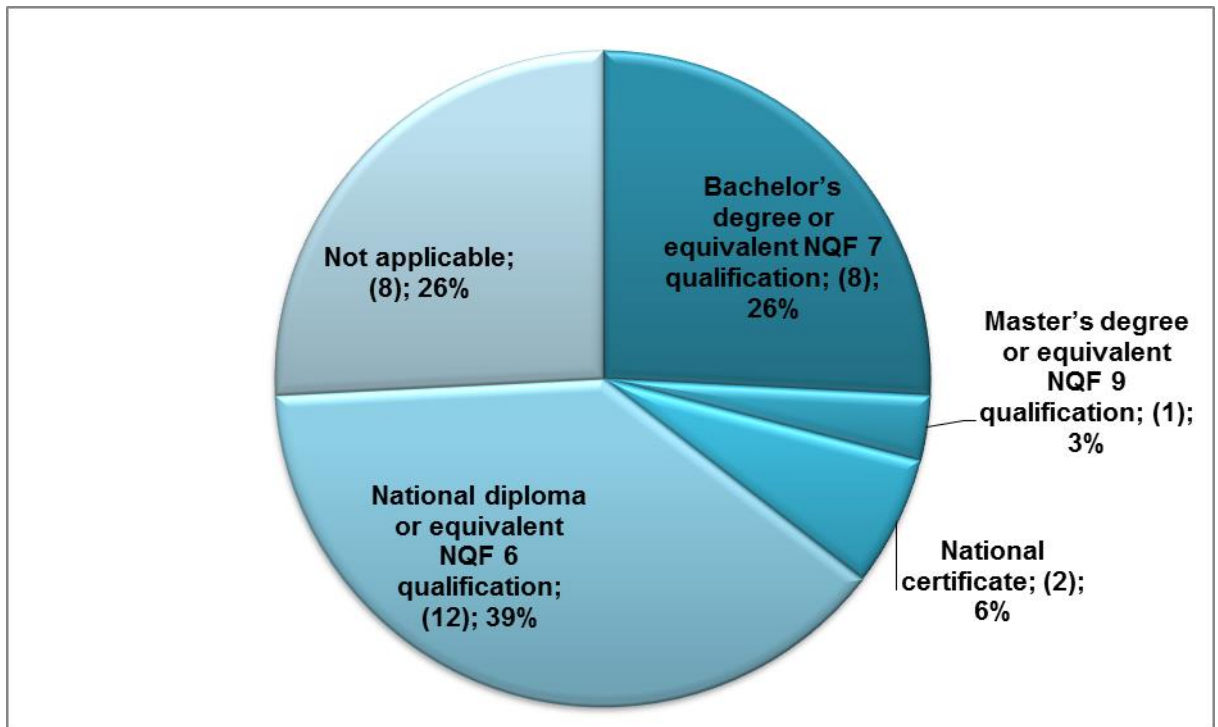
**Table 4: Mining related qualification**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Bachelor's degree or equivalent NQF 7 qualification	8	25.8	25.8	25.8
Master's degree or equivalent NQF 9 qualification	1	3.2	3.2	29.0



<b>National certificate</b>	2	6.5	6.5	35.5
<b>National diploma or equivalent NQF 6 qualification</b>	12	38.7	38.7	74.2
<b>Not applicable</b>	8	25.8	25.8	100.0
<b>Total</b>	31	100.0	100.0	

**Figure 5: Mining related qualification**



This multiple choice question is also part of the profile of the respondents. As can be seen in Table 4, this question also had 100% response rate. The mode occurred in the category national diploma or equivalent NQF 6 qualification with 12 (39%) occurrences in that category, followed by 8 (26%) with a bachelor's degree, 2 (6%) with a national certificate and 1 (35) with a master's degree. None of the respondents utilised the option of only having a specialist certificate, while 8 (26%) indicated that they did not have a mining related qualification.

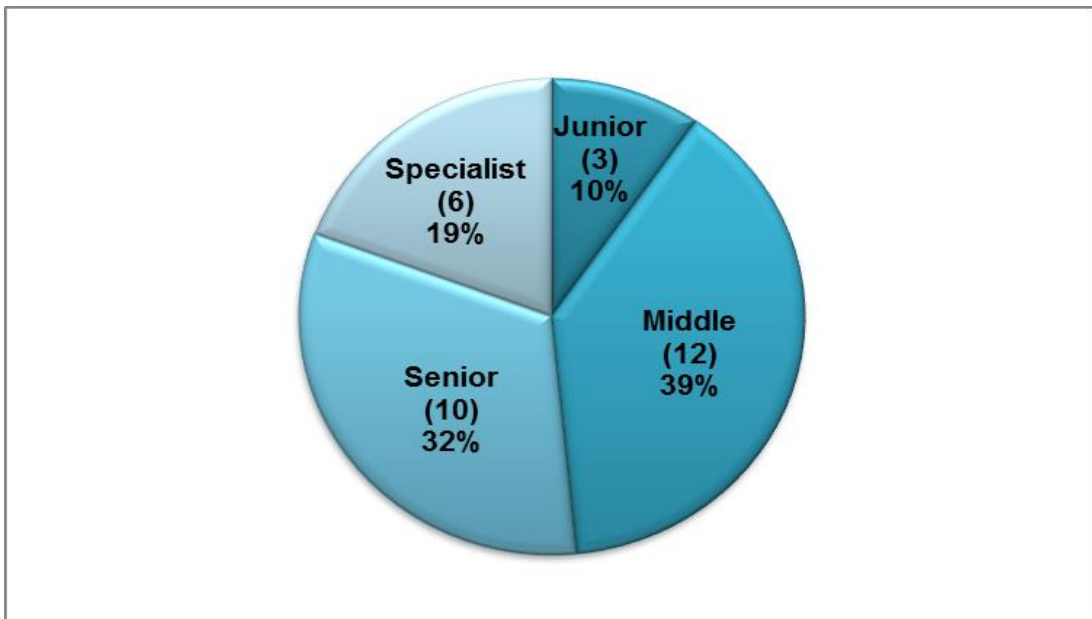
### 5.3 Question 3: Company hierarchy

What rank do you currently occupy within the organisational structure?

**Table 5: Company hierarchy**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Junior	3	9.7	9.7	9.7
Middle	12	38.7	38.7	48.4
Senior	10	32.3	32.3	80.6
Specialist	6	19.4	19.4	100.0
Total	31	100.0	100.0	

**Figure 6: Company hierarchy**



This multiple choice question is also part of the profile of the respondents. The question had a 100% response rate. The mode occurred in the category of middle ranking with 12 (39%) occurrences in that category, followed by 10 (32%) senior respondents, 6 (19%) specialist and 3 (10%) junior respondents.

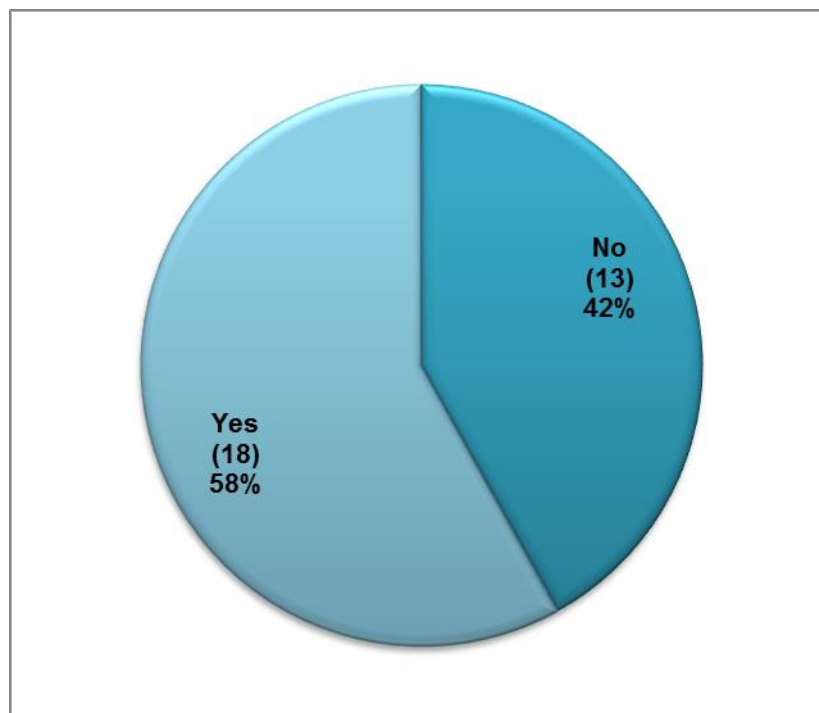
#### 5.4 Question 4: Majority career lifespan

Would you describe your tenure within the mining industry as having been the majority of your career life span?

Table 6: Majority career life span

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
No	13	41.9	41.9	41.9
Yes	18	58.1	58.1	100.0
Total	31	100.0	100.0	

Figure 7: Majority career life span



This yes/no question is part of the profile of the respondents. The question also had a 100% response rate. The most (58%) of the respondents answered that the majority of their careers have been spent in the mining industry, while 42%

of the respondents answered that the majority of their careers have been spent in other industries.

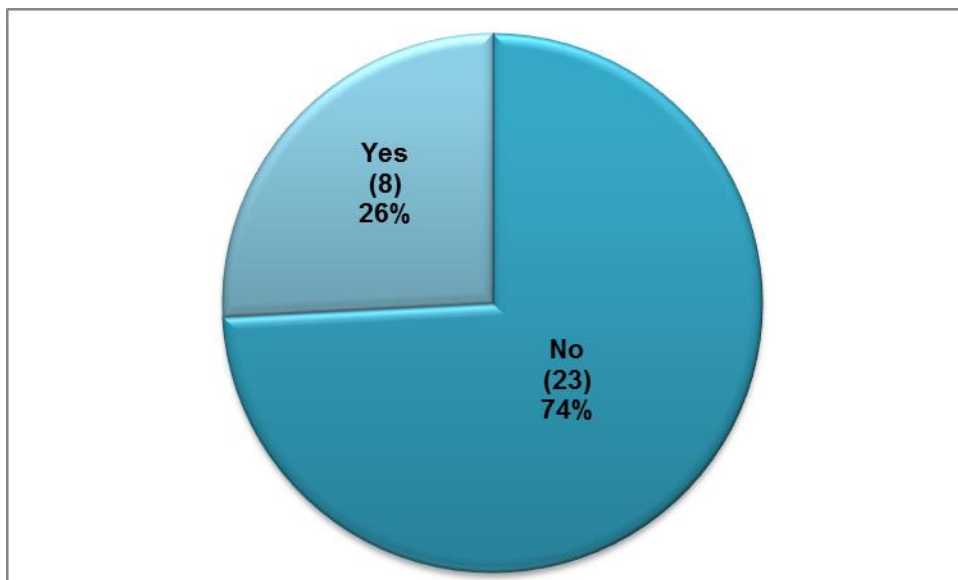
### 5.5 Question 5: Major breakthrough in production efficiency employment

**Were you employed in the industry when a major breakthrough in production efficiency occurred?**

**Table 7: Major breakthrough in production efficiency employment**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
<b>No</b>	23	74.2	74.2	74.2
<b>Yes</b>	8	25.8	25.8	100.0
<b>Total</b>	31	100.0	100.0	

**Figure 8: Major breakthrough in production efficiency employment**



This yes/no question attempted to determine whether participants had been employed in the industry during a period when a breakthrough in production efficiency occurred. This question had 100% response rate. The majority of respondents (74%) answered that they were not employed in the mining industry

when a major breakthrough in production efficiency occurred and the remaining 26% answered that they were employed in the mining industry when a major breakthrough in production efficiency occurred.

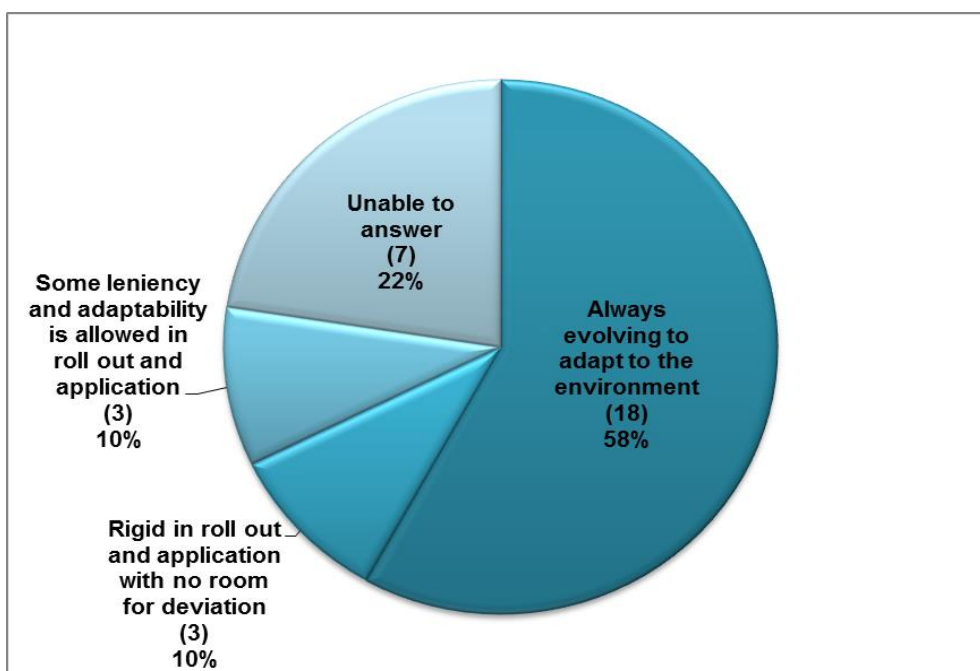
### 5.6 Question 6: Opinion of the production process

During your career in the mining industry what has been your opinion of the production process?

**Table 8: Opinion of the production process**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Always evolving to adapt to the environment	18	58.1	58.1	58.1
Rigid in roll out and application with no room for deviation	3	9.7	9.7	67.7
Some leniency and adaptability is allowed in roll out and application	3	9.7	9.7	77.4
Unable to answer	7	22.6	22.6	100.0
<b>Total</b>	<b>31</b>	<b>100.0</b>	<b>100.0</b>	

**Figure 9: Opinion of the production process**



This question attempted to determine participants' opinion of the production process of mining in South Africa. The question received a 100% response rate. The majority (58%) of respondents answered that the mining industry is always evolving to adapt to the environment. The mode occurred in the category of always willing to adapt to the environment with 18 responses and the next largest respondent group was unable to answer with 7 responses followed by 3 each in the remaining two categories.

### 5.7 Question 7: Opinion on efficiency of South African mining techniques

**In your opinion, how efficient would you rank the current mining production techniques used in South Africa?**

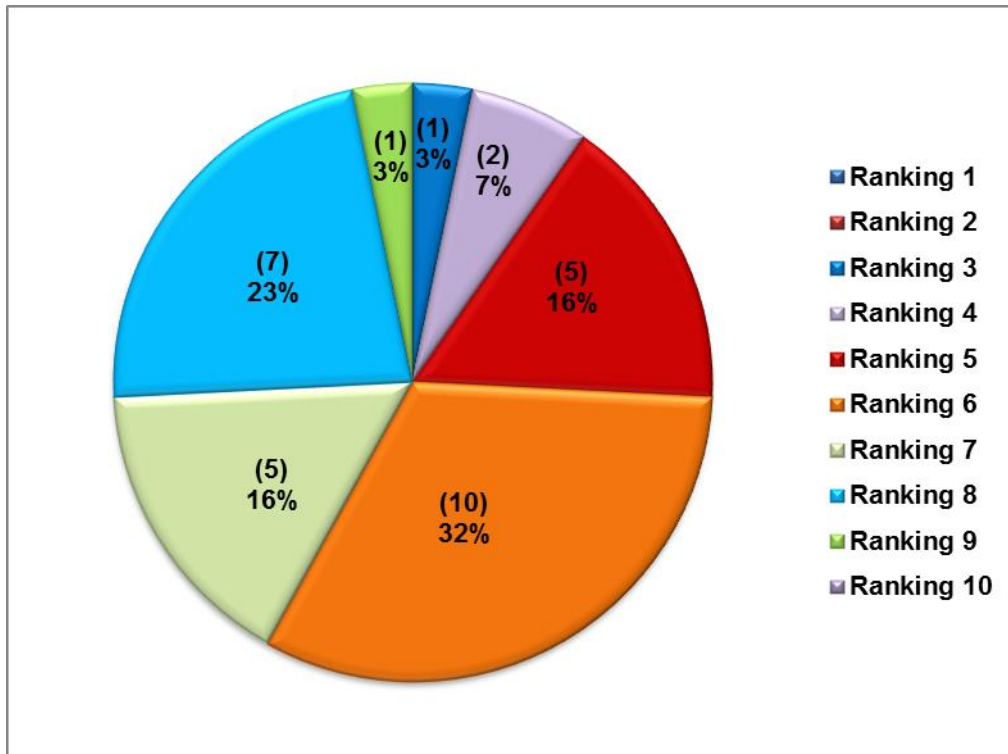
**Table 9: Opinion on efficiency of South African mining techniques**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Ranking 1	0	0	0	0
Ranking 2	0	0	0	0
Ranking 3	1	3.2	3.2	3.2
Ranking 4	2	6.5	6.5	9.7
Ranking 5	5	16.1	16.1	25.8
Ranking 6	10	32.3	32.3	58.1
Ranking 7	5	16.1	16.1	74.2
Ranking 8	7	22.6	22.6	96.8
Ranking 9	1	3.2	3.2	100.0
Ranking 10	0	0	0	0
<b>Total</b>	<b>31</b>	<b>100.0</b>	<b>100.0</b>	

This question attempted to determine the participants' opinion of the mining production technique in South Africa using a ranking scale numbered 1-10 , with 1 being the lowest point and 10 the highest point . The question received a 100%

response rate and the mode is at 6 with the highest ranking being 9 and lowest being 3 thus indicating a range of 6.

**Figure 10: Opinion on efficiency of South African mining techniques**



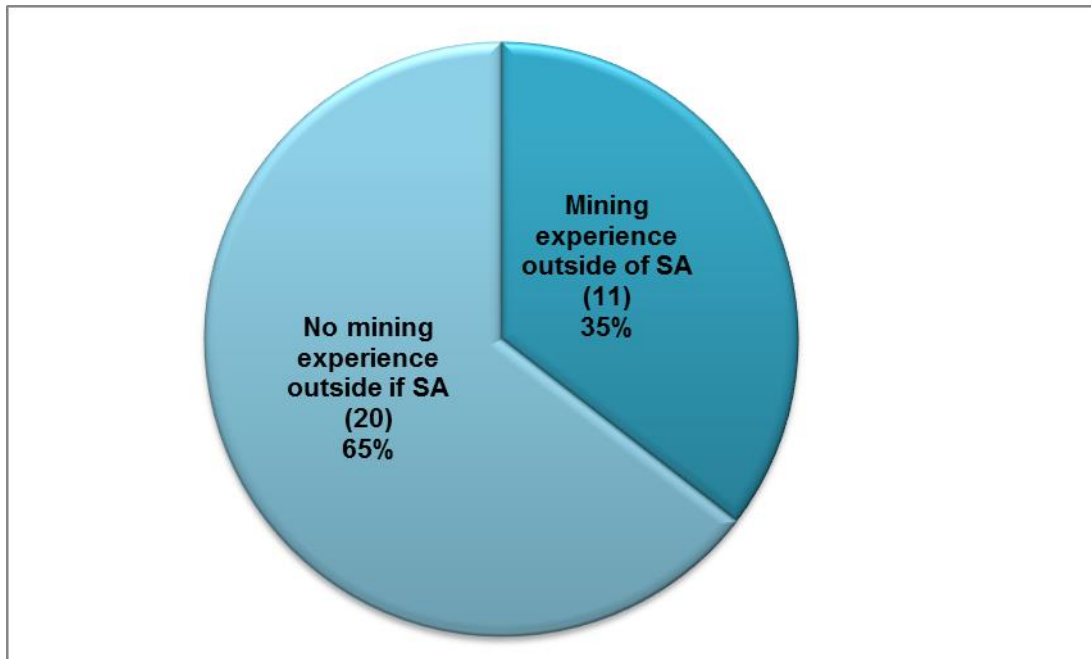
**5.8 Question 8: Opinion of efficiency of South African mining techniques compared to international mining techniques**

**If you have mining experience outside of South Africa, how efficient would you rank international mining production techniques, using the same opinion base as the last question?**

**Table 10: Opinion of efficiency of South African mining techniques compared to international mining techniques.**

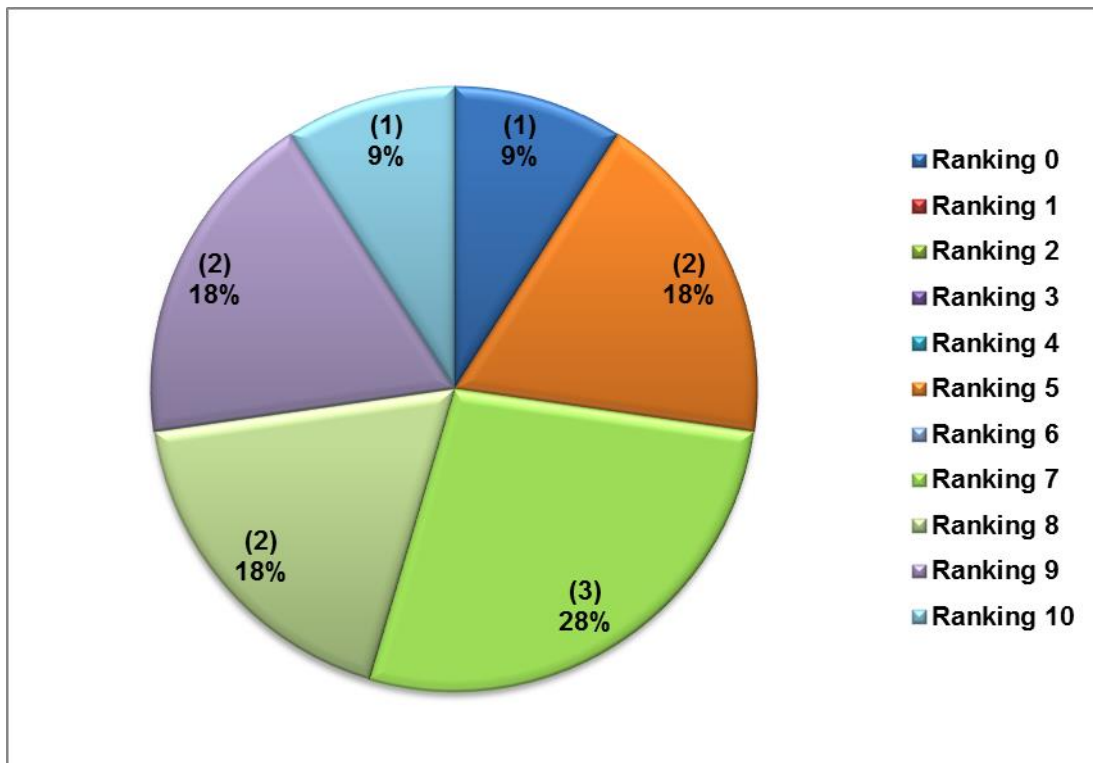
	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Ranking 0	1	3.2	9.1	9.1
Ranking 1	0	0	0	0
Ranking 2	0	0	0	0
Ranking 3	0	0	0	0
Ranking 4	0	0	0	0
Ranking 5	2	6.5	18.2	27.3
Ranking 6	0	0	0	0
Ranking 7	3	9.7	27.3	54.5
Ranking 8	2	6.5	18.2	72.7
Ranking 9	2	6.5	18.2	90.9
Ranking 10	1	3.2	9.1	100.0
No mining experience outside SA	20	64.5		
<b>Total</b>	<b>31</b>	<b>100.0</b>		

**Figure 11: Distribution of mining experience outside SA vs. no mining experience outside of SA**





**Figure 12: Opinion of efficiency of South African mining techniques compared to international mining techniques.**



This question attempted to determine participant’s opinion on mining techniques outside of South Africa. Participants were only asked to answer if they had the relevant experience. Due to this qualifier, this question received 11 responses from 31 participants, thus only 35% of the respondents have mining industry experience internationally and would have been able to rank international production techniques. The mode is at 7 with the lowest ranking being 0 and the highest ranking being 10. The 0 ranking is an outlier on the scale as there is only one occurrence, with the next scale level being at 5.

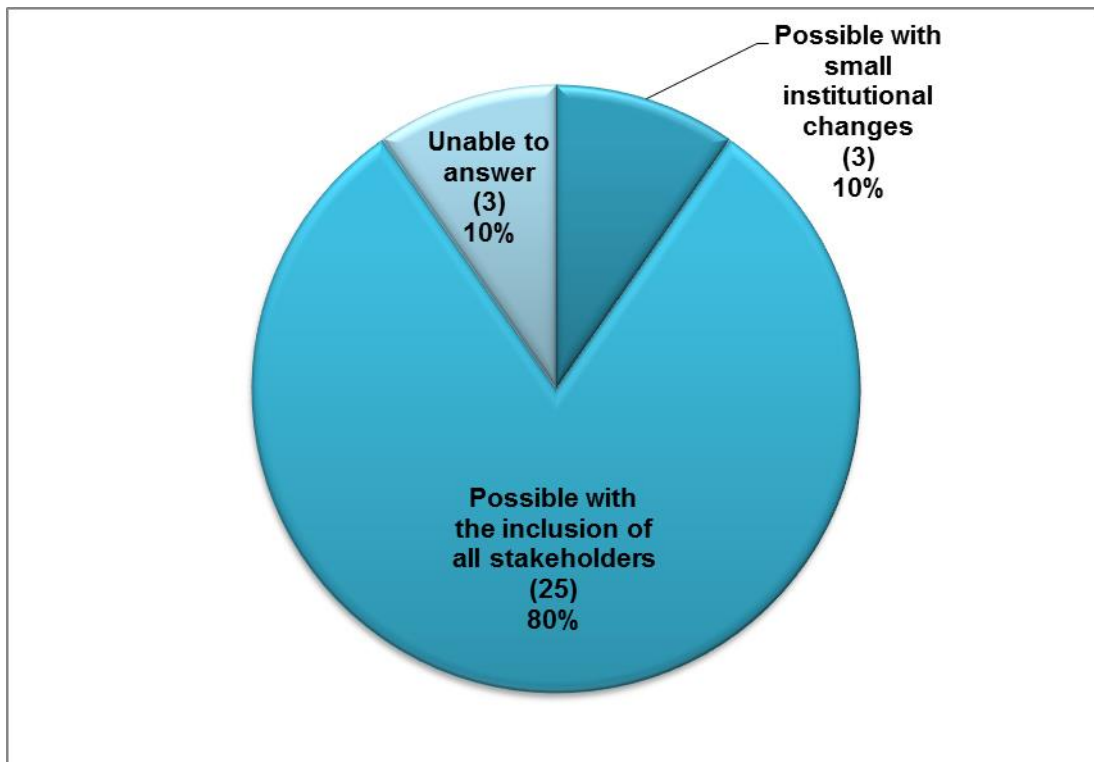
### 5.9 Question 9: Selection and implementation of efficient foreign production practices

In your opinion, to what extent, given the uniqueness of South Africa's environment, would it be possible to selectively pick and implement proven efficient foreign production practices?

**Table 11: Selection and implementation of efficient foreign production practices**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Possible with small institutional changes	3	9.7	9.7	9.7
Possible with the inclusion of all stakeholders	25	80.6	80.6	90.3
Unable to answer	3	9.7	9.7	100.0
<b>Total</b>	<b>31</b>	<b>100.0</b>	<b>100.0</b>	

**Figure 13: Selection and implementation of efficient foreign production practices**



This question attempted to determine participants' opinion on implementing proven international practises in South Africa. The question a 100% response rate. The mode occurred in the category of possible with the inclusion of all stakeholders, with 25 (80%) occurrences in that category, with the remaining two categories receiving 3 responses each. None of the respondents utilised the option of impossible.

#### 5.10 Question 10: Opinion on improved efficiency in production cycle areas

**Which area(s) within the production cycle would you identify as needing urgent changes to enable improved efficiency?**

**Table 12: Opinion on improved efficiency in production cycle areas (qualitative answers)**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
<b>Valid</b>	5	16.1	16.1	16.1
<b>Behaviour change (accountability)</b>	1	3.2	3.2	19.4
<b>Conditions of the mine employees</b>	1	3.2	3.2	22.6
<b>Educating and training heavy equipment operators</b>	1	3.2	3.2	25.8
<b>Education</b>	1	3.2	3.2	29.0
<b>Increased plant availability and utilisation</b>	1	3.2	3.2	32.3
<b>Labour, unions etc.</b>	1	3.2	3.2	35.5
<b>Lack of water resources</b>	1	3.2	3.2	38.7
<b>Main areas to be changed which would improve efficiency would be better techniques to be implemented and more control over labour such as monitoring production of staff etc.</b>	1	3.2	3.2	41.9



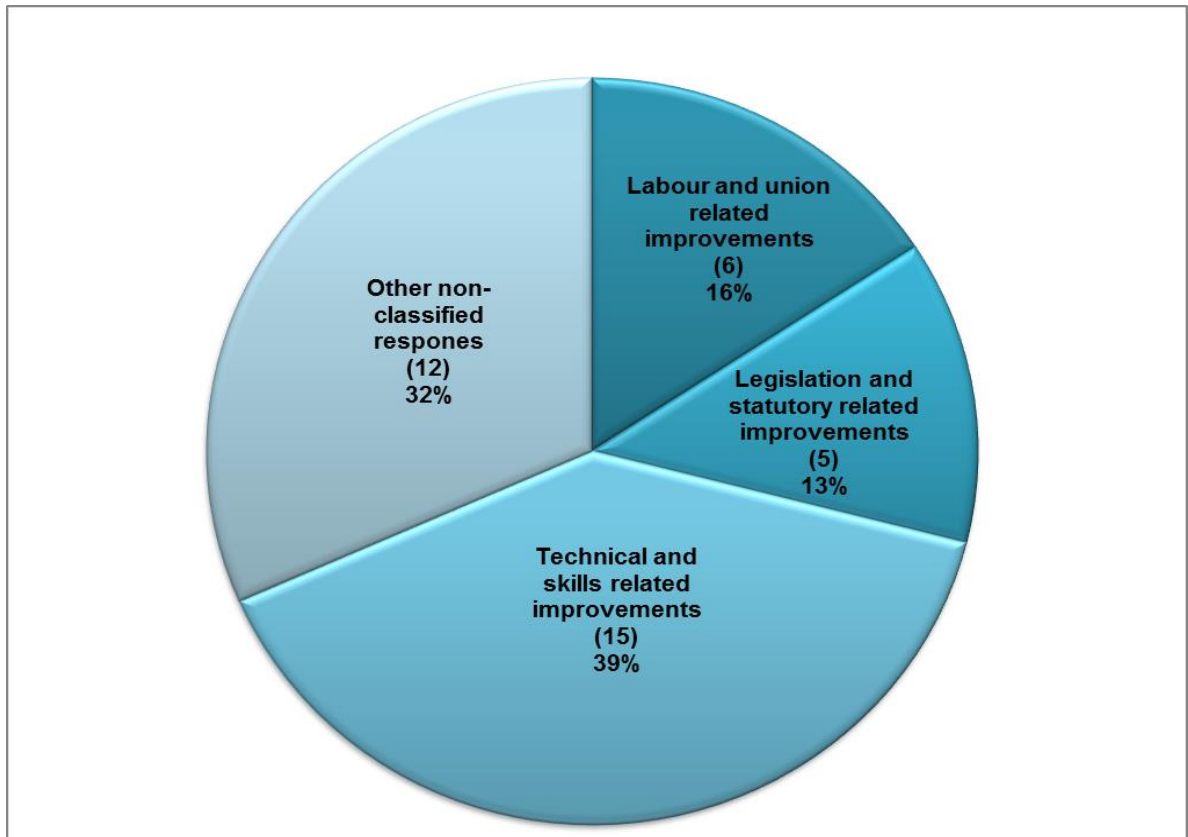
<b>Marketing to ensure products being developed is what the client really needs and that it will add value to the organization itself.</b>	1	3.2	3.2	45.2
<b>mechanize and training for it</b>	1	3.2	3.2	48.4
<b>Mining Charter</b>	1	3.2	3.2	51.6
<b>Mining development &amp; feasibility</b>	1	3.2	3.2	54.8
<b>Mining Legislation</b>	1	3.2	3.2	58.1
<b>Mining legislation (To be improved)</b>	1	3.2	3.2	61.3
<b>More practical approach to minor non-conformance issues by mine owners and DMR.</b>	1	3.2	3.2	64.5
<b>Operate for reliability</b>	1	3.2	3.2	67.7
<b>Operating equipment with reliability in mind</b>	1	3.2	3.2	71.0
<b>Operator behaviour</b>	1	3.2	3.2	74.2
<b>Operator training, in terms of technical training and then ownership of equipment from the operators point of view.</b>	1	3.2	3.2	77.4
<b>Safety</b>	1	3.2	3.2	80.6
<b>Skills</b>	1	3.2	3.2	83.9
<b>Structural</b>	1	3.2	3.2	87.1
<b>Technology and labour. More technology to be used for safety reasons. Labour demands need to be looked at</b>	1	3.2	3.2	90.3
<b>Training of junior to middle management staff &amp; teamwork</b>	1	3.2	3.2	93.5
<b>Training, mechanisation</b>	1	3.2	3.2	96.8
<b>Utilization vs. Availability of equipment</b>	1	3.2	3.2	100.0
<b>Total</b>	31	100.0	100.0	

This question, which was qualitative in nature asked for respondents' opinion on which areas within the production cycle were most in need of change. The question received 26 responses form 31 participants and has been grouped according to the following categories:

**Table 13: Categorisation of responses regarding opinion on improved efficiency in production cycle areas**

Labour and union related responses	Legislation and statutory related	Technical and Skills Related	Other non-classified responses
Main areas to be changed which would improve efficiency would be better techniques to be implemented and more control over labour such as monitoring production of staff etc.	Structural	Operator behaviour.	Marketing to ensure products being developed is what the client really needs and that it will add value to the organization itself.
Conditions of the mine employees	Mining legislation (To be improved)	Skills	Lack of water resources
Training of junior to middle management staff & Teamwork	Mining Legislation	mechanize and training for it	
Behavior change (accountability)	More practical approach to minor non-conformance issues by mine owners and DMR.	Main areas to be changed which would improve efficiency would be better techniques to be implemented and more control over labour such as monitoring production of staff etc.	
Labour, unions etc.	Mining Charter	Technology and labour. More technology to be used for safety reasons. Labour demands need to be looked at.	
Technology and labour. More technology to be used for safety reasons. Labour demands need to be looked at.		Mining development & feasibility	
		Operator training, in term sof techincial training and then ownership of equipment from the operators point of view.	
		Education	
		Training,mechanisation	
		Operate for reliability	
		Operating equipment with reliability in mind.	
		Educating and training heavy equipment operators	
		Utilization vs Availability of equipment	
		Safety	
		Increased plant availability and utilisation	

**Figure 14: Opinion on improved efficiency in production cycle areas  
(based on categorisation)**



Most respondents (39%) suggested that improvements can be made in the technical and skills fields where education, training and the changing of behaviour were specifically mentioned.

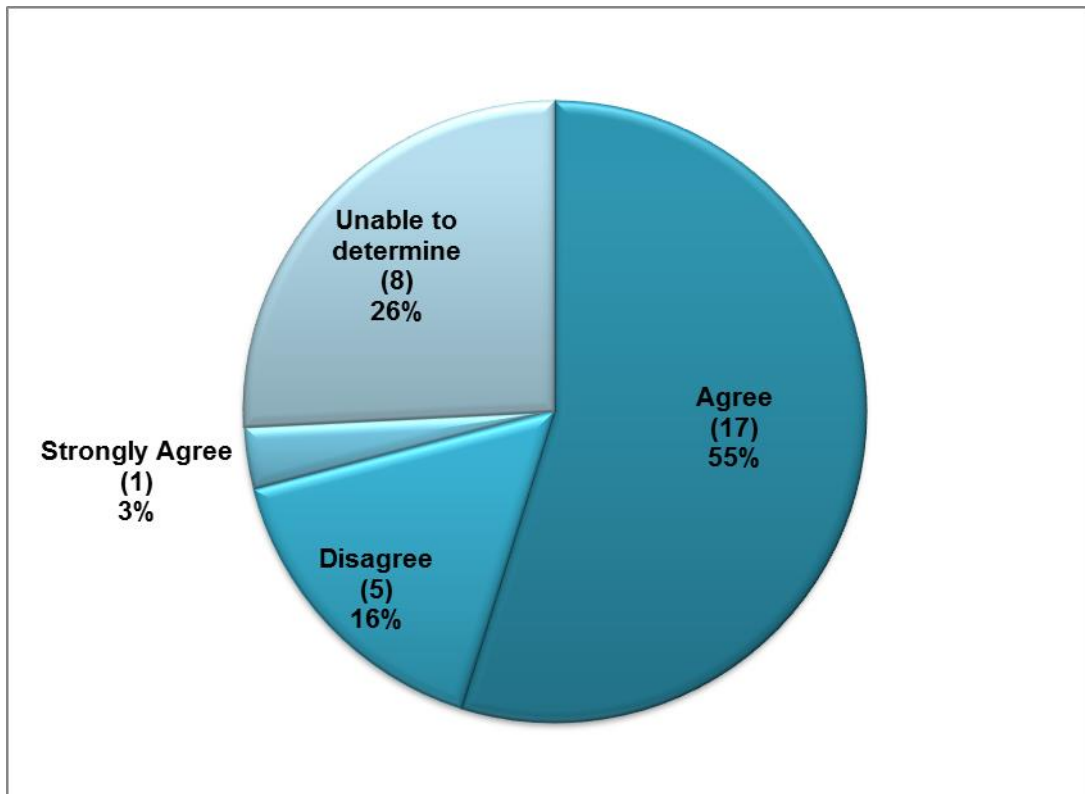
#### **5.11 Question 11: Education on advancements in production technology**

**In your opinion, are mining companies in South Africa educating the workforce on advancements in production technology, no matter how mundane it appears?**

**Table 14: Education on advancements in production technology**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Agree	17	54.8	54.8	54.8
Disagree	5	16.1	16.1	71.0
Strongly Agree	1	3.2	3.2	74.2
Unable to determine	8	25.8	25.8	100.0
Total	31	100.0	100.0	

**Figure 15: Education on advancements in production technology**



Question 11 was a scale type question with the respondents given the option to choose between options of either strongly agree, agree, unable to determine, disagree or strongly disagree. The question was an effort to determine respondents' opinion on education of advancements in production technology in the workplace. The question received a 100% response rate. The mode occurred at the category of agree with 17 (55%) occurrences, followed by 8 (26%)

respondents unable to determine, 5 (16%) disagreeing and 1 (3%) strongly agreeing. None of the respondents made use of the option to strongly disagree.

### 5.12 Question 12: Opinion on mining companies' ability to adapt quickly to changes in the market place

**In your opinion, have South African mining companies shown the ability to quickly adapt to changes in the market place?**

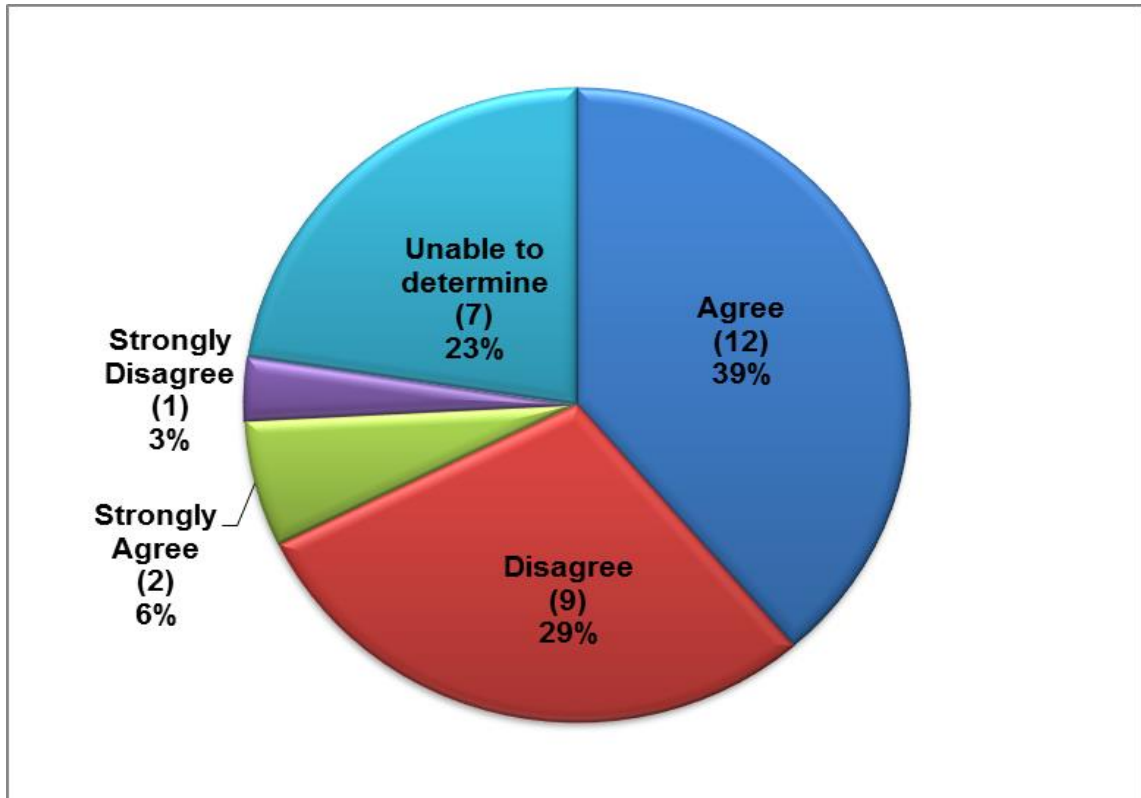
**Table 15: Opinion on mining companies' ability to adapt quickly to changes in the market place**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
<b>Agree</b>	12	38.7	38.7	38.7
<b>Disagree</b>	9	29.0	29.0	67.7
<b>Strongly Agree</b>	2	6.5	6.5	74.2
<b>Strongly Disagree</b>	1	3.2	3.2	77.4
<b>Unable to determine</b>	7	22.6	22.6	100.0
<b>Total</b>	31	100.0	100.0	

Question 12 was a scale type question with the respondents given the option to choose options of either strongly agree, agree, unable to determine, disagree or strongly disagree. The question was an attempt to determine respondents' opinions on the agility of South African mining company's .The question received a 100% response rate. The mode occurs at the category of agree with 12 (39%) occurrences, followed by disagree with 9 (29%), unable to determine with 7 (23%) respondents, strongly agree with 2(6%) respondents and 1(3%) respondent strongly disagreed.



**Figure 16: Opinion on mining companies' ability to adapt quickly to changes in the market place**



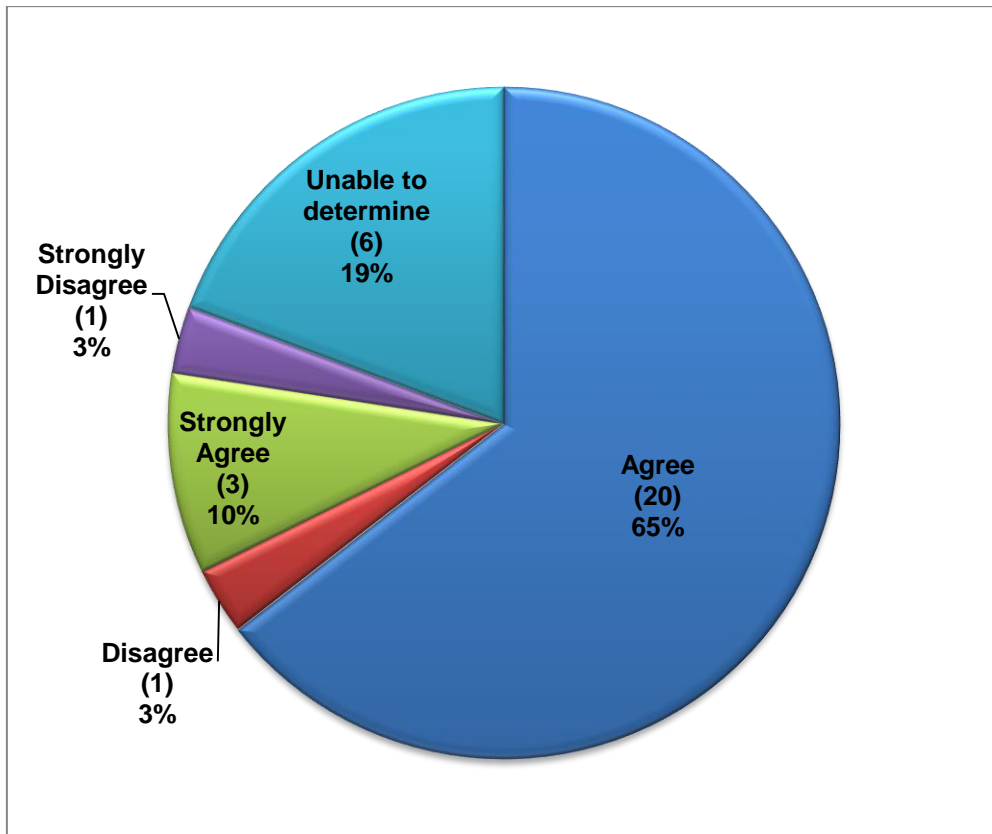
**5.13 Question 13: Opinion on cost cutting as opposed to innovating for production improvements as an efficiency and profitability measure**

In your opinion , have South African mining companies become too accustomed to adopting a mind-set of solely adapting cost cutting as opposed to innovating for production improvements, as an efficiency and profitability measure ?

**Table 16: Opinion on cost cutting opposed to innovating for production improvements as an efficiency and profitability measure**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
Agree	20	64.5	64.5	64.5
Disagree	1	3.2	3.2	67.7
Strongly Agree	3	9.7	9.7	77.4
Strongly Disagree	1	3.2	3.2	80.6
Unable to determine	6	19.4	19.4	100.0
Total	31	100.0	100.0	

**Figure 17: Opinion on cost cutting opposed to innovating for production improvements as an efficiency and profitability measure**



Question 13 was a scale type question with the respondents given the option to choose an option of either strongly agree, agree, unable to determine, disagree

or strongly disagree. The question was an attempt to gauge respondents' opinions on South African mining companies' methods of improving profitability via cost cutting and not innovating. The question received a 100% response rate from participants with the mode occurring at the category of agree with 20 (65%) occurrences, followed by unable to determine with 6(19%) responses, 3(3%) strongly agreed , while disagree and strongly disagree received 1(3%) response each.

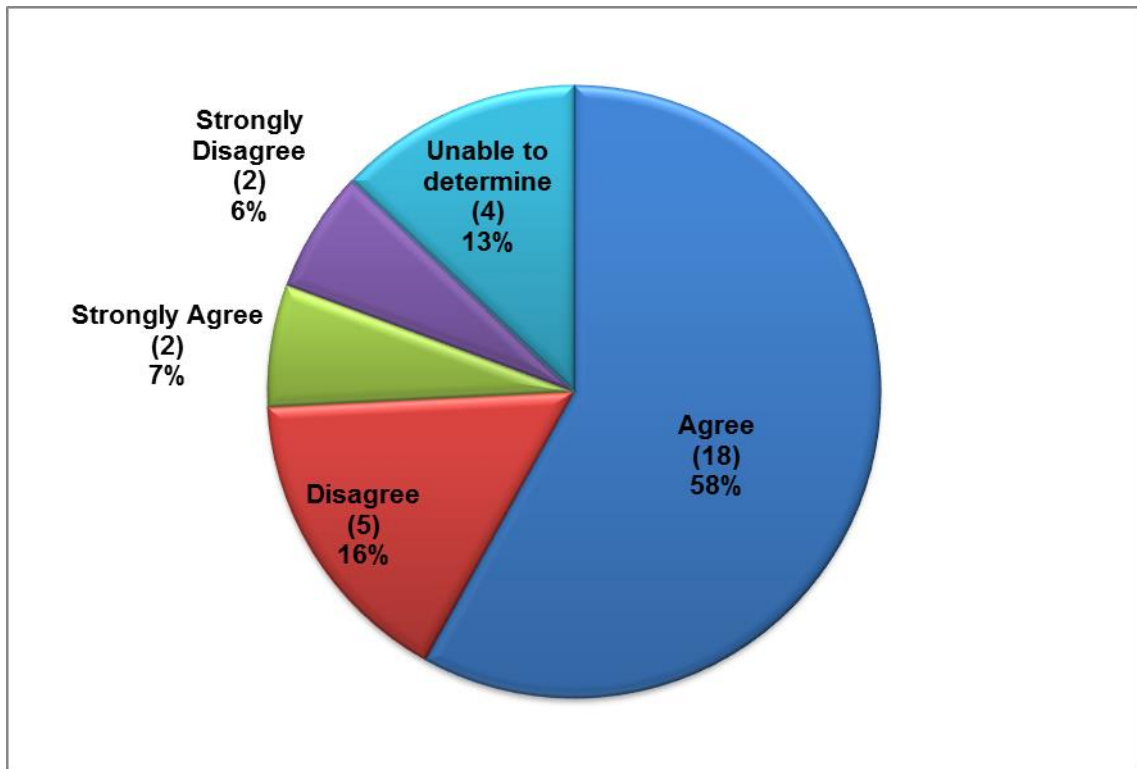
#### 5.14 Question 14: Opinion on improvements in production significant impact on South Africa's mineral output

**In your opinion, would improvements solely in production efficiency have a significant impact in South Africa's mineral output?**

**Table 17: Opinion on improvements in production significant impact on South Africa's mineral output**

	Frequency	Percentage	Valid Percentage	Cumulative Percentage
<b>Agree</b>	18	58.1	58.1	58.1
<b>Disagree</b>	5	16.1	16.1	74.2
<b>Strongly Agree</b>	2	6.5	6.5	80.6
<b>Strongly Disagree</b>	2	6.5	6.5	87.1
<b>Unable to determine</b>	4	12.9	12.9	100.0
<b>Total</b>	31	100.0	100.0	

**Figure 18: Opinion on improvements in production significant impact on South Africa's mineral output**



Question 14 was a scale type question with the respondents given the option to choose an option of either strongly agree, agree, unable to determine, disagree or strongly disagree. The question attempted to gauge respondents' opinions to whether improvements solely in production efficiency would have an impact in mineral output. The question received a 100% response rate with the mode occurring at the category of agree with 18 (58%) occurrences, followed by disagree with 5 (16%) occurrences, with strongly disagree and strongly agree receiving 2 (6%) response each and unable to determine receiving 4 (13%) responses.

**5.15 Question 15: Opinion on other non-production related factors have the largest impact on South Africa's mining production**

**In your opinion, what other non-production related factors have the largest impact on South Africa's mining production, and is stopping the country from becoming the dominant participant in the market?**

**Table 18: Opinion on improvements in production significant impact on South Africa's mineral output (qualitative answers)**

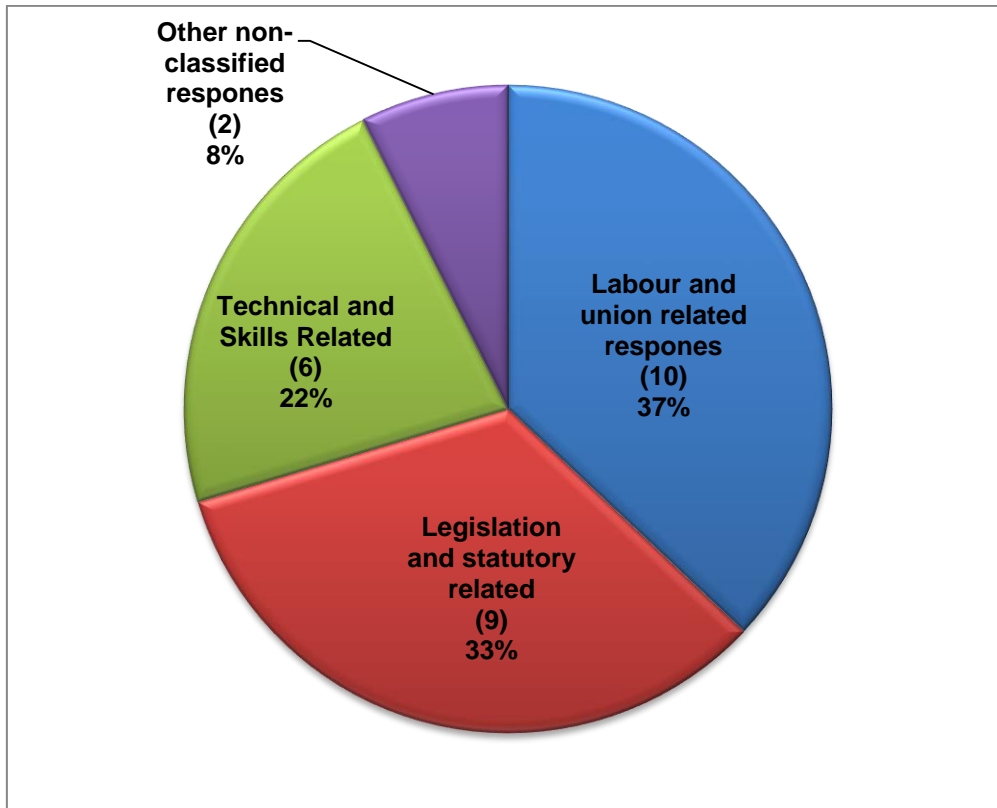
	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4	12.9	12.9	12.9
World economy slump, too much competition, retrenchments, power struggles	1	3.2	3.2	16.1
Bad attitudes from labour and unions.	1	3.2	3.2	19.4
Bureaucracy in terms of environmental legislation	1	3.2	3.2	22.6
Devide in unions, lack of ownership schemes to possibly drive performance and pride in quality and effeciency of work output	1	3.2	3.2	25.8
Education	2	6.5	6.5	32.3
Effective structures and more defined roles and responsibilities	1	3.2	3.2	35.5
Employees not wanting to change	1	3.2	3.2	38.7
Engineering practises. Marketing of products.	1	3.2	3.2	41.9
Governmental involvement, strength of the economy and exchange rates.	1	3.2	3.2	45.2
Labour costs	1	3.2	3.2	48.4
Labour demands by the unions. SA politics and greed.	1	3.2	3.2	51.6
Labour issues and constant strikes.	1	3.2	3.2	54.8
Labour relations, transformation.	1	3.2	3.2	58.1
Labour strikes and unsafe working environment ie there have been a number of collapses killing and trapping people.	1	3.2	3.2	61.3
Labour, corruption and white supremacy.	1	3.2	3.2	64.5
Mining Legislation and political interference	1	3.2	3.2	67.7
Mining legislation, labour relations and political interference	1	3.2	3.2	71.0
Political involvement	1	3.2	3.2	74.2
Politics in South Africa does sometimes have a negative influence to mining output. Community protests blockading mines access roads due to unhappiness with their political nominated councillors.	1	3.2	3.2	77.4
Regulatory, Governmental laws (uncertainty)	1	3.2	3.2	80.6
Safety measures are cumbersome	1	3.2	3.2	83.9
Stikes and workforce attitude	1	3.2	3.2	87.1
The engineering skills have diminished from previous years causing companies to seek specialists to assist. This does not allow the company room to improve on maintenance improving reliability and reducing costs on replacing equipment.	1	3.2	3.2	90.3
The issue of South African Politics	1	3.2	3.2	93.5
Unable to producer competent operators	1	3.2	3.2	96.8
World markets	1	3.2	3.2	100.0
<b>Total</b>	<b>31</b>	<b>100.0</b>	<b>100.0</b>	

This question, which was qualitative in nature asked for respondents opinion on which factors besides production techniques, have the biggest effect on productivity. The question received 27 responses form 31 participants and has been grouped according to the following categories:

**Table 19: Opinion on improvements in production significant impact on South Africa’s mineral output according to categories**

Labour and union related responses	Legislation and statutory related	Technical and Skills Related	Other non-classified responses
Stikes and workforce attitude	Governmental involvement, strength of the economy and exchange rates.	Education	World economy slump, too much competition, retrenchments, power struggles
Labour demands by the unions. SA politics and greed	Bureaucracy in terms of environmental legislation	Education	World markets
Labour relations, transformation	Politics in South Africa does sometimes have a negative influence to mining output. Community protests blockading mines access roads due to unhappiness with their political nominated councillors.	Safety measures are cumbersome	
Labour costs	The issue of South African Politics	The engineering skills have diminished from previous years causing companies to seek specialists to assist. This does not allow the company room to improve on maintenance improving reliability and reducing costs on replacing equipment.	
Employees not wanting to change	Mining legislation, Labour relations and Political interference	Engineering practises. Marketing of products.	
Devide in unions, lack of ownership schemes to possibly drive performance and pride in quality and effeciency of work output	Mining Legislation and Political interference	unable to producer competent operators	
Bad attitudes from labour and unions.	Regulatory, Governmental laws (uncertainty)		
Labour strikes and unsafe working environment ie there have been a number of collapses killing and trapping people.	Political involvement		
Labour issues and constant strikes	Effective structures and more defined roles and responsibilities		
Labour, corruption and white supremacy			

**Figure 19: Opinion on improvements in production significant impact on South Africa’s mineral output**



The majority of respondents answered that labour and union related issues (37%) and legislation and statutory issues (33%) are the largest non-production factors that have an impact on mining production.

### 5.16 Validity Test

A validity test on the four scale type questions were performed to ensure reliability. The test performed was Cronbach’s Alpha:

**Table 20: Reliability statistics**

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.463	.434	4

The relevant variables are displayed below in Table 21.



**Table 21: Relevant variables**

<b>Item-Total Statistics</b>					
	<b>Scale Mean if Item Deleted</b>	<b>Scale Variance if Item Deleted</b>	<b>Corrected Item-Total Correlation</b>	<b>Squared Multiple Correlation</b>	<b>Cronbach's Alpha if Item Deleted</b>
<b>In your opinion, are mining companies in South Africa educating the workforce on advancements in production technology, no matter how mundane it appears?</b>	7.68	4.559	.048	.096	.560
<b>In your opinion, have South African mining companies shown the ability to quickly adapt to changes in the market place?</b>	7.39	2.712	.468	.225	.151
<b>In your opinion, would improvements solely in production efficiency have a significant impact in South Africa's mineral output?</b>	7.65	3.037	.333	.131	.318
<b>In your opinion , have South African mining companies become too accustomed to adopting a mind-set of solely adapting cost cutting as opposed to innovating for production improvements , as an efficiency and profitability measure ?</b>	7.97	3.966	.231	.183	.423
<b>In your opinion, are mining companies in South Africa educating the workforce on advancements in production technology, no matter how mundane it appears?</b>	7.68	4.560	.048	.096	.560
<b>In your opinion, have South African mining companies shown the ability to quickly adapt to changes in the market place?</b>	7.39	2.713	.468	.225	.151
<b>In your opinion, would improvements solely in production efficiency have a significant impact in South Africa's mineral output?</b>	7.65	3.1895	.333	.131	.318



## 5.17 Conclusion

This section provided the results of the data collection tool, namely the online survey. As explained in Chapter 4, due to the data collected being of the nominal and ordinal variety as well as the sample selection not being random the only valid statistical tests are of the exploratory descriptive type.

## CHAPTER 6: DISCUSSION OF RESULTS

### 6.1 Introduction

This chapter discusses the results of the findings presented in chapter 5. These findings will be linked back to the literature in chapter 2 in order to offer explanations for the questions presented in chapter 3.

### 6.2 Profile of respondents

The sample contained 31 respondents from across various levels and sectors of mining production. The demographic part of the survey with regards to aspects such as gender, racial diversity and age was not necessary as it could not offer any information relevant to the research questions. The sample size was very small due to the time constraints and other factors mentioned in chapter 3. The concentration of respondents could run the risk of being homogenous.

As shown in section 5.1 (table 3, figure 4) of the 31 respondents, 11 respondents indicated a 0-5 year tenure and another 11 indicated 15+ years tenure. The remaining respondents have been employed in the mining industry between 5 and 15 years, this range of response has given good representation across a range of longer serving and newer employees in order to provide a rounded view point instead of a biased sample.

The education levels also presented a similarly diverse range from the respondents with 38.7% having a national diploma as the highest qualification followed by 25.8% having a bachelor's degree as the highest qualification. This indicates that the sample of respondents is well educated and skilled and are probably using this skills and knowledge acquired through the qualifications in the workplace, due to the qualification being mining related as shown in section 5.2 (table 4, figure 5).

Organisational rank detailed in section 5.3 (table 5, figure 6) provided a more concentrated view with 38.7% respondents indicating a middle rank within the organisation and 32.3% indicating senior ranking. With junior employees

making up 9.7% and specialist employees 19.4%. This distribution could possibly introduce a viewpoint heavily influenced by more senior members of an organisation.

As can be seen by the above discussion most of the respondents have either been employed in the mining industry for less than 5 years (36%) or more than 15 years (35%). As can be gathered from section 5.4 (table 6, figure 7) most of the respondents (58%) have also spent the majority of their careers in the mining industry. Also, the respondents mostly have mining industry related tertiary qualifications and they are from the middle and senior tiers of companies. These answers aids in the conceptualisation of a profile of the respondents in order to give the context to the rest of the discussion

### **6.3 Discussion of research question 1: Are South African mining techniques optimised for competing in the global market?**

This question was formed in response to the literature summary indicating a decrease in mining production in South Africa, despite the country having large amounts of proven mineral reserves. Further review of the literature indicated that other mineral producing countries have increased production year on year in response to the current commodity boom whilst South African production has seen movement in the opposite direction. The research question was posed in order to understand whether South African production techniques are sufficiently competitive in a global industry.

Within the South African context, the implementation of new practises in a labour intensive environment such as mining is an arduous exercise (Seekings and Natrass, 2002) even though in section 5.6 (table 8, figure 9) of the research it can be gathered that the majority of participants within the sample group, indicated with 58.1% that the mining industry is willing to adapt techniques to the changing environment and this could be seen as a positive.

This is somewhat in contradiction to when asked if they had witnessed a production technique breakthrough in their career that 74.2% of respondents responded in the negative as detailed in section 5.5 (table 7, figure 8). This figure

indicates that no innovative new techniques have been implemented in the span of the vast majority of respondents' careers.

As most of the respondents have more than 15 years mining industry experience and have spent most of their career in the mining industry as can be seen through section 5.1 and 5.4, it can be assumed that very little production efficiency breakthroughs have occurred or have been implemented in at least the last 10 to 15 years. It is then quite interesting that the majority of the participants said that the industry is always evolving. The question could be asked whether it is in fact evolving in the field of production efficiency.

As determined by both Cetin in 2013 and Hana in 2015 innovation is a driver of economic success and organisations need to recognise the importance of innovation in the global market. Considering 64.5% of the sample have spent more than five years of their careers in the mining industry, this points to a very low implementation of new techniques.

The researcher suspects that the 58.1% of the respondents that indicated that the mining industry in South Africa adapts their technique to the environment could have misconstrued the question and are in fact referring to the subtle adaptations required to implement standard practise across differing physical environments. This suspicion was brought about by the next largest respondent category to the query whereby 22.6% of the respondents were unable to answer.

When asked in section 5.7 (table 9, figure 10) to rate South African production techniques on a score out of 10, the most frequently occurring score was 6. This was then compared to an evaluation of international mining techniques where the most frequently occurring response was 7 out of 10. As respondents were asked to use the same conceptual scale for both questions the implication is that international mining techniques are more efficient than South African techniques.

Most of the participants ranked the South African production techniques high but they also ranked the international production techniques higher (taking into account that 65% of the participants did not have international mining

experience). Due to the global competitiveness of mining (Sprague, 2015), countries cannot afford to be behind the competition in terms of efficiency. In the mining industry this is especially important due to the industry being a price taker and any extra cost borne out by inefficient practises are often difficult to pass onto customers (Vernier, 2012) as customers will simply look for a producer who is cheaper. While recognising that the technique needs some refinement in South Africa, implementation of proven productivity techniques has been difficult due to the above mentioned labour structure (Seekings and Natrass, 2002).

Encouragingly, when asked about the implementation of new techniques as detailed in section 5.9 (table 11, figure 13), none off the respondents indicated that it was impossible, with the vast majority of respondents (80.6%) indicating that this is possible with the inclusion of all stakeholders. This inclusion of all stakeholders is necessary to repair the damage that has been done in the relationships between mining companies, government and labour (Venier, 2014) with all sides showing a deep mistrust of each due to a complex history, there is need for a realisation of mutual benefit to rebuild any trust.

When asked which areas within the production cycle were in most urgent need of changes the respondents answers were varied and diverse, as shown in section 5.10, due to the qualitative nature of the question. These answers were grouped into categories derived from the literature and also from common themes within the responses (table 13, figure 14). These categories were labour and union related, legislation and statutory, technical and skills and other. The majority (39%) of the improvements were suggested regarding technical and skills improvements mentioning specifically education, training and behaviour changes.

As can be seen, the biggest response group by far was in the technical and skills category, with a very strong bias towards operator improvements and plant availability. In section 5.11 (table 14, figure 15), it can be seen that the majority of the participants are of the opinion that the industry is sufficiently educating employees in advancements in production technology. The push towards improving plant longevity and utilisation via operator training seems to be the

recurring theme within that category and points towards the need for mining companies to have global operating practises. Even though global operating practises rolled out across all borders is not always the ideal solution (Sprage,2015), the benefits of adopting proven operating practises from countries that have benefitted from the current commodity boom, should be weighed against any potential backlash. This adoption of globalised measures could lead to cost saving, quality improvements and a shorter time to market that South Africa needs to compete globally (Steianman, Vollmar and Voigh, 2012).

An unexpected finding from section 5.11 is the perception from respondents that South African mining companies are educating the workforce on improvements on mining process. That combined with the low scoring of the mining technique indicate that even though the workforce has been educated, there is little implementation or utilisation of new knowledge which is in keeping with the findings of Norman ,2010 and his assertion of skills not being passed on via succession planning and the lack of mentoring within mining companies

Rhee, Park and Yoo (2015) stated that a moderate degree of standardisation is all that is necessary to stimulate innovation, but with mining companies in South Africa seemingly not interested in stimulating innovation at all, it seems likely that South African mining companies will not be able to take advantage of the current commodity boom even though it has been long and sustained, due to continuous demand from developing nations (Radetzky, 2013)

The above discussion, although providing some finding that were sometimes contradictory to each other point towards the same conclusion. South African production techniques, while not entirely ineffective need to be overhauled in order to be complete at a global level. As shown by the respondents, the implementation of new techniques is possible with the inclusion of all stake holders and this opportunity has to be taken if South Africa wants to rise to the top rank of world mineral producers.

#### **6.4 Discussion of research question 2: What other factors affect South African mining production and how do these factors affect the industry?**

When asked in section 5.15 what factors, besides technique affects production the respondents had varied and diverse answers (due to the qualitative nature of the question). These answers were grouped into categories derived from the literature and also from common themes within the responses. These categories were labour and union related, legislation and statutory, technical and skills and other (table 19, figure 19). The categorical framework is similar to section 5.10 due to the commonality of answers which was made evident in during the analysis process

Labour and union related issues presented the majority of responses followed by legislation and statutory issues. This agrees with the findings of Vernier (2014) who determined that one of the factors affecting mining investment in the country was the labour issues. As explained by Seekings and Natrass in 2002, South Africa has a very structured labour segment due to the history of the country.

Due to this structure, the unions across nearly all sectors are very powerful and are often seen as agitators in conflicts between labour and the employer. Some of the response provided such as “bad attitudes ....” , “strikes ....” , “ labour demands “ point towards a very strained relationship between unions and companies. This is further exacerbated by unions being split within the sector such as the recent AMCU (The Association of Mineworkers and Construction union) and NUM (national Union of Mineworkers) debacle.

This sort of behaviour , whereby actions have become legitimised is known as institutionalised behaviour (Najee,2014) Even though institutionalised behaviours are the vital to providing stability to organisations , this very same behaviours does not allow for fast changes due to the structural stability ( Lustick,2011)

In the current minerals environment where the buyer simply goes to the cheapest supplier this sort of inability to adapt to shifting global trends will ensure the redundancy of a competitor. Kahler, 2014 explains that globalisation, which is the process of economic integration at a global level, pits the volatility against

improved economic performance. The inability to be fluid in a dynamic market will lead to irrelevancy

In section 5.12 (table 15, figure 16) it can be seen that most participants (39%) believe that mining companies have the ability to quickly adapt to changes in the marketplace which also links to section 5.6 where most participants answered that the mining industry has the ability to evolve and adapt to changing environments. Although, through section 5.13 (table 16, figure 17) it can be seen that participants are of the opinion that mining companies would rather use cost cutting as opposed to encouraging innovation, for production improvements as an efficiency and production measure.

This indicates that the mining industry adapts and evolves but by means of cost cutting rather than using production improvements. This could be because of the labour and union issues in the country. As explained by Norman (2010), when explaining the lack of scarce skills in the sector, this approach of showing improvements in profitability has its pitfall over the medium to long term. 58% of the participants (section 5.14, table 17, figure 18) is of the opinion that improvements solely in production efficiency will have significant impact in South Africa's mineral output.

Innovation within an environment that competes globally is imperative to ensure relevancy within the global market. This was demonstrated by Chanturia, Kozlov, Mateeva and Lavrinenko in 2015 when they detailed how the Russian platinum industry benefitted from improvements in technique via innovation. The South African mining industry to all intents and purposes owes its existence to innovation, even though it might not have been labelled as such in the previous century (Muller, 2016)

The similarity between table 11 and table 13 point towards a common perception in terms of how respondents view the current mining environment with the identification of non-technical aspects having a determining impact on mining productivity within South Africa.



Leon, 2012 claims that these non-technical reasons are the idea behind mining companies not wishing to invest further in South Africa and produced a detailed list of factors hindering investment. These factors which included a BEE policy that was riddled with problems, mine nationalisation and the emergence of a state-owned mining company. All these factors point towards the uncertainty around legislation and statutory requirements

In order for South Africa to avoid falling into the trap that has befallen other resource rich countries of low growth rates and high inequality (Van der Ploeg, 2011) the uncertainty created by weak institutions need to be allayed and instead replaced by quality institutions that encourage efficiency over rent seeking behaviour, (Faradic, Islam and Moslehi, 2015)

A portion of respondents (22%) indicated that the skills and training needed to effectively operate within the globalised mining environment have diminished in recent years. This supports the findings of Norman, 2010 who found that the skills needed in the mining sector are diminishing and that the current programmes and curriculums needed to effectively manage these operations are inadequate and need of redesign. This could also be attributed to mining companies looking to implement short term gains and lower training costs.

The above discussion points towards a conclusion that paints a bleak picture for the South African mining sector if left unattended. The institutionalised behaviours of unions and labour will have to change to come to the realisation that evolution of the mining industry in South Africa is necessary due to the evolution of the global industry. Coupled with the lack of skills, and the uncertainty around legislations and statutory, mining conglomerates have not invested into the future of resources in the country and have instead decided to look further afield for opportunities that are more lucrative and less prone to bureaucracy and complex political interference.

## 6.5 Conclusion

Through the above analysis and discussion of the research results it can be concluded that the mining industry faces a few complex problems. A majority of respondents have more than 15 years mining industry experience but have not witnessed any significant production breakthroughs in their careers. It is believed that the mining industry adapts and evolves well to the changing environment and marketplace but this not done through production efficiency improvements but rather through the implementation of cost cutting. It was also found that labour, legislative and statutory issues prevent the mining industry in South Africa from improving but the participants are of the opinion that improvements could be made in the fields of training. It is also believed that production improvements could have a significant impact on the future of the mining industry.

## CHAPTER 7: CONCLUSION

### 7.1 Introduction

This chapter illuminates the main findings from the research and provides a link between the reason for research and results.

### 7.2 Principal findings

The results of this research seem to indicate that while production technique in South Africa is in need of an overhaul, a major barrier to mining production is the relationship between various stakeholders. The animosity by companies towards labour and the vice versa, coupled with governmental policies that are often criticised have led to a cycle that needs correction at the first step, which is the initiation of an improved more cohesive, symbiotic relationship between all stakeholders.

This recognition that the relationship should be mutually beneficial and not one of mistrust and suspicion should assist with the retention and growth of the technical skills needed within the sector. When short term cost cutting exercises are applied across mining companies, a loss of critical skills is often the result, which not only ensures the company loses a vassal of knowledge but also discourages innovating for improved efficiency processes.

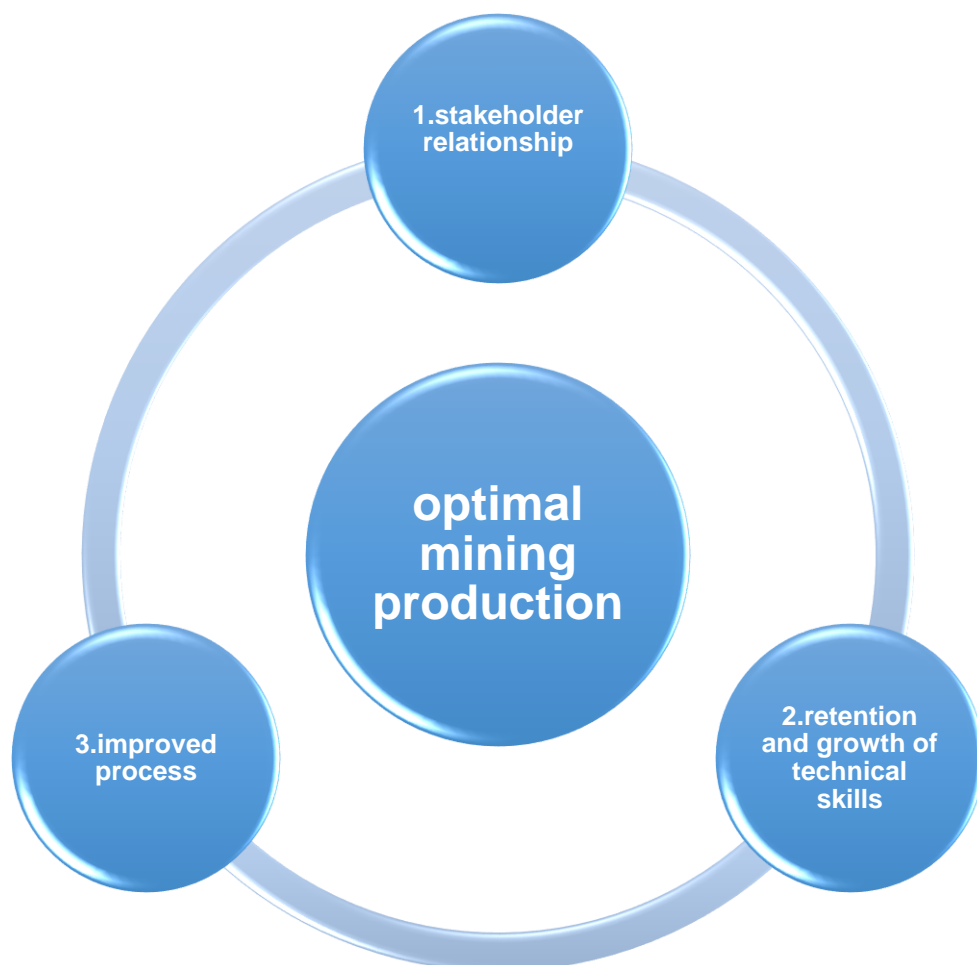
This improved efficiency process leads to a more favourable cost to production ratio and ensures relevancy and sustainability in a global market.

The above steps can be summarised into the figure below. Due to the results of the finding the steps have to be implemented at the first step which is improving stakeholder's relationships. These relationship refers to the relations between labour and management, or labour and the union, or management and government or government and union or any other combinations that are present in the sector. It is this multitude of relationships that leads to complexity and misgivings amongst stakeholders, which then affect operational activities.

This improvement in trust and understanding between all parties will allow for step 2 to be implemented, which is the retention and growth of the skills needed to operate mines efficiently. This lack of skills is described as one of the hindrances to the sector due to retirement and curtailing of budgets by mining companies.

The implementation of step 2 should lead to natural progression to step 3 which is an improved process. Improved skills and working environment will assist in the fostering of implementation of more efficient processes whether by innovation or implementation of proven techniques Even though the process starts at Step 1, it is vital that it is ongoing as halting the process will lead to regression.

**Figure 20: Optimal mining production**



### **7.3 Implications for stakeholders**

The results of this research and the implications to all stakeholders within the mining within South Africa, indicate a new approach and perspective to mining and realisation that the old South African model of labour intensive, monopolistic mining approaches do not work in an environment shaped by global competition. In an environment that is constantly evolving, the sector cannot ignore that previous dominance in an industry is not a guarantee of future relevance and sustainability.

### **7.4 Limitations of the research**

The results and conclusion of this research can only be attributed to a very small section of the open cast mining sector in South Africa. This is due to the non-probability method of random sampling used, as the total population is unknown and the subsequent non availability of a sampling frame. This narrow sample might exhibit characteristics not present in other spheres of open cast mining so the results should not be extrapolated to the rest of the population. The questionnaire, through flawed design, did not allow for proper and full expansion of the qualitative answers thereby not allowing respondents to fully express themselves and elaborate on pertinent points.

### **7.5 Suggestions for future research**

Due to the very exploratory nature of this study, there are certain shortcomings and one of those is being unable to extract as much information as possible from within a certain response field. The researcher would recommend that further research be done in the field of improving relationships between stakeholders within the mining industry, perhaps by engaging a much larger sample group over a much wider spectrum of the industry. Ideally, this should be done in a manner that allows for the collection of as much qualitative data as possible as this area of concern deals almost exclusively with human behaviour.

The second area of research the researcher would recommend is a direct comparison of international mining techniques versus South African mining techniques in open pit mines. This sort of comparison would involve interaction between various mining houses across borders. This sort of research should obviously be undertaken at each mineral sector (coal, iron, manganese, etc.). This will ensure that mining companies are able to focus their efforts and ensure that the latest and most efficient techniques are introduced into the production stream.

The third area of suggested research is that of the feasibility of the beneficiation of minerals in South Africa. Beneficiation is the process of improving the value of minerals by removing impurities and concentrating the product. This type of process would work as the next step to raw material extraction and could assist in employment creation. If materials could be extracted and beneficiated in close proximity to each other this could possibly lead to a national competitive advantage.

## **7.6 Conclusion**

This research study set out to determine if South African mining production techniques are as optimised as they should be to enable competitiveness in a global market and to determine which other factors have an effect on mining production. The results of this study have indicated that South African mining techniques are not off the standard required to be competitive in the global market and that there are a multitude of areas outside of direct production that affect mining production in this country, which has the undesired consequence of dramatically curtailing investment in South Africa by mining companies.

In a world characterised by what could best be described as a Volatile, Uncertain, Complex and Ambiguous (VUCA) environment the researcher hopes that this research has contributed in a miniscule manner to understanding the challenges and shortcomings facing South African mining production, in the face of ever increasing global competition.

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## APPENDIX A: QUESTIONNAIRE

1. How many years have you been employed within the mining industry?
  - 0-5 years
  - 5-10 year
  - 10-15 years
  - 15 + years
  
2. Do you have a mining related qualification? If more than one , please chose the highest ranked option
  - Master's Degree or equivalent NQF 9 qualification
  - Bachelor's Degree or equivalent NQF 7 qualification
  - National Diploma or equivalent NQF 6 qualification
  - National Certificate
  - Certification in a specialist skill ( e.g. Blasting )
  - Not applicable
  
3. What position do you currently occupy within the organisation?
  - Senior
  - Middle
  - Specialist
  - Junior
  
4. Would you describe your tenure within the mining industry as having been the majority of your career life span?
  - Yes
  - No
  
5. Where you employed in the industry during a period when a major breakthrough in production efficiency occurred?
  - Yes
  - No
  
6. During your tenure in the mining industry, what has been your opinion of the production process?
  - Always evolving to adapt to environment
  - Rigid in roll out and application with no room for deviation
  - Some leniency and adaptability is allowed in roll out and application
  - Unable to answer
  
7. In your opinion how efficient would you rank the current mining production techniques used in South Africa
  - Ranking numerical scale

8. If you have mining experience outside of South Africa, how efficient would you rank international mining production techniques, using the same opinion base as the question above?
  - Ranking numerical scale
  
9. In your opinion to what extent, given the uniqueness of South Africa's environment, would it be possible to cherry pick and implement proven production efficiency practises?
  - Impossible
  - Possible with the inclusion of all stakeholders
  - Possible with small institutional changes
  - Unable to answer
  
10. Which area(s) within the production cycle would you identify as needing urgent changes to enable improved efficiency? (open ended question)
  
11. In your opinion, are mining companies in South Africa educating the workforce on advancements in production technology, even if it is seemingly mundane?
  - Strongly Agree
  - Agree
  - Unable to determine
  - Disagree
  - Strongly Disagree
  
12. In your opinion have South African mining companies shown the ability to quickly adapt to changes in the market place?
  - Strongly agree
  - Agree
  - Unable to determine
  - Disagree
  - Strongly Disagree
  
13. In your opinion, have South African mining companies become too used to adopting a mind-set of solely adapting cost cutting as opposed to innovating for production improvements as an efficiency measure ?
  - Strongly Agree
  - Agree
  - Unable to determine
  - Disagree
  - Strongly Disagree
  
14. In your opinion would improvements solely in production efficiency have a significant impact in South Africa's mineral output?



- Strongly agree
- Agree
- Unable to determine
- Disagree
- Strongly Disagree

15. In your opinion what other factors, besides production related issues, have the largest impact on South African mining production, and is stopping the country from becoming the market leader? (open ended question)

## APPENDIX B: INFORMED CONSENT

Thank you for clicking on the link and accessing this short questionnaire.

I am conducting research into the maximisation of productivity in mining .To facilitate the process, I would ask you to please complete the questionnaire to the best of your ability .This will help the researcher better understand the requirements for an optimum model of production efficiency. The questionnaire should take no more than 20 minutes of your time, probably much less than that.

Your participation is voluntary and you can withdraw at any time without penalty. All data will be kept confidential and by completing the survey you indicate your participation has been voluntary. Please do not hesitate to contact either myself or my supervisor if you have any questions or concerns.

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